SMART REGION

CONCEPT OF OPERATIONS

FINAL

February 2019

Prepared for:

SACOG

Contract No. 17180016

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LIST OF ABBREVIATIONS

AMQP-Advanced Message Queuing Protocol
ATMS - Advanced Traffic Management System
ATP – Active Transportation Program
ATSPM – Automated Traffic Signal Performance Measures
BOS- Bus on Shoulder
CAD – Computer Aided Dispatch
CAV – Connected /Automated Vehicle
CCTV – Closed Circuit Television
CHP – California Highway Patrol
CIP – Capital Improvement Plan
CMAQ – Congestion Mitigation and Air Quality
CMS – Changeable Message Signs
CoAP – Constrained Application Protocol
ConOps – Concept of Operations
CRISP-DM – (Cross Industry Standard Process for Data Mining)
CTC – California Transportation Commission
DDS – Data Distribution Service
DOT- Department of Transportation
DSRC- Dedication Short Range Communications
EMS – Emergency Medical Services
FCN- FOG Computing Nodes
FD- Fire Department
FHWA – Federal Highway Administration
FSP – Freeway Service Patrol
ICM – Integrated Corridor Management
ITIP – Interregional Transportation Improvement Program
IoT- Internet of Things
ITS – Intelligent Transportation System
IVR – Interactive Voice Response
M2M- Machine to machine
MPO – Metropolitan Planning Organization
MTP – Metropolitan Transportation Plan
NHTSA- National Highway Traffic Safety Administration
O&M – Operations and Maintenance
OCF – Open Connectivity Foundation
OMG – Open Management Group
PCT – Placer County Transit
PD – Police Department
RSTP – Regional Surface Transportation Program
RTIP – Regional Transportation Improvement Program

SACOG – Sacramento Area Council of Government
SacDOT – Sacramento Department of Transportation
Sac Region 511 – Sacramento Region 511
SacRT – Sacramento Regional Transit
SCAS – Sacramento County Airport System
SCS – Sustainable Communities Strategy
SE- Systems Engineering
SHA – State Highway Account
SMAQMP- Sacramento Metropolitan Air Quality District
SMUD - Sacramento Metropolitan Utility District
SOV – Single Occupancy Vehicle
SRTP – Short Range Transit Plan
SRFECC – Sacramento Regional Fire / EMS Communication Center
SRRCS – Sacramento Regional Radio Communication System
STARNET – Sacramento Transportation Area Network
STIP – State Transportation Improvement Program
TASAS – Traffic Accident Surveillance and Analysis System
TMC – Transportation Management Center
TOC – Traffic Operations Center
TRPA – Tahoe Regional Planning Agency
VMT – Vehicle Miles Travelled
YCTD – Yolo County Transportation District

SCOPE AND SUMMARY

The SACOG Smart Region is a regional program that integrates technology to meet the current and future needs of the Sacramento region. The Smart Region program strives for effective investment in transportation, "to improve system performance, safety and sustainability." The Smart Region builds upon the existing Intelligent Transportation Systems (ITS) network and plans to implement new technologies that require involvement from SACOG and its partner agencies.

The SACOG Smart Region is defined by a large area that is made up of cities and communities that include urban, suburban, and rural landscapes. In total the area has six counties and 22 cities. This makes the project area unique, as it covers a large region and should address needs in different contexts. The SACOG Smart Region Plan is being developed with the goal of creating a Smart Region that integrates local and regional infrastructure to coordinate operations.

The SACOG Region is experiencing congestion as a byproduct of the significant growth the region has experienced. SACOG is actively seeking innovative solutions to combat the area's mobility challenges. Home to major freeways, such as I-5, I-80, US-50, the region experiences congestion, especially during peak periods. There is a strong agriculture industry in Sacramento County and recreational tourism is prevalent in the Lake Tahoe area. The Sacramento Region is also influenced by the Bay Area, which leads to more congestion in the region. This neighboring congestion makes the region susceptible to other challenges beyond its local traffic condition.

The Smart Region plans to utilize new technologies to maximize existing roadway and ITS infrastructure to create a cohesive system, where urban, suburban, and rural needs can all be addressed. Moreover, the Concept of Operations (ConOps) aims to promote interagency collaboration and data sharing for an effective use of resources and coordination.

1.1 Introduction and Document Contents

The Sacramento region is well positioned to be a Smart Region because of the area's diversity, economic growth, and shifting technological needs. Smart Regions implement systems to promote connectivity between urban and rural areas, allow for greater mobility to provide access to economic opportunities, improve transportation system safety, and design a sustainable Smart Region that can adapt to emerging technologies.

SACOG has identified a need to maintain existing ITS infrastructure and implement new technology in the region. With the assistance of partner agencies and Kimley-Horn, SACOG plans to develop a system that promotes coordination between stakeholders and infrastructure. These plans accommodate new technology to promote system-wide modernization, including but not limited to, reliable communications between stakeholders, real-time traffic data, promoting transit and active transportation, integrated corridor management, ITS maintenance strategies, central system management, and traveler information services that are timely in times of emergency.

The ConOps provides stakeholders with an outline of the proposed system and provides details on which roles each stakeholder will assume once the project is put into operation. To create the system, the project stakeholders will need to accept the concepts in this document.

The document is divided into the sections below to streamline the review process:

- Introduction
- Scope and Summary
- References

- Background: Existing Scope and Operational Characteristics
- Objectives
- Concept for the Proposed System
- Operational Scenarios
- Emerging Technologies
- Big Data
- Next Steps

The ConOps develops a framework for coordination between stakeholders. It presents potential strategies that can be adopted, but also lays the groundwork for future projects. The document provides Next Steps, which can lead to stakeholder action to implement new projects in their jurisdiction, while integrating with the existing regional ITS infrastructure and operations.

1.2 Development of Concept Operations

The Concept of Operations is an important step in the Systems Engineering (SE) process. The Concept of Operations defines the roles of each stakeholder once the project is placed in operation. **Figure 1** is taken from the Federal Highway Administration (FHWA), and illustrates where the Concept of Operations falls in the SE timeline. The FHWA requires all transportation projects with federal funding to use the SE process. Projects will also opt to use the process as each step helps organize and facilitate the comprehensive planning of SE projects. The process allows for documentation of stakeholder goals to ensure that they are met.

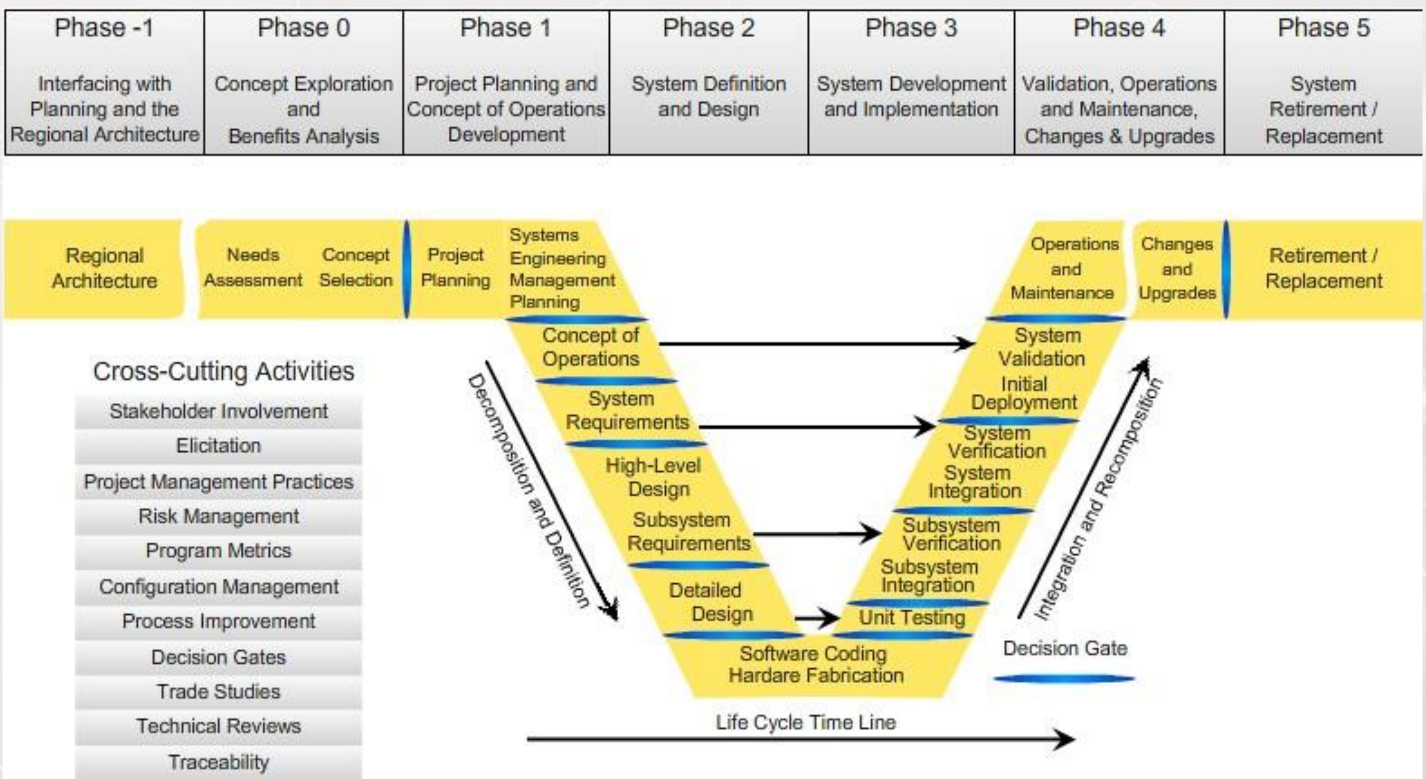

Figure 1: The Systems Engineering Diagram

The ConOps is one step in this process that works in concert with the Local Technology Implementation Plans and the Regional Technology and Mobility Master Plan. These documents serve as guidelines that can help individual agencies and the region in providing a baseline set of guidelines to implement local and regional projects. Below is a graphic of each step of the planning process for the Smart Region project (**Figure 2**).

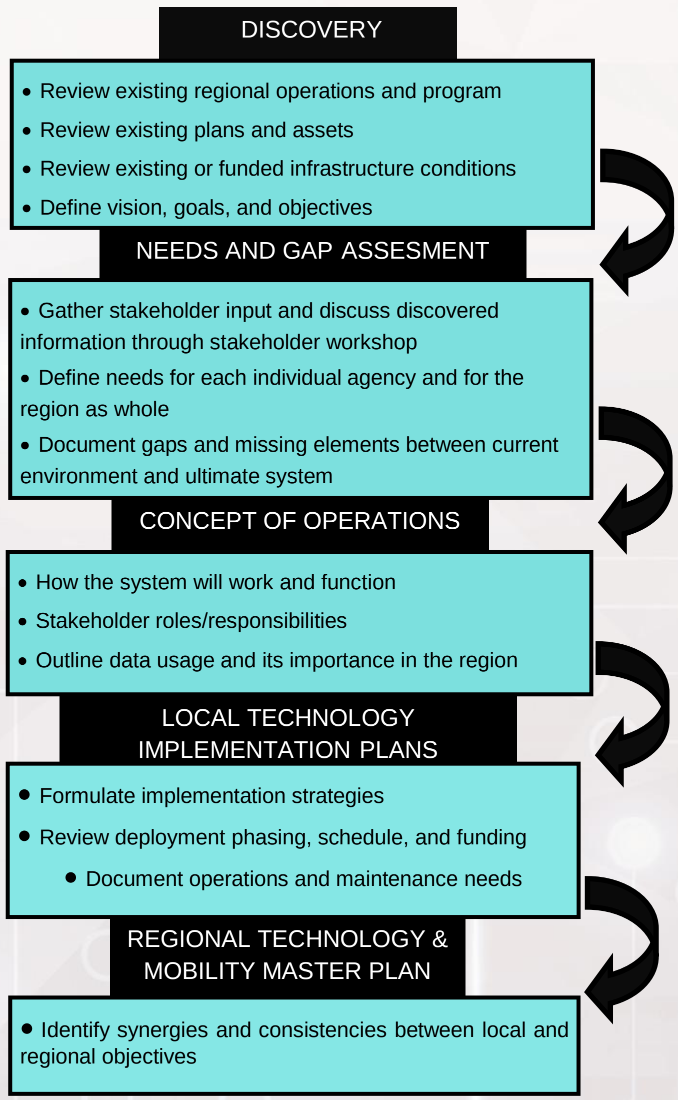

Figure 2: Smart Region Sacramento Development Process

REFERENCES

The Systems Engineering process requires information gathering to determine needs. This information gathering was executed in various ways for the Smart Region. Regional needs were determined, alongside local needs. Multiple cities in the region were approached for information about their jurisdiction. This information helped inform an existing conditions document, and eventually led to the Local Implementation Plan. Information was not provided for all areas, but existing conditions memoranda and local implementation plans were produced for the following jurisdictions:

- Local Implementation Plan: City of Citrus Heights
- Local Implementation Plan: City of Elk Grove
- Local Implementation Plan: City of Folsom
- Local Implementation Plan: City of Sacramento
- Local Implementation Plan: El Dorado County
- Local Implementation Plan: City of Rancho Cordova
- Local Implementation Plan: Sacramento County
- Local Implementation Plan: Caltrans District 3
- Regional Technology and Mobility Master Plan

These documents are used as reference material throughout the ConOps to provide information regarding inventory, operations, and other existing conditions for the agencies. There are other important local stakeholders that are not included in this list, but some are referenced later in the document. The ConOps also provides suggestions and a framework for other SACOG partner agencies to adopt.

BACKGROUND: EXISTING SCOPE AND OPERATIONAL CHARACTERISTICS

This chapter discusses the current conditions of the system to better understand its current limitations to establish goals for the future. Below is a description of existing regional operations and programs that service the Sacramento Region. Having a clear understanding of existing infrastructure and operators is helpful to determine regional needs and gaps. Furthermore, it provides a framework for which the new system can build upon.

The Concept of Operations is one of many documents that will be produced for the Smart Region project. Before developing the Concept of Operations, the Project Development Team met with stakeholders to understand the existing conditions in the local jurisdictions and the region. Some agencies provided extensive information, which was gathered to produce an Existing Conditions and Needs Memorandum. These documents were produced for the following stakeholders:

- City of Sacramento
- City of Citrus Heights
- City of Elk Grove
- City of Folsom
- City of Rancho Cordova
- Sacramento County
- El Dorado County
- Caltrans District 3

There are other critical stakeholders who will be mentioned throughout the document that are not included on this list. They can be found in **Table 1**.

The Existing Conditions provides inventory of both local and regional equipment. Therefore, leading to a greater understanding of what existing systems the Smart Region could add to and what systems were non-existent. This led to the production of a Needs Assessment for not only the region, but also each of the local jurisdictions. The Needs Assessment provides the necessary information to create the Concept of Operations. This Concept of Operations builds on the previously developed Needs Assessments. The needs are not repeated here, but are used to inform the operation concepts as part of the traceability in the Systems Engineering process.

Sacramento Regional Stakeholders and Institutional Partners

SacRT (Sacramento Regional Transit)
SacRT serves as the regional transit agency for the region. The system consists of bus, light rail, paratransit, and shuttle service. Additionally, SacRT released a new MicroTransit shuttle system in Frank-South Sacramento called SmaRT Ride and is planning future light rail stations. SacRT was awarded additional funds to expand the SmaRT Ride service. SacRT was also awarded additional funds for new light rail trains to extend the line to Folsom. The agency provides accessibility services and shuttle services to Golden 1 Center. The system also promotes biking and provides bicycle racks on buses and new light rail cars. Some of the stations also provide bike lockers for safe parking.

SCAS (Sacramento County Airport System)
SCAS oversees four airports in Sacramento County: Sacramento International Airport, Mather Airport, Executive Airport, and Franklin Field. SCAS and SacRT have partnered to develop future light rail extensions to make the airports transit accessible.

FSP (Freeway Service Patrol)
The FSP is a joint-program provided by Caltrans and CHP. FSP Valley Division oversees Sacramento, Yolo, Placer, El Dorado, and San Joaquin Counties. FSP provides roadside assistance and help after incidents have occurred. The FSP trucks are deployed to clear scenes and remove any obstructions from the road. Their goal is to reduce congestion and have traffic return to normal operations, all while maintaining safety on freeways.

CHP (California Highway Patrol)
CHP is the law enforcement agency for California highways. CHP helps administer the Motorist Aid Services (MAS) program in partnership with Caltrans. CHP manages incident operations, directs roadway operations, directs actions of Caltrans, tow truck drivers, others, and advises various TMCs of the status of incident management and roadway conditions. During incidents, CHP will coordinate with agencies such as Fire and Emergency Services. CHP dispatches through 911 and the CHP Sacramento Communications Center (SCC). CHP also gathers incident data, which is helpful in providing accurate traveler information.

Sacramento Police Department
The Sacramento Police Department aims to protect the public safety of the community and holds partnerships with many different community organizations. They provide communications with the public through the 911 system. These 911 services are in the CHP Sacramento Communications Center (SCC). It is located with Sacramento Regional TMC which is operated by Caltrans. This allows for interagency communication and cooperation in times of emergency.

Rancho Cordova Police Department
The Rancho Cordova Police Department provides law enforcement for the City and promotes public safety. Rancho Cordova PD provides patrol services throughout the City at all times of the day. They hold units for crime suppression, problem-oriented policing, and traffic. The traffic unit consists of traffic police and parking enforcement. They communicate with the 911 system to dispatch officers when needed.

Elk Grove Police Department
The City of Elk Grove has a police department for law enforcement. They hold division that provides administrative, field, investigative, and support services. Within field services is the traffic bureau, which manages traffic and pedestrian safety. Elk Grove PD is connected to 911 and will send out police resources based on the severity of the incident.

Citrus Heights Police Department
Citrus Heights PD holds various divisions that include investigative and patrol services. Traffic falls under patrol services and aims to promote motorist, bicycle, and pedestrian safety. Citrus Heights PD will send out officers based on 911 calls and requests made through the dispatch system.

Folsom Police Department
The Folsom PD holds various divisions and units. This includes patrol and traffic services. The traffic unit manages traffic as needed and monitors motorist behavior. They will assist motorists as needed and ensure the safety of drivers, cyclists, and pedestrians. Folsom PD will send out resources as requested when reports are made to 911, and other agencies.

Sacramento Metropolitan Fire
Sacramento Metropolitan Fire department ensures public safety by providing full-service fire services. The Department operates 24 fire stations and takes part in automatic aid agreements with bordering agencies. The Fire Department provides services related to fires, medical

emergencies, hazardous materials, technical and water rescues. The Fire Department also provides administrative and prevention services.

Emergency Medical Services provides pre-hospital care when emergencies occur. First responders operate from the fire station and provide 24-hour services. Each vehicle is staffed with two firefighters and one paramedic.

Sacramento Regional Fire / EMS Communications Center (SRFECC)
The SRFECC serves as the Regional Fire and Emergency Medical Services dispatch service. This center dispatches services from various agencies depending on when the incident occurs. The SRFECC is linked to various fire departments including Folsom, Cosumnes, Sacramento, Metro, Courtland, Herald, Isleton, River Delta, and Walnut Grove, and Wilton. Many of the fire departments in the SACOG Smart Region are linked to this Center, allowing for coordination between the different agencies.

Tahoe Regional Planning Agency (TRPA)
The Tahoe Regional Planning Agency is responsible for the conservation and planning of the Tahoe region. Their goals support environmental and community health. Their strategic plan provides environmental and organizational goals for accountability and community service. The Agency is responsible for producing monthly progress reports. They have focused their efforts on transportation planning to develop a regional system. This includes parkways, highways, transit, waterways, bicycle facilitations, goods movement, and public transportation facilities. Their goal is to reduce reliance on the automobile and provide alternative modes of transportation to reduce noise and air pollution through the area. There is currently a transit system in the South Shore area and a transit terminal in Kingsbury Grade.

Commuter Express Trains

The Capitol Corridor Route connects the Bay Area and Sacramento Region and is managed by the Capitol Corridor Joint Powers Authority (CCJPA). In the Sacramento region there are multiple stations including Davis, Sacramento, Roseville, and Rocklin. The train spans 170 miles and is operated by Amtrak. This route is important to commuters as Bay Area housing prices have skyrocketed, yet the area holds a wealth of employment opportunities. Travel patterns have changed, and some people find themselves moving to cities such as Sacramento for lower cost options. There are additional expansions for commuter rail such as the Valley Rail project, which plans to connect Sacramento the ACE service and the Amtrak San Joaquins train.

Freight Industry

With two million people and a thriving agriculture industry, Sacramento sees a lot of goods movement through the region. Trucks typically use I-80 / I-5 for goods movement. The Port of West Sacramento is located near the I-5 / I-80 interchange. Rail freight travels through Downtown Sacramento, and a regional switch yard is located in Roseville. SACOG currently oversees the Goods Movement Advisory Group. This group brings together individuals from a variety of different agencies such air quality management, trucking companies, the Port of Sacramento, Port of Stockton, the Union Pacific Railroad, the Sierra Northern Railroad, and the Sacramento County Airport System. SACOG announced that they are undergoing the process of producing a Regional Goods Movement Study to better integrate freight into their regional planning process.

OBJECTIVES

Stakeholder input is important in guiding the project. After going through different steps to determine needs and gaps, stakeholders developed goals for how the new system should operate. Through research, workshops, and meetings, the SACOG Smart Region developed six objectives for guiding the project:

1. Address smart transportation strategies for urban, suburban, and rural communities
2. Prepare for smart region infrastructure adaptive to new technology
3. Reduce user frustration by providing consistency and reliability
4. Proactively improve transportation system safety
5. Improve traveler information and dissemination to public and within region
6. Coordination between stakeholders for planning, implementing, and operating ITS projects
7. Disaster preparedness and response

These primary objectives are important to consider throughout Smart Region development and implementation because they provide guidelines for identifying strategies and creating performance measures to evaluate program efficacy.

CONCEPT OF THE PROPOSED SYSTEM

The concept of the Smart Region plan is based on technology implementation at both local and regional levels, and interagency coordination. The system should be able to function independently on the local level, and cooperatively on the regional level.

Wireless communication technologies are referenced throughout the document as both 5G and Dedicated Short-Range Communications (DSRC) radio. Until the National Highway Traffic Safety Administration (NHTSA) proceeds with a mandate for which technology to use, the decision to use 5G or DSRC will occur at the local level. The document describes how these technologies can be used for connected vehicles, big data, and other communication applications.

The project stakeholders are listed in **Table 1** and their roles and responsibilities in both operating and maintaining the Smart Region are described. These responsibilities include operating and maintaining the existing infrastructure, as well as new additions to the Smart Region. Agencies are also responsible for coordinating updates to the regional ITS Architecture.

Table 1: Smart Region Stakeholder Roles and Responsibilities for Technology

Stakeholder	Roles and Responsibilities
Caltrans District 3	▪ Operate and maintain all freeways, including existing and new technology on the freeways ▪ Implement new devices including ramp metering, vehicle detection, additional CCTV cameras, managed lanes, BOS, and additional CMS ▪ Monitor all new and existing ITS field equipment ▪ Maintain Caltrans QuickMap with location information ▪ Oversee freeway traffic operations at the TMC ▪ Coordinate with other agencies to implement incident management plans ▪ Coordinate traffic operations with local agencies ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Assist in the event of an emergency through disseminating information via CMS, QuickMap, and other necessary actions ▪ Initiate ITS field equipment as needed for incidents or emergencies
SACOG	▪ Oversee the planning and implementation of transportation projects throughout the region ▪ Promote long-range planning practices including, but not limited to, ITS Architecture updates, the ITS Master Plan, and other regional transportation technology efforts ▪ Own and maintain STARNET regional data sharing, while promoting data quality ▪ Own and operate 511 ▪ Coordinate regional transportation operations ▪ Share data and coordinate operations across agency boundaries ▪ Manages the regional real-time data and live video sharing system: STARNET

	▪ STARNET provides information to traffic operators and emergency responders in the area ▪ STARNET helps connect data from partner agencies ▪ SACOG also manages Sac Region 511, which is the region's traveler information platform that communicates with the public ▪ SACOG oversees the IVR, website, and mobile application components of the 511 system ▪ Sac Region 511 provides information on mode choice options, traffic updates, and emergency and weather alerts
California Highway Patrol (CHP)	▪ Serve as law enforcement on California freeways to promote safety and efficiency on the road ▪ Coordinates incident management ▪ Partners with Caltrans to provide Motorist Aid program ▪ Releases alerts in the event of emergency, for example SigAlerts, Amber and Blue Alerts ▪ Coordinate with Fire / EMS, PD, and other relevant agencies in times of emergency ▪ Provide necessary traffic control during incidents and emergencies ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento Regional Transit (SacRT)	▪ Coordination with all related local agencies ▪ Coordinate transit operations with connected transit agencies ▪ Work with cities regarding transit signal priority as well as traffic signal coordination ▪ Provide real time transit data to customers ad 511 ▪ Participate in STARNET regional data sharing ▪ Maintain Connect Card Electronic Payment system ▪ Coordinate with Fire / EMS, PD, and other relevant agencies in times of emergency ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento County Department of Transportation (SACDOT)	▪ Oversee large regional infrastructure projects and programs within the County ▪ Maintains and operates traffic signals in the City of Rancho Cordova through remote access into the Centracs system ▪ Provide local level and regional assistance when called on during emergencies ▪ Local assistance will be provided for the jurisdictions that SACDOT manages ▪ Maintain and operate all existing traffic signals, communication, and ITS field equipment and any additional equipment from the Implementation Plan ▪ Operate County TOC ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Freeway Service Patrol (FSP)	▪ FSP works in conjunction with CHP to keep roads clear and safe ▪ Their role in the SACOG Smart Region is to: ▪ Continue their operations, and expand when it is necessary

	▪ Explore opportunities for new technology that promotes FSP driver safety, motorist safety, and prompt response time to incidents ▪ Provide towing and assistance to stopped vehicles ▪ Keep communication with CHP who can issue alerts and disseminate information to the public ▪ Coordinate with CHP to provide necessary assistance ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento County Airport System (SCAS)	▪ Serves as a critical link to SACOG's regional transportation network ▪ Provides access to the SACOG region from other locations in the nation ▪ Maintains all existing ITS field devices ▪ Implements new ITS field devices as it pertains to airport security, traffic management, and traveler information ▪ Maintains communication with other regional agencies when it is necessary about changes in operations, planned events, and emergencies ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
El Dorado DOT	▪ Maintain and operate all existing traffic signals, communication in El Dorado County's jurisdiction, and ITS field equipment and any additional equipment from the Implementation Plan ▪ Provide planning and project management for projects in unincorporated areas ▪ Responsible for weather maintenance on roads in their jurisdiction ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
El Dorado Transit	▪ Oversee the maintenance and operations of El Dorado transit lines (including lines 20, 30, 40, 50X, 60, 70, Sacramento Commuter, and all Saturday Service) ▪ Responsible for coordinating with local agencies over traffic signal coordination ▪ Coordinate transit operations with connected transit agencies ▪ Work with cities regarding transit signal priority as well as traffic signal coordination ▪ Provide real time transit data to customers ad 511 ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Yolo County Transportation District (YCTD)	▪ Oversee YOLOBUS, which makes connections to Unitrans, Fairfield-Suisun Transit, and RT and LRT in Sacramento. ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Coordinate transit operations with connected transit agencies ▪ Work with cities to operate transit signal priority as well as traffic signal coordination ▪ Provide real time transit data to customers and 511

City of Citrus Heights	▪ Responsible for maintaining and operating all new and existing traffic signals in Citrus Heights ▪ Manage and own city's (existing and new) traffic signal communications network, CCTVs, CMS, and detection systems ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction
City of Elk Grove	▪ Responsible for maintaining and operating all new and existing traffic signals in Elk Grove ▪ Manage and own city's (existing and new) traffic signal communications network, CCTVs, CMS, and detection systems ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction
City of Folsom	▪ Responsible for maintaining and operating all new and existing traffic signals in Folsom ▪ Manage and own city's (existing and new) traffic signal communications network, CCTVs, CMS, and detection systems ▪ Manage Folsom's transit services, including its bus fleet and dial-a-ride ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction
City of Lincoln	▪ Responsible for maintaining and operating all new and existing traffic signals in Lincoln ▪ Manage and own city's (existing and new) traffic signal communications network, CCTVs, CMS, and detection systems ▪ Share data and coordinate operations across agency boundaries Participate in STARNET regional data sharing ▪ Partnering with Placer County Transit to run fixed-route, dial-a-ride, and other transit operations ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction
City of Rancho Cordova	▪ Rancho Cordova's TMC is accessed remotely by the County through Centracs ▪ The County operates and maintains (existing and new) traffic signals, communications network, CCTVs, CMS, and detection systems in Rancho Cordova ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries

	▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction
City of Roseville	▪ Responsible for maintaining and operating all new and existing traffic signals in Roseville ▪ Manage and own city's (existing and new) traffic signal communications network, CCTVs, CMS, and detection systems ▪ Coordinate with any local or regional transit agencies that pass through the jurisdiction ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction
City of Rocklin	▪ Responsible for maintaining and operating all existing traffic signals ▪ Responsible for coordinating with involved transit agencies such as Amtrak (that serves the Rocklin Multimodal Train Station), Caltrans (who oversees major highways in the area), and Placer County Transit (who provides bus service). ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Participate in STARNET regional data sharing ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction ▪ Coordinate with any local or regional transit agencies that pass through the jurisdiction
City of Sacramento	▪ Responsible for managing and operating all existing and new traffic signals, detection systems, communications network, CCTVs,, and the Transportation Management Center ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Participate in STARNET regional data sharing ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction ▪ Coordinate with any local or regional transit agencies that pass through the jurisdiction
City of West Sacramento	▪ Responsible for managing and operating all existing and new traffic signals, detection systems, communications network, CCTVs, red light cameras ▪ Coordinate with the Port of West Sacramento to ensure safe, efficient, and courteous delivery of goods ▪ Coordinate with any local or regional transit agencies that pass through the jurisdiction ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries ▪ Coordinate with partner and regional agencies in the event of an emergency, this may include alternate routes through their jurisdiction

Sacramento Police Department	▪ Responsible for protecting public safety of the community ▪ Handle calls regarding accident on arterials and local streets ▪ Provide communications through 911 system ▪ Coordinate traffic control for incidents ▪ Communication with CHP, County Sheriff, and other local police departments ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento Fire Department	▪ Responsible for maintaining safety which includes providing emergency medical services, fire suppression, and special operations ▪ Answers to 911 dispatch requests when called on to traffic incident scenes ▪ Provides emergency responses in major and emergency scenarios ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento Metropolitan Air Quality District (SMAQMD)	▪ Responsible for monitoring air quality and providing mitigating measures to improve air quality ▪ Evaluate contributing factors to air quality ▪ Ensure projects do not make a significant negative impact on air quality ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento Metropolitan Utility District (SMUD)	▪ Provide electric power to homes, businesses, streets in Sacramento ▪ Provide power for existing and new infrastructure in the project area to function ▪ Share data through regional platform (STARNET) and coordinate operations across agency boundaries
Sacramento Regional Radio Communication System (SRRCS)	▪ SRRCS is maintained and operated by the County of Sacramento and allows for information to be disseminated at a county level to agencies in the region ▪ CHP does not use this system, and relies on their own communication system ▪ Role is to serve as the regional radio network that can provide regional public safety services ▪ Provide radio communication infrastructure for local police departments, correctional facilities, Caltrans, colleges, transportation agencies, health services, fire departments, and other various local agencies in the region
Media	▪ Media includes news outlets which can release information on radio, television, video, websites, and social media. ▪ Media will have access to reported incidents and other alerts sent from TMCs. ▪ The media's role is to disseminate information via different platforms to the public, while utilizing accurate data sources
Commercial Vehicle Operators	▪ Continue to operate as before, while making use of CVO improvements with SACOG Smart Region ▪ Will have access to freight-specific data, including travel times, freight routes, and parking, which will be provided by

	various partner agencies through the STARNET data sharing regional hub
Third-party applications	▪ Third-party applications can strengthen data quality and accessibility through new platforms. Their role is to: ▪ Create partnerships with public agencies to strengthen their data quality ▪ Disseminate important information to the public ▪ Through developed partnership, share data with STARNET
Other SACOG Partner Agencies	▪ Includes SACOG's five counties (El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba) and 22 cities ▪ Within these jurisdictions are important agencies such as: transit, planning, law enforcement, fire, and EMS ▪ These agencies should operate similarly to those mentioned in this table. Operations will account for new projects and will include coordination with partner agencies as it benefits the region ▪ *Transit:* Operate and maintain bus fleet, dial-a-ride, and other transit services. ▪ *Transit:* will adopt any new technology infrastructure and operational improvements such as real-time data sharing with the region ▪ *Planning agencies:* Shall provide recommendations for new projects, update planning documents for the region, and provide funding to a jurisdiction when it is applicable. ▪ *Planning agencies:* continue to manage jurisdictions and facilitate programs as it pertains to current and long-range planning ▪ *Law enforcement:* Protects public safety, provides accurate and pertinent reports to the region, and facilitates incident assistance when necessary ▪ *Fire / EMS:* Continues to provide fire and emergency services, while adopting new procedures when called on ▪ *Fire / EMS:* Provide data to CAL FIRE, which can be shared by Caltrans via QuickMap, Sac Region 511, and STARNET

OPERATIONAL SCENARIOS

Operational Scenarios identify how various components of the Smart Region will respond to different situations. While these scenarios are not all inclusive, they should provide a framework for how these systems can adjust when regular congestion and unexpected events occur. Each scenario includes description of the scenario, potential impacts on the system, steps of operation, users involved, and applicable concepts. These scenarios define roles and responsibilities for each stakeholder so they can better understand what actions to take. The stakeholders below are identified in the following operational scenarios. This is not meant to be an all-encompassing list of stakeholders, but instead provides example scenarios that speak to urban, suburban, and rural environments. Other partner agencies that are not mentioned in these scenarios may consider how they would operate in these scenarios.

Stakeholders involved in the example scenarios include:

- Caltrans D3
- CHP
- City of Citrus Heights
- City of Sacramento
- City of West Sacramento
- El Dorado County
- FSP Valley Division
- Placer County
- Sacramento DOT
- Sacramento FD
- Sacramento PD
- Sacramento TOC

These scenarios are not all encompassing for all SACOG partner agencies. The operational scenarios are intended as examples for how stakeholders should behave in different scenarios within the Smart Region. Other scenarios may be applicable depending on the type event.

Scenario 1: Daily Operations Non- Peak

Description: This scenario explains operations during non-peak hours where there is no recurring congestion, no incidents, or events that impact the freeway and arterials in the Smart Region.

Response Plan: There is no response plan to address this scenario.

Steps of Operation: During non-peak hours, the Smart Region will operate with the follow procedures

1. Freeway monitoring through Caltrans detection system on freeways, ramp metering, local detection system on arterials, a connected regional CCTV camera network
2. Agencies are contributing real-time traffic and transit data to STARNET and it is disseminated to traveler information platforms and Regional Open Data Portal.
3. Real-time traveler information shared through QuickMap, Sac Region 511, and third-party applications to reach a wide audience
4. A parking management system in urban areas can help ease congestion and provide valuable information to motorists.
5. Adaptive ramp metering can optimize traffic flow on the freeway in certain conditions when traffic conditions are not typical for the time of day.

6. Response will be to operate the system normally, meaning traffic signals will operate under typical timing and will coordinate with other transportation modes to ensure proper signal priority. Arterials will be monitored by local authorities at TMCs, and all stakeholders will be ready to communicate if an event occurs.
7. Operation of traffic signals will vary depending on the agency involved. Some agencies may use adaptive signal timing, some may use time of day with monitoring, and some may not operate traffic signals at all.
8. The Regional Asset Management System is kept up-to-date to ensure equipment reliability.

Users involved:

- Caltrans District 3
- Local transit authorities
- Local agencies

Applicable Concepts:

- Real-time traffic monitoring by Caltrans District 3 TMC
- Real-time traffic monitoring by each local TMC/local traffic operations
- Communication between local systems and Caltrans monitoring equipment
- Traveler information released through Sac Region 511 and QuickMap
- Data sharing through STARNET
- CCTV Sharing Agreements
- Central Regional Video Management System
- Parking Management

Maintenance: Maintenance will occur between different owning entities of the Smart Region. This includes Caltrans and all applicable local cities. For a scenario involving daily operations during non-peak hours, all entities would be required to perform regular operations and maintenance. Maintenance will depend on the geographic location, the amount of traffic that area experiences, truck volumes that cross through, and weather conditions. Maintenance will be recorded and managed through the Regional Asset Management system.

Connected Vehicles: Connected vehicles use Dedicated Short-Range Communications (DSRC) or 5G wireless technology to foster communication between vehicle-to-infrastructure and vehicle-to-vehicle. In this scenario, a connected vehicle would operate as normal. Connected vehicle technology would push out incident alerts when necessary.

Scenario 2 - Daily Operations – Peak

This scenario describes daily operations during peak periods, which are defined by recurring congestion, which typically happens during standard commute times. Recurring congestion will lead to slow-down in many jurisdictions.

Example scenario: A common scenario for the area is recurring congestion on I-80 eastbound during the evening commute time. This is typical for the area, especially close to Downtown Sacramento where many people commute to/from work. While it often becomes congested during typical commute times in the AM/PM, it is not uncommon for congestion to happen in this area on off-peak hours also.

Potential impacts to traffic: This represents a typical scenario during the peak evening commute. It can often lead to slow down and causes delays for commuters traveling towards residential areas such as North Highlands, Citrus Heights, Roseville, Rocklin, and Granite Bay.

Response Plan: During times of recurring congestion, there will not be diversion of traffic onto arterials. However, there will be monitoring and different tactics in place to ensure that the system can operate as efficiently as possible

Response will be to operate the system normally, meaning traffic signals will operate under typical peak hour timing and will coordinate with other transportation modes to ensure proper signal priority. Arterials will be monitored by local authorities at TMCs, and all stakeholders will be ready to communicate if an event occurs.

Users involved:

- Caltrans District 3
- Local transit authorities
- Local agencies

Applicable Concepts:

- Traffic monitoring by Caltrans District 3 TMC and local TMCs
- CCTV from Caltrans and local agencies are connected to monitor entire system through CCTV Sharing Agreements
- Traveler information released through Sac Region 511 and QuickMap
- Regional Network Monitoring System
- Regional ATMS to promote data sharing within the region
- Regional ATSPMs to ensure signal performance is adequate on arterials and is not causing unnecessary congestion
- Signal timing along transit corridors with transit signal priority to ensure transit is a viable option during peak periods
- Caltrans and local authorities provide traveler information and traffic data to public and third-party mobile applications about slow-downs on freeways and arterials
- Caltrans District 3 ramp metering equipment will automatically respond during congestion
- Adaptive ramp metering can optimize traffic flow based on corridor-wide congestion conditions
- Transit authorities provide LRT preemption to coordinate with traffic signal operations on arterials
- Caltrans and local authorities provide reliable real-time data with third party applications to reach larger audience
- Data sharing through STARNET

Maintenance: For daily peak hours, all freeways (in this case I-80) would be operated and maintained by Caltrans. For arterials, the involved local entities would be responsible for operations and maintenance.

Connected Vehicles: Connected vehicles would use DSRC to foster communication between vehicle-to-infrastructure and vehicle-to-vehicle. In this scenario, a connected vehicle would operate as normal. It would maintain a safe speed, which in this case would be quite slow due to recurring congestion. Connected vehicle technology would push incident alerts to update the vehicle.

Scenario 3 - Freight

Goods movement is prevalent in the Sacramento Region. There are several ports that influence Sacramento: The Port of West Sacramento and two neighboring ports that are not in the immediate region: The Port of Stockton and the Port of San Francisco. Additionally, there is a large agriculture industry in the region, which generates a considerable amount of truck trips through the region. I-5 and I-80 serve as critical cross-country freight routes, making this region important to national goods movement.

This scenario describes typical operations for goods movement. Goods movement occurs during specified times where congestion is less likely occur. As per the Surface Transportation Assistance Act (STAA) of 1982, large trucks are restricted to freeways and specified arterials that are defined by the National Network.

Example scenario: A shipment comes into the Port of West Sacramento that needs to go out for distribution. One of the large deliveries is to the Amazon Warehouse, which is located near the Tahoe Park neighborhood of Sacramento. A minor incident occurs on I-80 E causing congestion in the right most lanes as vehicles try to exit the freeway.

Response Plan: Minor incidents do not reroute unless they escalate into something more serious. In this scenario, the response plan would be to monitor the situation. If a reroute was necessary, the truck driver would be provided with an alternative route that can accommodate large commercial vehicles.

Users involved:

- Caltrans District 3
- Local agencies if arterials need to be used for rerouting
- Port of West Sacramento
- Sacramento County DOT

In the event of a minor incident stakeholders should take the following steps:

1. Freeway monitoring through Caltrans detection system on freeways, ramp metering, local detection system on truck-approved arterials, and a connected regional CCTV camera network. Caltrans operators will communicate with CHP. CHP will determine if a reroute is necessary to get the truck off the freeway. This will likely occur if the incident is major and prevents the truck from moving.
2. Data sharing between Caltrans and local agencies to update clear truck routes.
3. Communication with the Port of West Sacramento to ensure that deliveries are made on off-peak hours. Trucks and freight delivered by rail should comply with quiet zone and non-peak hour deliveries. It will be up to the City of West Sacramento and the Port of West Sacramento to enforce this.
4. Real-time truck information shared through STARNET and released through Sac Region 511. These platforms should provide updates with all available routes for drivers and provide access to a parking management system that allows drivers to know where it is available.
5. Response will be to operate the system normally, meaning traffic signals will operate under typical timing and arterials will be monitored by local authorities at TMCs. All stakeholders will be ready to communicate if an event occurs. Trucks will remain on the freeway unless the incident is major and requests many lane closures.

Maintenance: Trucks are expected to drive on approved routes to ensure that these routes are equipped to handle large vehicles. These truck routes should be maintained with a fix-it-first approach. Caltrans will be responsible for maintaining freeways and local agencies will be responsible for their arterials. The Port of West Sacramento is owned by the City of West Sacramento and managed in partnership by SSA Marine.

Connected Commercial Vehicles: The rise of connected vehicles has spread to the trucking industry as well. There are currently self-driving truck tests underway around the United States. In preparation for the dissemination of this technology, there are concepts that can be applied to self-driving trucks, including vehicle-to-infrastructure communications and vehicle-to-vehicle communications, wherein personal and commercial vehicles are in communication with one another. Connected vehicle technology would push out incident alerts to the commercial vehicle when necessary.

Applicable Concepts:

- Time of day restrictions
- Quiet zones
- Freight-specific traveler information
- Regional Network Monitoring System
- CCTV sharing agreements
- Regional ATMS for data sharing
- Vehicle-to-infrastructure communications
- Vehicle-to-vehicle communications
- ICM
- Freight parking management

Scenario 4 - Major Freeway Incident

There are various ways to define an incident, but it is typically described as, "a non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand." The Federal Highway Administration expands on this by explaining that the definition changes for stakeholders. For example, emergency services and law enforcement define an incident when their response is a required. Beyond the definition of the word, there are various ways to classify the type of incident. For the purposes of this document we will put incidents into two categories: major and minor incidents.

Example Scenario: A major incident occurs during the evening commute time on I-5 north between the Sacramento International Airport and Downtown Sacramento.

Potential impacts: This scenario has the potential to impact airport traffic as well as commuter traffic coming from Downtown Sacramento traveling north on 1-5 towards Woodland. Delays on I-5 has the potential to cause delays for commuters, those traveling to the airport, and for freight and transit.

Response plan: To maintain reliability of the freeway and arterial network, coordinate with local agencies and transit authorities, to inform the public, and adapt if the situation warrants a change in operations.

A major freeway incident is described as an event with multiple lanes blocked for multiple hours. Major incidents also involve one or more of the following characteristics:

- One or more fatalities
- Involvement of hazardous materials, and / or
- Deployment of law enforcement

Users involved:

- Caltrans District 3: Caltrans is responsible for monitoring the freeway at all times, and can deploy different ITS strategies (such as CMS displays) to help mitigate the impacts of a major incident and inform the public. Caltrans has the responsibility to communicate with local agencies if the freeway incident images major arterials.
- CHP will be deployed to manage the incident and direct others in incident response, record a report of the incident, and coordinate with other necessary agencies such as FSP. CHP will direct closures and release SIGALERTS as needed.
- Local agencies (if a detour is required): CHP should communicate with the local jurisdiction when the incident occurs. If necessary, CHP will ask for permission to deploy information via CMS on surrounding local arterials.
- FSP dispatched through CHP system when an incident warrants (such is the case with major incidents).

In the event of a major incident the Caltrans TMC should take the following steps:

1. Determine the location and impact of the incident using available data feeds, information from CHP, first responders and feedback from the TMC. CHP will manage freeway incident management by determining closures and necessary equipment.
2. When the incident is verified as “major”, it will trigger an ICM event using STARNET to coordinate traffic operations and implement specific coordinated timing plans. Only in extreme cases will vehicles be redirected off the freeway, which will be done under the authority of CHP. In most instances they will be redirected into different lanes to avoid the incident.
3. Information will be shared with motorists through various channels including: CMS, Sac Region 511, Quick Maps, DSRC/5G technology, and data sharing with third-party mobile apps., such as Google and Waze.
4. CHP will provide updated incident reports, which can be released to partner agencies and eventually disseminated to the public. Caltrans TMC can verify traffic conditions through various information sources such as CCTV cameras and system detection.
5. If the incident requires rerouting traffic, Caltrans TMC staff will notify the affected local agencies before rerouting motorists onto their streets and information will be released on QuickMap. The rerouting is calculated by the ICM system depending on the location of the incident and the time of day.
6. If the identified route is experiencing abnormal congestion, TMC and local agencies will work together to identify alternative routes. These will be initiated by the ICM.
7. Adaptive ramp metering can help optimize corridor-wide congestion during the incident.
8. Local agencies will be informed of reroute through the regional radio communications network. If fire or other emergency services are needed, the SRFECC can dispatch these services with the corresponding agency.
9. Information of new route will be sent to motorists through various platforms such as Sac Region 511, CMS, dynamic trail blazer signs, third party apps, and local media.
10. If the incident persists, Caltrans and local agencies will work together to provide information regarding transit options, park and ride, and alternative transportation modes. Caltrans can divert traffic onto I-5 HOV lanes around the incident.

Applicable Concepts:

- Regional Modernized CAD Integrations
- Dynamic lanes
- Regional Monitoring System
- Regional ATMS for shared data
- Regional ATSPMs for signal timing plans for rerouting
- CCTV Sharing Agreements
- Central Regional Video Management System
- Regional Network Operations Center
- Adaptive ramp metering

Maintenance: Maintenance of equipment on freeways should be proactive to promote long equipment lifespan. Equipment functionality is important when dealing with incidents as this is what provides detection to TMCs and can push out information to motorists when an incident has occurred. Maintenance also includes incident management and clearance. Debris and hazardous waste should be removed as quickly as possible from the freeway to ensure that the lanes and shoulder can serve other motorists.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. Connected vehicle technology would push out incident alerts, updating the vehicle of the traffic conditions and if a reroute is necessary.

Scenario 5 - Minor Freeway Incident

An incident is defined by a non-recurring event that causes a reduction in roadway capacity. A minor incident is determined by the duration of time and the amount of traffic lanes it impacts. Generally, minor incidents will create a delay of 30 minutes of less. In some cases, a minor incident may be for delays of one hour and under. CHP will determine the severity of an incident and what resources are needed.

Example Scenario: A minor incident occurs that creates a slow down on US-50 freeway during peak time for morning commuters.

Potential Impacts: While this scenario describes a minor incident, it could still impact the transportation network. This is a frequented route; commuters make their way from Rosemont and pass Cal State Sacramento. It is important that a minor incident gets cleared as soon as possible to minimize commuter delays.

Response Plan: A minor freeway delay during peak hours would not require any diversion. It would require action on behalf of tow-truck drivers and law enforcement. Caltrans would be responsible for monitoring the incident, taking necessary actions, and communicating with local agencies when necessary. Once cleared, operations would return to normal.

Users involved:

- Caltrans D3 is responsible for monitoring traffic and operations
- CHP is responsible for contacting FSP Valley Division to clear the scene if motorists have not already.

- FSP Valley Division will be responsible for clearing the scene as quickly as possible of debris and vehicles.
- Local first responders and law enforcement will be called to assist if the 911 dispatch notifies them of a call. They will remain in communication with Caltrans TMC

Stakeholders should take the following steps**:**

1. Reported incident - The incident is reported to the TMC by detection system or from CCTV cameras. This information is delivered to the traffic operators at the Caltrans TMC.
2. Incident confirmation – Operators at Caltrans TMC confirm an incident has occurred and take the necessary steps to disseminate the information and deploy correct personnel for incident management.
3. Traveler information – Notification of a minor incident will be released to motorists through CMS, Sac Region 511, QuickMap, and third-party apps. Sac Region 511 updates will be available via IVR, website and mobile application.
4. Response Plan- Once the incident has been verified, CHP should be ready to respond. Their response will depend on the severity of the incident. For minor incidents, CHP can coordinate with traffic operators to deploy tactics, such as CMS to divert traffic into different lanes and ramp metering to prevent further congestion on merge lanes. Adaptive ramp metering can help optimize corridor-wide congestion during the incident.
5. Addressing the incident – CHP / FSP will be responsible for clearing the incident. When called, CHP is responsible for recording the incident and FSP tow-trucks are responsible for removing damaged vehicles and debris.
6. Monitoring the freeway- Caltrans TMC operators will then monitor the freeway to determine when congestion has improved. If congestion increases, then Caltrans can utilize different strategies that are typically used for major incidents. If the incident gets better, traffic operators can eventually move into normal operations and motorists will be notified through traveler information platforms and through push notifications
7. Debrief- Once the incident is finished and operations will return to normal. For minor incidents, it is not possible to do a formal debrief after each one, but regular meetings can help discuss ways to improve operations during both minor and major incidents. They can determine what should be improved moving forward.

Applied concepts

- Center-to-center communications
- Vehicle-to-infrastructure communications
- CCTV Sharing Agreements
- Data sharing
- Traveler information
- CMS
- Ramp metering

Maintenance: Maintenance on freeways should be proactive to promote long equipment lifespan. Equipment functionality is important when dealing with incidents as this is what provides detection to TMCs and can push out information to motorists when an incident has occurred. Maintenance also includes incident management and clearance. Debris and hazardous waste should be removed as quickly as possible from the freeway to ensure that the lanes and shoulder can serve other motorists.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. For connected vehicles traveler information will be released directly to the vehicle and will provide alerts regarding incidents, detours, and construction. This will instruct the vehicle to follow the proper procedure.

Scenario 6 - Major Arterial Incident

The definition of a major arterial incident can vary depending on the location. Major arterial incidents are often categorized by one or more lane closed for more than one hour. However, other factors can play a role in determining that level of incident such as if there are available alternate routes, time of day / day of week, and available roadway capacity.

Example Scenario: A major incident occurs on Cosumnes River Blvd near the intersection of Franklin Blvd in Sacramento.

Potential Impacts: A major incident has the potential to cause slow-down in an area with limited arterials and routes to I-5.

Response Plan: The response plan will require coordination between local agencies and law enforcement to get the incident cleared and to have operations return to normal.

Users:

- Sacramento TMC
- Neighboring local transportation agencies:
- Sacramento Police Officers
- Sacramento Fire Department

Stakeholders should take the following steps:

1. Identify Incident – The Sacramento TMC should receive notification from either detection or law enforcement that there has been an incident on Cosumnes River Blvd. TMC verifies that the incident is causing delays and impacting one of the two lanes heading west towards I-5. The TMC will also identify through detection systems that travel speeds have decreased. The TMC should determine the severity of the incident and its exact location.
2. Data Sharing- Data is shared through Regional ATMS and is released to STARNET so it can be disseminated to third parties and motorists.
3. Traveler Information Traveler information should be disseminated through Sac Region 511 system and picked up by other third-party traveler information platforms. The notification should provide a summary, the location, and estimated delay of the incident. Information can also be released on nearby CMS.
4. Respond – Law enforcement and tow truck services should be ready to respond to get the incident cleared from the westbound lane as quickly as possible. The TMC should be ready to divert traffic into the unaffected lane.
5. Traffic Operations – Sacramento will use STARNET to coordinate operations with neighboring jurisdictions by sharing real time performance measure data, CCTV cameras images, and alerts on queues and increasing travel time. Other local agencies will use STARNET to assess cross-jurisdiction corridor operations and adjust signal timing accordingly.
6. Monitor Response- TMC should monitor the event using detection system and updates from law enforcement. Once the incident has been cleared, operations will return to normal

and westbound traffic can return two lanes. If the incident shuts down both lanes a reroute could be initiated.

7. Debrief – Once operations have returned to normal, the involved parties should debrief on the event. This should include a discussion what happened, how it was handled, and if a similar situation were to occur again, how would the team handle it. This should include discussion of what worked well and what could be improved when another major incident occurs. Involved parties should keep record for future protocol.

Applicable concepts:

- Center-to-center communications
- Sacramento TMC
- Data sharing
- Real-time data collection
- Traveler information (Sac Region 511, Google Maps, Waze)
- CMS
- Sacramento TMC monitoring
- Regional ATSPM
- Regional ATMS
- CCTV Sharing Agreements

Maintenance: Maintenance of equipment on arterials should be proactive to promote long equipment lifespan. Maintenance should be documented through the Regional Asset Management System to ensure that local jurisdictions are performing routine maintenance. This keeps the street network well maintained. Equipment functionality is important when dealing with incidents as field equipment communicates with the TMC, can assist with new signal timing plans, and can push out information to motorists when an incident has occurred. Maintenance also includes incident management and clearance. Debris and hazardous waste should be removed as quickly as possible from arterials to ensure that streets look nice for the city and remain uncongested.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. Connected vehicle technology would push out incident alerts, updating the vehicle of the traffic conditions and if a reroute is necessary

Scenario 7 - Minor Arterial Incident

Example Scenario: An incident is detected on Sunrise Blvd. between Woodmere Oaks Drive and Sungarden Drive in the City of Citrus Heights.

Potential Impacts: The incident causes slow down, therefore impeding traffic on an arterial in Citrus Heights.

Response Plan: The Citrus Heights TMC would be responsible for monitoring the arterial and ensuring that traffic returns to typical speed. Operations would not change.

Users involved:

- City of Citrus Heights
- Citrus Heights TMC operators

Stakeholders should take the following steps:

1. Notification of the Event – Local TMC receives notice that there is a slow-down on Sunrise Blvd. This notification is received through different local detection systems.
2. Traveler Information – Real-time data is collected and delivered to Sac Region 511 and third-party applications. This information will notify the public of a minor slow-down but will not lead to a change of route. Real-time information will be sent to STARNET.
3. Response Plan / Monitor Operations – There is no response plan required for a minor incident. Local TMC should monitor the situation and be ready to react if the incident becomes more serious.
4. Information is shared with STARNET, but STARNET is not utilized to monitor the situation.
5. Debrief – A debrief is only warranted if the situation grows worse and the TMC needs to respond.

Applicable concepts:

- Real-time data collection
- Data sharing
- Regional ATSPM
- Regional ATMS

Maintenance: Maintenance of equipment on arterials should be proactive to promote long equipment lifespan. Maintenance should be documented through the Regional Asset Management System to ensure that local jurisdictions are performing routine maintenance. This keeps the street network well maintained. Equipment functionality is important when dealing with incidents as field equipment communicates with the TMC, can assist with changes in operation if necessary.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. Connected vehicle technology would push out incident alerts, updating the vehicle of the traffic conditions and to change lanes if necessary to avoid the incident.

Scenario 8 - Planned Events

The Sacramento Region incorporates different counties with rural, suburban and urban communities. In this region there are often planned events that can impact not only freeway traffic, but also local roads. Events require coordination between various agencies to minimize impacts.

Scenario: There is an event in Squaw Valley in Lake Tahoe during July with about 30,000 people expected to attend.

Potential Impacts: A major event in a rural area can have a major impact on the highways, arterials, and local streets. This could lead to congestion and challenges for residents and park visitors.

Response Plan: Plan includes coordination between Caltrans and local agencies to prepare for heavy congestion.

Users:

- Event planning staff

- Caltrans D3
- Placer County Public Works (PCPW)
- El Dorado Transportation Commission
- Placer County Transportation Planning Agency (PCTPA)
- Placer County Transit (PCT)
- Local law enforcement
- Tahoe National Forest
- Tahoe Area Region Transit

Stakeholders should take the following steps**:**

1. Pre-event planning - Festival representatives will contact Placer County and Caltrans to inform them of the event, detailing how many motorists are expected based on projections and ticket sales. They should also provide a parking plan and routes in and out of the festival. Placer County should involve emergency response staff, law enforcement officials, neighboring El Dorado County, and Tahoe National Forest staff. Placer County Public Works (PCPW) oversees bus/ transit service, traffic management, public works projects, and bicycle infrastructure. PCPW should determine if there are any signal timing adjustments that need to be made. Changes in bus service can help accommodate the influx of people. PCPW can also confirm that there is no road maintenance or schedule construction project on any of the main routes. If there are obstacles, the event planning staff and agencies should determine how they want to navigate these challenges.
2. Data sharing – Agencies should release real-time information pertaining to the day of the event. This can include traffic, transit, and parking data for visitors.
3. Traveler information – Traveler information will be released in advance of the special event. It should target all neighboring communities that live on the local and main routes in the Lake Tahoe area. These main routes include I-80, California State Route 88/89, 4, and 247, and US Route 50. Sac Region 511 and QuickMap will be utilized to provide advance and day of traveler information including parking and transit modes.
4. Event Management – To prepare for the event, there should be established protocol between event staff and agency partners during the event. There should an established team with clear responsibilities to manage the area before, during, and after the event. Caltrans will be responsible for monitoring their roads, and this should be done with appropriate strategies such as portable CMS to display updated alerts regarding the event and traffic conditions. Placer County is responsible for local roads. There should be clear communication between Caltrans, Placer County, El Dorado County, and the Park Service.
5. Monitor Operations – It will be up to Caltrans, Placer County, El Dorado County, and the Park Service to monitor roads via CCTV, field equipment and QuickMap. STARNET can receive data on travel times and congestion levels. Operators will determine if a change of route is warranted to promote better circulation. This may also include local priority for residents to get in and out of their homes. Signal timing across jurisdictions will be implemented using the ICM through the STARNET interface that monitors regional traffic signal operations.
6. Debrief on Event Protocol Following the event, all parties involved should reconvene to discuss strategies they used to prepare for and manage the event. Festivals typically occur on an annual basis and number of attendees can increase too. During this meeting the involved parties should discuss new strategies to improve operations for the upcoming year.

Applicable concepts:

- Center-to-center communications
- Traveler information (Sac Region 511, QuickMap, Tahoe National Park website, Google Maps, Waze)
- Regional ATMS
- STARNET
- Real-time traffic and transit data
- Signal timing along transit corridors
- Regional Network Operations Center
- Event signal timing and bus service
- Caltrans District 3 TMC
- Portable CMS to notify motorists of traffic conditions

Maintenance: Maintenance on freeways, state routes, and local arterials should be proactive to promote long equipment lifespan and to accommodate major events. Equipment functionality is important to maintain communication with agencies and push out information to motorists.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. Connected vehicle technology would push out event alerts, updating the vehicle of the traffic conditions and if a reroute is necessary.

Scenario 8 - Unplanned Events

Unplanned events are events that agencies are not expecting, but still have an impact on the transportation network. The Sacramento region sometimes encounters these and so, it is important for agencies to be prepared even for unplanned events.

Example Scenario: A demonstration occurs on Capitol Mall, causing street closures in Downtown Sacramento. This leads to extreme congestion on Capitol Mall and prevents drivers from moving on neighboring streets. This congestion spills over to those trying to exit I-5 freeway.

Potential Impacts: Demonstrations often lead to unplanned street closures and congestion. They can lead to large populations traveling to the same area through different modes such as vehicles, bikes, and transit.

Response Plan: Response plan includes coordination between Caltrans, local agencies, and transit authorities to minimize congestion. Coordination will allow for alert dissemination to keep motorists away from Capitol Mall area and to divert traffic away from the area to prevent further congestion.

Users:

Caltrans - Caltrans will be responsible for using ITS technologies minimize congestion and to alert motorists on freeways to avoid exits leading to Capitol Mall

Local agencies - Traffic operators at Sacramento TMC will be responsible for monitoring and diverting traffic away from Capitol Mall area. Local law enforcement will also be deployed to protect public safety and to manage traffic in areas where street closure has occurred.

Transit - Transit agencies will be responsible for providing service to those traveling to and those traveling away from the protest, as well as coordinating with local agencies in the event of street closures

Stakeholders should take the following steps**:**

1. Notification of the Event – Notification from local authorities that there has been an unplanned event (sometimes this can be hinted at beforehand through social media and other media platforms).
2. Confirmation of the Unplanned Event – This will require ITS field equipment such as CCTVs, detection systems, or interagency communication
3. Traveler Information – Information is disseminated via various platforms: Sac Region 511, Google Maps, Waze, CMS, and local media. These systems will release information about the street and / or major event. Traveler information platforms will release this information and can provide alternative routes to users.
4. Response Plan- Response should include agency coordination using transit, local arterials and freeways to divert traffic away from the street closure. Strategies may include CMS, different signal timing, and transit signal priority. Consistent alerts and updates should be exchanged between law enforcement, public safety agencies, Sacramento TMCs, Caltrans, and STARNET.
5. Monitoring the operations – TMC should monitor cameras and detection systems for real-time speeds and share information via STARNET. Once the event is over, streets should reopen. Operations will be restored to their normal process once participants clear the area and congestion returns to a normal level for the area. Signal timing across jurisdictions will be implemented using the ICM through the STARNET interface that monitors regional traffic signal operations.
6. Debrief on Event- While unplanned events are unexpected there are various ways to prepare for them. After the event has ended, the involved parties should meet to discuss the procedures they used to calm the situation. They should determine which procedures were successful and which ones could be improved. They should develop a revised plan to better prepare any future unplanned events and come up with adaptive strategies for different events.

*Applicable concepts***:**

- CMS
- Center-to-center communication
- Data sharing through Regional ATMS
- Regional ATSPM
- Regional Modernized CAD Integration
- Regional Network Monitoring System
- Regional Network Operations Center
- Signal timing adjustments
- STARNET
- Traveler information

Maintenance: Equipment functionality is especially important during unplanned events to maintain communication with agencies and push out information to motorists. Both preventative and reactive maintenance will have an influence on equipment health.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. Connected vehicle technology would push out event alerts, updating the vehicle of the traffic conditions and if a reroute is necessary.

Scenario 9 - Emergencies

In times of emergency (such as fires, flood, terrorism, etc.) the protocols should be different from major and minor incidents. The Caltrans TMC, CHP, local and regional transportation agencies are responsible for determining the severity of the situation. Emergencies trigger emergency services which goes through the dispatch system. If additional assistance is needed, the Emergency Operations Center (EOC) will offer support. There should be multiple evacuation routes identified, which will be dependent on the magnitude of the emergency, the location of the emergency, and the type of emergency. Local jurisdictions will also have their own evacuation plans, which can be considered when determining regional plans. Evacuation plans should be coordinated and consistent throughout partner agencies.]The nature of the emergency will impact how the transportation network is affected by turn of events. Alternate routes and flush plans can help with evacuation in the event of an emergency. Response is often started at the local level, but then can involve regional agencies when it is necessary. Major agencies such as CHP may be involved when it is necessary to change operations on the freeway. They would then coordinate with Caltrans as needed. Coordination between the major regional agencies and local agencies can create a support network for cities to assist one another.

Users:

- Caltrans D3
- Local TMCs and transportation agencies
- Emergency Operations Center
- Local first responders
- Public safety agencies
- Other emergency agencies
- Transit agencies

In the event of emergency several steps should be taken:

1. Emergency Protocol – Assess the situation, and determine type of emergency, magnitude of emergency, location of emergency, and potential threats of the emergency
2. Evaluate the regional network – Based on the location and nature of the emergency, Caltrans TMC, local TMCs, local first responders, law enforcement, and EOC should determine which areas should be restricted for public safety. CHP will determine if a freeway closure is warranted and the necessary change of routes. Based on the type of emergency, they should also determine if the emergency could move into new areas. This could be based on current or predicted weather conditions.
3. Evacuation network – After considering the mentioned factors, the stakeholders should prepare for diversion. If the situation permits, traffic can be diverted on appropriate freeways and arterials. This is performed under the authority of CHP. Local authorities will need to be informed of route changes, so they can be prepared to assist with evacuation.
4. Data sharing and alerts – Clear instructions and information will be vital in the event of an emergency. Data can be fed through various local TMCs, but should be released through STARNET, QuickMap, and Sac Region 511 to ensure that there is one consistent source.

5. Traveler Information - Informing the public will occur through various forms of communication: signage, alerts through Quick Maps, 511 system, third-party applications, local and regional communications and media.
6. Transit- Transit can play an important role in evacuation. If evacuation is necessary, transit operators will be contacted directly by the EOC. Transit agencies will need to be informed of restricted areas and if possible, should assist with evacuation.
7. Adaptability – Due to the unpredictability of emergencies, the evacuation plan and team should be ready to adapt to various outcomes. If response plan needs to change, this should be clearly communicated. Public will need to be informed too of any changes. These changes may require less automation of the system and more manual decisions. Depending on the emergency, the ICM via STARNET could be initiated. For some extreme situations, a manual lane reversible may be considered. Signal timing across jurisdictions will be implemented using the ICM through the STARNET interface that monitors regional traffic signal operations.
8. After Action Review – After an emergency, all involved parties should regroup to evaluate how the situations was handled. This meeting should discuss who was involved, what protocol was covered, and what adaptive strategies were used. Collectively the group should determine what changes in protocol should be made. This should be a comprehensive evaluation of all systems including communication protocol, traveler information, data sharing, evacuation network, transit, and involvement of agencies.

Applicable concepts:

- Regional Modernized CAD Integration
- Central Regional Video Management System
- Regional Network Monitoring System
- Regional ATSPM
- Emergency plans
- ICM
- Signal timing adjustments
- CMS
- Traveler information
- Regional ATMS for data sharing between agencies
- STARNET
- Transit evacuation plans
- Emergency Operations Center

Maintenance: Proactive maintenance ensures equipment lifespan. Equipment functionality is especially important during emergencies to maintain communication with agencies and push out information to motorists.

Connected Vehicles: Connected vehicles utilize vehicle-to-infrastructure and vehicle-to-vehicle communications. Connected vehicle technology would push out emergency alerts, updating the vehicle of the traffic conditions and if a reroute is necessary.

EMERGING TECHNOLOGIES

The SACOG Smart Region incorporates technology to create strategies for urban, suburban, and rural communities, while still allowing for adaptability to future innovations. Sometimes emerging technologies are also called disruptive technologies. This is term is used when new technology makes a large unplanned impact in a short amount of time. However, technologies do not necessarily need to be disruptive; government agencies can plan and integrate them into their systems to reap the benefits of these innovations. There are emerging technologies that should be considered as they could have a positive impact on the SACOG Smart Region. Below are summaries of some of these technologies that will likely make an impact on the future of transportation technology.

Mobility as a service (MaaS) or Transportation Network Companies (TNCs)

MaaS has been around for a while now, but in recent years the phrase has been used more often. Taxi cabs have been providing mobility as a service for many decades. However, the awareness of MaaS has come with companies such Uber and Lyft that provide their service at a lower price with greater ease. This shift away from taxi companies, relies heavily on smartphone technology that has really made an impact on the last decade. With the success of Uber and Lyft, other companies have considered their business model and other mode choices that may provide the same benefits of being affordable and convenient.

Other companies have considered bicycles, scooters, electric vehicles, and even drones as MaaS products.

Automated and Connected Vehicles

Automated and connected vehicles use technology that allows for communication between vehicles and infrastructure. This allows the vehicle to operate without a human behind the wheel, with the goal of eliminating human error from the road. Currently, some vehicles are semi-automated with features such as cruise control and self-parking features. These features allow the car to provide these functions without driver assistance, but the technology still requires a driver at the wheel to initiate these commands. Full-automation technology remains in the testing stages, but these vehicles are expected to hit the market in less than 10 years. This also depends on cooperation with agencies to ensure infrastructure provided to enable vehicle-to-infrastructure communication and allow vehicles to better ingest real-time data. A set of standards will also need to be developed for these vehicles to guide rules and regulations.

There are many predicted benefits with the arrival of these new vehicles. Benefits include increased safety, by eliminating driver error and efficiency through coordination of vehicle-to-vehicle communications.

Advanced Traveler Information

Traveler Information dissemination through 511 systems has been around for over 20 years. However, as technology has advanced so have 511 systems. Many have moved from the operator to IVR systems, accompanied by websites and mobile application. With emerging technologies such as automated and connected vehicles, transportation information centers will be able to feed alerts directly to vehicles. There are also Personalized Traveler Information which can feed individuals information based on location, emergencies, and other tailoring mechanisms.

FHWA released information regarding Enabling Advanced Traveler Information Services (EnableATIS), which allows for a new information network that focuses on multimodal systems. This system is comprised of data sharing, analytics, personalized information and enhanced delivery mechanisms. EnableATIS collects real-time data through connected vehicles, users, and

P3s. This allows for a comprehensive stream of data that allows for greater reliability than data capture from one source.

Smart Cities

Smart Cities integrate technology into cities and regions to optimize existing and new systems. USDOT released the 2015 Smart Cities Challenge to narrow in on technology in transportation in the US. However, Smart City holds a global meaning as well and places like Bangalore, India have launched into the goal of making their own city equipped with smart technology. This includes applications of new technologies in a variety of areas including infrastructure, operations, and institutions. Smart Cities implement strategies that include real-time data capture and sharing, communications, and adaptive systems to create a system that is safe and efficient.

Mobility hubs

Mobility hubs are best described as major transit stations where many lines or modes converge. They typically connect to regional lines and are surrounding by residential and commercial destinations. They are becoming more popular, and have been identified as areas where land use and transportation planning intersect. A great example of a mobility hub in Sacramento is Sacramento Valley Station, which has recently started the Master Plan process.

Microtransit

Data plays a big role in the transportation industry today. It provides users information about traffic conditions to transit routes and has also educated companies on travel patterns and behaviors. Over the years, commuter services and different vanpooling systems have emerged. Microtransit can integrate with public transit and address first mile / last mile problems that are common in many US cities. Microtransit can be applied to a wide variety of modes, but for the purposes of this discussion, microtransit typically works with van, shuttle, or “minibus” services. Some of these services are even moving in a fully-automated direction. Microtransit is seen as a Demand Reponsive Transit, and caters to a specific travel behavior. These services can often offer flexible routing, whereas many public transit services (with the exception of dial-a-ride services and the like) are typically fixed route. These services are typically operated by private sector companies, which in turn has consequences. Many of these companies cater to specific populations in ways that public transportation cannot. This might include only providing service to specific industries or companies. A key objective for these companies should be planning routes effectively to promote efficiency and reduce VMT.

Ride Sharing

While the public is already used to having readily available ride sharing services, their involvement in transportation networks has only seemed to solidify. Ridesharing platforms have become big data collectors and now provide to various public and private agencies. Some public agencies have partnerships with these companies to address first mile / last mile problems in their area. An example of a current public-private partnership (P3) is Uber and the City of Cincinnati. This partnership has provided Cincinnati access to Uber’s data, which is not publicly available. This data sharing provides the city with information about where Uber users are picked up and dropped off, which illustrates travel behaviors.

E-scooters and E-bikes

E-scooters and e-bikes are often seen on city streets and sidewalks. Some companies, like Bird, seemed to appear overnight, and now seen as a mode for short trips around cities. E-scooters and e-bikes can be either owned and shared. The ones that are shared are typically linked to a mobile application that provides GPS and inventory of the fleet. URB-E is another popular company that provides electric bicycles that can fold compactly for other transit modes such as buses and light rail transit.

It is especially important to acknowledge the products that are linked to shared mobility systems as they undoubtedly have an impact on the public right of way. In the past, Bird Scooters have been criticized for their lack of coordination with public agencies and the haphazard placement of the rentals around the city. There have also been concerns about their safety. However, the company has now identified the opportunity to partner with cities. For most cities, this could develop into a set of standards for companies like this to ensure safe practices. Companies like these also have potential to make a positive impact on local transportation networks, as they can help close gaps and some last mile challenges.

Curb Management

As cities grow more populated, parking demand often outpaces supply. In response to this, cities have created parking management strategies to develop adequate pricing systems. Some cities have developed dynamic curb pricing mechanisms, allowing for the price to park at the curb to fluctuate according to demand. Cities are also rethinking how curb space is allocated and evaluating alternative uses for the curb, such as using it as small public gathering spaces (“parklets”), allowing for delivery vehicle parking at certain times of day, or allocating space for bike and scooter storage. The need for loading zones is also growing, as ride sharing platforms become more popular. Parking spots that were occupied for two hours may now be occupied five minutes for picking up and dropping off riders. Curb space is valuable real estate and if the demand for long-term parking decreases, that space can be used differently, and could lead to more complete streets.

Bus on Shoulder (BOS)

Bus on Shoulder has become a viable solution to congestion issues on freeways. BOS allows buses to utilize shoulders during times of congestion or under other permitted circumstances. Prioritizing buses by providing them with their own lane can improve bus speeds during peak hours, which provides people a greater incentive to use public transit. BOS can often support a transportation system on a regional level. Most BOS systems integrate technology into their systems to promote safe driving. This can include a variety of different detection systems to ensure that BOS systems operate safely and stay within the shoulder lane.

Drones

Drone technology is on the rise and has become a large part of conversations about goods movement. Companies like Amazon see this technology as highly supportive of their business model for fast and cheap delivery. Regulations spark many questions as consumer-grade drones have already received a lot of attention. They often pose risks to certain area and can be privacy and security threats. The National Transportation and Safety Board, as well as the federal Department of Transportation provide existing regulations for drones. However, if businesses absorb drones into their delivery fleets, there will be more devices in the air, causing greater complication. While all of this may raise some concerns, it is also important to acknowledge that there are potential benefits to drone technology. Drones could alleviate some trucks from local roads, resulting in less disruptive delivery methods and cleaner emissions. Therefore, freeing up space on the road and reducing traffic, noise, and pollution concerns.

BIG DATA

The emergence of new technologies such as Internet of Things (IoT) and large-scale wireless sensor systems enables the collection of data from an increasing volume and variety of networked sensors. This is especially true within modern ITS network for Smart Regions. This chapter discusses the latest developments in Big Data technologies, with specific focus on how value is extracted from the Big Data system. This includes discussion on the standard Big Data process including acquisition, cleaning, aggregation, modeling, and interoperability. Furthermore, it provides a framework for which the new system including the upcoming 5G technologies can build upon. The chapter concludes with a discussion on 5G outlook and challenges in discovering insight from large scale and complex Smart Region data.

Managing and analyzing data has always been one of the greatest challenges within organizations across industries. Finding an efficient and scalable approach to capturing, integrating, organizing and analyzing information about customers, products, and services can be a perplexing task for any organization regardless of the size or line of business. In the age of the Internet and digital transformation, the notion of Big Data reflects the changing world we live in. Everywhere around the world, more and more data are being collected and recorded. Companies are beginning to be overwhelmed by the complexity and sheer volume of their data. While some data is still structured and stored in traditional relational databases or data warehouses, a majority of modern data sources are producing unstructured data including documents, conversations, pictures, videos, Tweets, posts, Snapchats, sensor readouts, click streams and machine-to-machine data. Further, the availability and adoption of newer, more powerful mobile devices, coupled with ubiquitous access to global networks, is continuously driving the creation of new sources for data. The value of data is growing in parallel with its volume and diversity. Data is emerging as the world's newest resource for competitive advantage, as it enables efficient, data driven decision making. As the value of data continues to grow, new technologies are emerging to support new requirements.

Defining Big Data

There has been much hype about Big Data in the past several years for various reasons. Before investigating the major drivers of Big Data's popularity, we must first define the meaning of Big Data as a term.

Dictionary.com defines Big Data as:

> *…data sets, typically consisting of billions or trillions of records, that are so vast and complex that they require new and powerful computational resources to process.*

The *British Dictionary* defines Big Data as:

> *Data held in such large amounts that it can be difficult to process.*

Big Data can be defined and often is described in terms of its four major characteristics: volume, velocity, variety and veracity as shown in **Figure 3**:

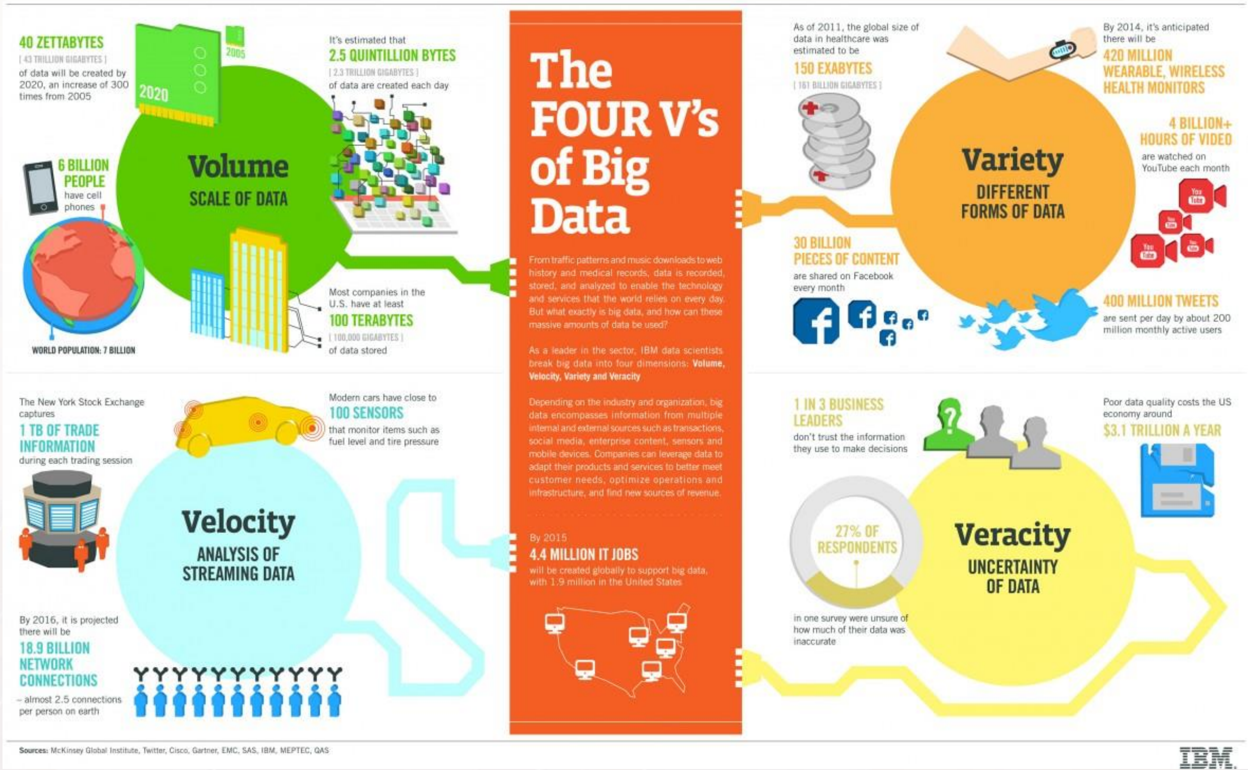

Figure 3: IBM's 4 Vs of Big Data
https://www.ibmbigdatahub.com/infographic/four-vs-big-data

Volume
Volume indicates how much data has been collected. It is one of the most obvious characteristics of Big Data, as the current amount of data created is quite staggering. For example, in one minute on the Internet, Snapchat users share 527,760 photos, YouTube viewers watch 4,146,600 videos, Twitter users post 456,000 tweets, Instagram aficionados post 46,740 photos, and so on. All of these transactions can be archived for later consideration.

Velocity
Velocity refers to the speed at which data is being generated. Streaming data can arrive in milliseconds and require a response within seconds or less. For example, Facebook's data warehouse not only stores hundreds of petabytes of data, but needs to accommodate the velocity of the data coming in at the rate of more than 600 terabytes of incoming data per day. Similarly, Google processes more than 3.5 billion searches per day, which translates to a velocity of over 40,000 search queries per second.

Variety
The huge variety of the types and structures of data has become one of the critical challenges of Big Data. Big Data requires systems to handle structured data, but also semi-structured and unstructured data as well. As described above, most Big Data is in unstructured forms such as audio, images, video files, social media updates, log files, click data, machine and sensor data, etc. Unfortunately, most analytics techniques in the past have been focused on analyzing only structured data, so new techniques and approaches need to be developed. This fact helps explain why there is such a large growing number of startups in Big Data.

Veracity
One of the most important aspects of the four V's is veracity. Veracity describes how accurate and trustworthy data is in predicting business value through Big Data analytics. Uncertainty is typically due to data inconsistency, incompleteness, latency ambiguities, approximations, etc. Data must be able to be verified based on both accuracy and context. It is necessary to identify the right amount of high-quality data that can be analyzed in order to impact business outcomes.

These four definitions suggest that Big Data typically requires resources (computation and data infrastructure, tools, techniques, expertise, etc.) beyond the current capabilities of many organizations. Big Data solutions typically comprise a set of analytical tools that are geared toward the fast, meaningful processing of large data sets. This is a key aspect of Big Data analytics, as the goal is to derive meaning or insight from data that can be used for making data-driven business decisions.

Turning data into Insight
In order to convert this vast amount of data into insight, it is important to consider the functional requirements for Big Data. **Figure 4** illustrates a set of iterative steps in the Big Data functional requirements lifecycle. Data first needs to be captured, then organized, integrated, cleaned and prepared. After this phase is successfully implemented, data can be analyzed to solve the business problems at hand. Often this analysis includes developing predictive models utilizing Data Science approaches. Finally, the organization can act based on the outcome of the Big Data analysis, frequently via the implementation and utilization of the predictive models.

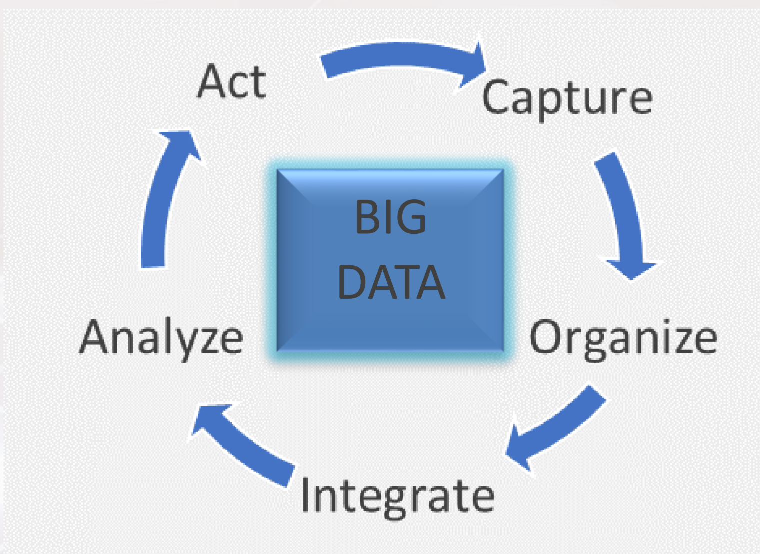

Figure 4: Big Data Lifecycle

Big Data Management and Computing Platforms
As the volume and velocity of data grows, so grows the need to manage and process it. Optimization**,** enabling rapid formulation and testing of multiple and diverse models and real-time operations, becomes essential, especially in the case of streaming data. Distributed and parallel processing approaches are well suited for these kinds of problems.

The Apache Hadoop software library is an open source framework that allows for the distributed processing of large data sets across clusters of computers using simple programming models. It is designed to scale up from single servers to thousands of machines, each offering local computation and storage. Rather than rely on hardware to deliver high-availability, the library itself is designed to detect and handle failures at the application layer. This enables it to deliver a highly-available service on top of a cluster of computers where each machine may be prone to failures. Additional open source projects have built around the original Hadoop implementation with the addition of Spark and specifically designed scalable Machine Learning libraries. **Figure 5** depicts the entire Hadoop environment, which enables large scale data management and computing.

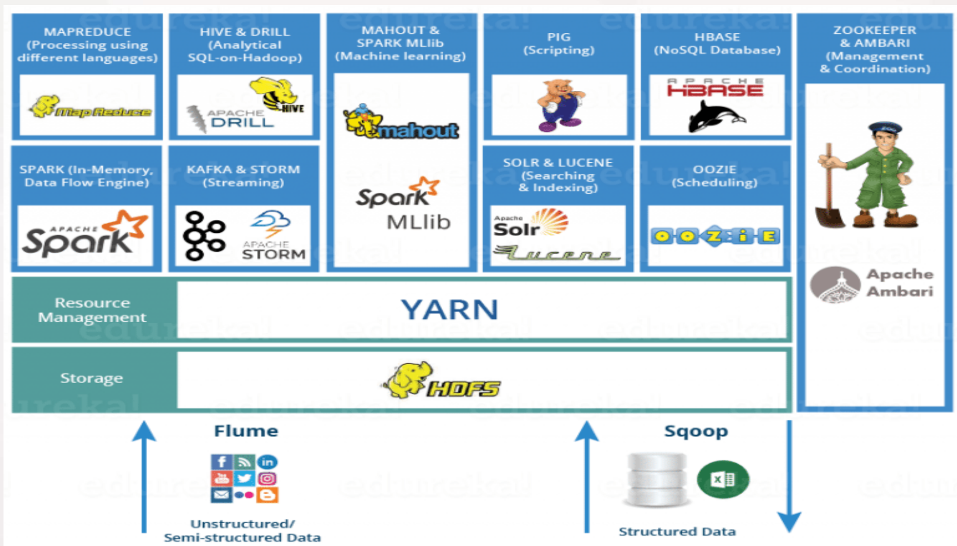

Figure 5: Hadoop Ecosystem

The list of all of the apache projects can be found at: https://hadoop.apache.org/

Big Data Analytics

Hadoop and Spark based systems enables filtering, aggregating, transforming, enriching, and analyzing sensor data. Integrating real-time data with existing enterprise databases data for a comprehensive view of operations is critical for enabling fully operational Smart Regions. Enabling the data-in-motion to respond to time-sensitive operational events such as changes in traffic or equipment conditions, together with the addition machine learning algorithms allow for accurate and timely decisions that maximize operational productivity while reducing costs.

There are several levels of sophistication in analytics moving from descriptive, to diagnostic, to predictive and finally prescriptive modelling. Descriptive analytics help understand what has happened in the past, while diagnostic analytics looks into reasons of why something might have happened. Predictive analytics build machine learning models to predict what will happen. These models can then they can be fed into prescriptive models, which take the process directly to decision making and action by recommending what should be done under certain conditions. The Intelligent transportation system is essential to build smarter cities and regions. Machine learning based transportation prediction are a highly promising approach by delivering fast and accurate insight.

Developing Predictive and Prescriptive Models

While it can be costly to collect, store and secure Big Data properly, the real return on investment (ROI) hinges on the ability to extract information from the data. The field of Data Science is one angle from which to approach the data deluge. Data scientists endeavor to extract meaning and tell the story of the data in order to provide insight and guidance. Data science is a set of technologies that uncovers relationships and patterns within large volumes of data that can be used to predict future behavior and events. This technology learns from experience to predict the future outcomes to drive better business decisions. It is typically used to extract meaning from data or interesting knowledge, often extracting rules, regularities, patterns and constraints from raw data. Data science is an interdisciplinary field that combines of artificial intelligence (AI), machine learning, visualization and statistical analysis to discover information that is "hidden" in the various forms of either structured or unstructured data.

The Cross Industry Standard Process for Data Mining or CRISP-DM

The CRISP-DM standard, depicted in Figure 6, identifies the six major phases of the Data Mining process. When approaching predictive model development, it is essential to deeply understand the application domain characteristics. This is the goal of the Business Understanding phase. Once the business problem and the underlying concept and goals are fully understood, the Data Understanding and description phase follows. Technology, theory and business goals are still considered as the creation of the dataset to be used for creating predictive models is initiated. Creating the dataset may involve bringing together data from different sources of different type to be able to develop comprehensive models. Data preprocessing and cleaning undertaken in the Data Preparation phase are typically the most important and time-consuming tasks to be considered before identifying the data science functions to be employed. Once models are developed ("trained") in the Modeling phase, implementing, evaluating, validation and presentation of the methods in the Deployment phase finalizes this iterative process.

Each of these phases may leverage any number of the many tools and methods available today. Deciding on the tools and methods to use based on the scale of Big Data project and the desired deliverables is an essential and critical component of a successful Big Data Project.

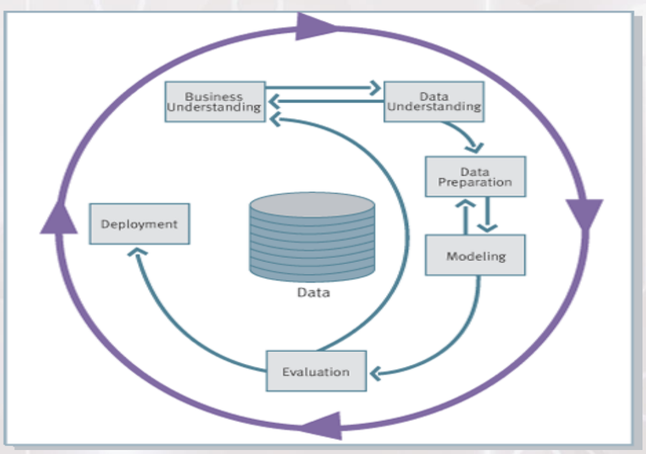

Figure 6: CRISP-DM Process Model

Big Data for Transit

As the Big Data revolution continues its sweep across major industry sectors, it is starting to rapidly transform and disrupt various facets of the transit industry. By leveraging successful application examples of Big Data analytics in transit, the field of transit systems can also leverage Big Data to extract its great benefits. Big data has the potential to promote better operations in transit and to provide more reliable information to riders. Due to the massive continuing digital transformation, complex challenges have emerged in the effort to build efficient, safe, and sustainable urban transportation systems. Rising congestion, increased demand for public transit, continuously changing human travel behavior and transportation preferences have one common requirement - the need for good quality data and insight derived from that data. Data is available from diverse sources including smart cards, GPS, roadside and in-road sensors, video, social media, connected autonomous vehicles, etc., and data size and complexity is increasing dramatically. Traditional tools and techniques for collection and analysis of this size and complexity of data is inefficient and inadequate. Big Data tools and algorithms can create more accurate models and forecasts for predicting future trends and behaviors by efficiently processing these massive, diverse data sources.

Finally, the USDOT has recently released new federal guidance for automated vehicles named "Preparing for the future of Transpiration: automated Vehicles 3.0 (AV 3.0). The advent of autonomous vehicles promises to further escalate the volume, velocity and utilization of transportation related data. These same advancements could propel automated shuttles and bus fleets as the technology continues to advance.

Traffic Management

As more and more of the world's population moves to cities, urban commuters time spend in traffic increases dramatically, straining transportation systems. Big Data approaches can help understand the causes of congestion and enhance traffic management by providing predictive models that enable congestion management. Big data techniques can process car speeds, weather conditions, community events, and sources of acceleration and deceleration by utilizing the combination of real time information, historical trends and predictive algorithms. For example, Big Data techniques could identify the top origin-destination pairs during peak morning and evening commuting hours, as well as reveal where the largest first-mile and/or last-mile transit gaps are located. With up-to-date, real-time travel pattern data and stream processing, transit alternatives can be offered to the drivers in real-time to shift modes. Big Data analytics can provide insight into travelers' journey patterns in the transportation network. Such insight can then be utilized for improved public transportation service planning, enabling travelers to reach their destination via the most suitable route in the shortest possible time.

As human behaviors evolve, so do the locations of work, residence and recreation. Public transit capacity and routes also likewise to adapt. With the recent growth in passengers pursuing more environmentally friendly options, the demand for public transportation and ride sharing is also growing. Big Data from mobile devices and connected cars can reveal public transit gaps and expansion opportunities.

Similarly, the need for bike and pedestrian infrastructure is growing. The number of commuters who regularly bike to work has dramatically increased in the last decade, and walking is steadily growing as a preferred mode of transportation. Big Data analytics can help reveal the impact of bike and pedestrian infrastructure improvements on vehicle traffic. Additionally, it can identify travel patterns characterizing particular roads as potentially good candidates for bike and pedestrian share infrastructure. Similar kinds of analysis can also provide insight in placing and implementing electric vehicle (EV) charging networks to encourage further widespread adoption of greener alternatives.

Big Data analytics can improve public transit's safety level. Using advanced sensor and detection techniques, massive amounts of real time transportation information can be obtained. Big Data analytics methods can effectively aid in the reduction of risks of traffic accidents, or, in case of an accident occurrence, enable more efficient real-time emergency and rescue response capability.

Asset Management

Big Data analytics can offer new opportunities to identify and alleviate a transportation system's asset, operations and maintenance challenges. Big Data can help enable condition-based or predictive maintenance decisions and prevent a failure state before it ever occurs. Many assets in the transportation system are dependent on large amounts of data to operate and maintain. A proper asset maintenance approach can protect the infrastructure investment and reduce maintenance costs. By analyzing complex engineering data from various sources, comprehensive Big Data Approach can provide engineers with the information they need to make better decisions and reduce cost. Data sources like maintenance logs, field tables, visual and acoustic sensors, temperature, humidity, and GPS can all provide a rich data set that influences both automated and human decision making. For example, predictive models or often called predictive or condition-based maintenance, can help guide the expenditure of a finite maintenance budget into the most critical areas, thereby maximizing ROI. Implementation of such a program enables a shift from a purely reactive maintenance approach to a proactive one.

Data Interoperability and Standards

Data interoperability is a mandatory prerequisite for achieving the promise of Big Data. However, it is still a difficult and unresolved challenge. Big data is typically characterized by four Vs including volume, velocity, variety, and veracity. These characteristics create significant challenges in the ability of two or more systems or components to exchange information and productively utilize the information that has been exchanged. Over time, several frameworks have been proposed to capture the many aspects of interoperability. However, interoperability is not a simply technical issue, it is a problem affecting the interaction of entities at various levels including: organizational, semantic/contextual and technical. Implementing data interoperability requires grappling with data integration and data exchange as well as enabling effective use of the data that becomes available.

One of the major interoperability challenges is the lack of a common framework that can be used to describe the interoperability challenges in a structured and unified manner. A recently developed standard, NIST's Big Data Public Working Group (NBD-PWG), was established together with industry, academia and government to address this issue. It aims to create a consensus-based, extensible NIST Big Data Interoperability Framework (NBDIF) that is a vendor-neutral, technology- and infrastructure-independent ecosystem. In addition, the Industrial Internet Reference Architecture v 1.8. First published in 2015 and best known as the IIRA, this standards-based architectural template and methodology enables Industrial Internet of Things (IoT) system architects to design their own systems based on a common framework and concepts.

Individual data elements have not changed dramatically with the onset of Big Data; however, the size, variety and complexity of the data has created new challenges. Many standards for basic data types already exist within the ISO standard ISO/IEC 11404:2007 General Purpose Datatypes and we will continue utilizing them. For example, IEEE P2413 – Standard for an Architectural

Infrastructure for the Internet of Things, a standardization project aims at identifying similarities in IoT environments as diverse as intelligent buildings, intelligent transport systems or healthcare.

There are four important aspects of IoT data interoperability: technical, syntactical, organizational and semantic. In terms of technical operability, most active IoT standards definitions are focusing on machine to machine (M2M) interoperability. Device-level M2M interoperability is the one most common IoT standards under development, including Open connectivity foundation (OCF), Web of Things Interest group at W3C, OmaSpecworks and IoT Smart Objects created by IPSO, and OneM2M standards for M2M. Interoperability at M2M level can be achieved among a group of devices with compliant implementations of a common specification and shared middleware. OPC Unified Architecture (OPC-UA) is an industrial machine-to-machine (M2M) communication protocol for interoperability developed by OPC Foundation. The Advanced Message Queuing Protocol (AMQP) is an OASIS standard or specification for application layer protocol in message-oriented middleware. The Constrained Application Protocol (CoAP) is a specialized web transfer protocol for use with resource constrained devices and networks (in IoT). CoAP is designed based on RFC 7252 for M2M applications such as smart energy and building automation. Extensible Messaging and Presence Protocol is a communications protocol for message-oriented middleware. Data Distribution Service (DDS) is a machine-to-machine (M2M) middleware standard promoted by Object Management Group (OMG) that aims to enable scalable, real-time, dependable, high-performance and interoperable data exchanges between publishers and subscribers for M2M communication. In addition, The Industrial Internet Reference Architecture (IIRA) is focused on industrial IoT applications. In Europe the IoT-EPI or the European Initiative for IoT platform development is defining IoT interoperability ad information sharing standards. In addition, project Iot-A in Europe is working on developing interoperable architectures that can be applied in different domains. Another open source initiative called IoTivity is aimed at guiding and promoting cooperation between companies and developers. However, many different IoT standards exist with incompatible data models and definitions without a universal integration platform. The aggregation or service-level level interoperability across domains and specifications is crucial in enabling practical usage of the IoT data aggregations.

An increasingly important component of semantic interoperability is the concept of metadata, which is often described as “data about data”. Typically, three distinct types of metadata are referred to inducing descriptive, structure and administrative. Metadata should itself be viewed as data with all the same requirements for tracking, change management, and security. This field is starting to converge with master data management and analytics enabling the machine learning downstream. Metadata management facilitates access control and governance, change management, and reduces the complexity and scope of change management. Several existing standards have already been developed for general metadata coverage (e.g., ISO/IEC 11179-x15) and discipline-specific metadata (e.g., ISO 19115-x16 for geospatial data) and will be utilized in the proposed framework.

Additionally, while metadata helps assign meaning to the data, there is a need for provenance information – describing the history of a how data was derived. As more multifaceted data becomes available and connected, it becomes critical to enable information about how data was collected, transmitted, and processed. Knowledge of metadata provenance guides users to correct data utilization when the data is repurposed from its original collection process to extract additional value. Moreover, semantic metadata is required, to provide description and context of a data element to assist with proper interpretation.

An additional component of an interoperability framework are ontologies. Often, ontologies are conceptualized as a graphic model, representing a semantic relationship between entities. A number of mechanisms exist for implementing these unique descriptions, developed by World Wide Web Consortium (W3C) efforts on the semantic web, and these will be included in the proposed approach. Semantic data is important for Big Data to enable cross-cutting meanings for terms, especially in cases of linked data. Additionally, taxonomies represent metadata about data element relationships, especially hierarchical relationship between entities.

Transportation data models are often represented in Unified Modeling Language (UML). UML diagrams are intuitive for understanding transportation concepts and their relationships and provide standardized ways to construct transportation data models. Recent advances in UML specifically supporting IoT have been developed with the UML4IoT automating the generation process of the IoT-compliant layer. However, UML does not consider semantics, sharing UML data can be difficult. In contrast, web ontology language (OWL) describes the semantics of ontology enabling easier knowledge sharing and logical inference. OWL data are easier to share and better for performing logical inference. Transportation data represented in OWL can have many advantages, including facilitated data sharing and inference.

There are several different approaches to data interoperability from agreement-based to mediator-based. Typically, interoperability scenarios are complex, and require the combination of solutions to be resolved. Agreement-based approaches consist of agreeing on a set of principles that achieve a limited amount of homogeneity among heterogeneous entities including standards. Developing comprehensive approaches is complex due to the fact that data interoperability is a problem that goes beyond technical aspects. The best approach to data interoperability encompasses an approach to reconcile all the differences arising between data providers and data consumers with respect to organizational, semantic and technical characteristics governing their exchange of data. The first step in achieving data interoperability with the Smart Region is to arrange a data audit to better understand available data types, quality and quantity.

The data infrastructure should provide basic functionalities for all data sources, regardless of how they interoperate, as well as a rich array of sophisticated functionalities for enhancing the level of interoperability among any target set of data sources. The data interoperability strategy needs to be based on several key components: a shared and comprehensive interoperability framework, an infrastructure offering interoperability-enabling tools and services and an environment promoting the development, testing and certification of new interoperability-enabling tools and services. The interoperability framework is a comprehensive model that is used to characterize the data interoperability facets in a systematic way, as well as to characterize the existing and forthcoming solutions and approaches both from the technical layer to the organizational layer including semantic aspects.

Implementing such an application would require the system to be capable to access data – directly or via protocol translators - from different domains such as legacy systems, automation systems, vehicle systems and IoT systems. In addition, it would require meta-data and sensor-user associations or attributions for predictive model building and data personalization.

This approach will enable a minimal viable set of interoperable data and meta-data formats that work across devices and domains. These formats need to be augmented with naming and taxonomy systems that would allow interested applications to discover and access sensors of interest, interpret their observations and perform actuations where and when appropriate. This should include basic and contextual information such as: sensor ID/name, observation/reading, engineering units, time of acquisition, location, etc. The list of items and meta-data of interest can quickly grow to include: sensor type, frequency of reporting, mobile or static location, owner, domain, associations, access rights, privacy policy and restrictions, accuracy, calibration, manufacturer, model number and others. This information will be used to formulate a coordinated naming, taxonomy/ontology and meta-data system that together give valuable information in each observation, and allow the rest of the information of interest to be obtained by querying the sensor node or cloud/data lake data structures.

Integration of such desperate systems can enable significant new opportunities for services, Big Data, and predictive analytics. To fulfil that promise, Big Data systems need to be designed to support data interoperability and at least some level of commonality in taxonomies, ontologies, naming, meta-data assignment and processing.

5G TECHNOLOGY

The rapid emergence of the today's mobile and connected society is driven by a tremendous growth in number of connected devices, connectivity and traffic volume. The explosive growth in global data traffic is expected to increase by more than two orders of magnitude from 2010 to 2020, and an additional two orders of magnitude before 2030. The 5th Generation of wireless technology in mobile networks (5G) is being developed to meet new and extraordinary demands of today's society.5G features lightning fast speed, ultra-low latency and enhanced capacity to a carry massive number of connections simultaneously. With these enhanced features and improved usability, 5G networks have the potential to revolutionize many industries and applications, particularly the transportation sector.

5G mobile technology is expected to provide a new and much wider set of frequency bands along with wider spectral bandwidth per frequency channel. In addition to providing a significant increase in bitrate and peak bit rate, 5G is also enabling larger data volume per unit area, concurrent and instantaneous connectivity, lower battery consumption, lower cost of infrastructural development and higher reliability. With the wide range of high bandwidth radio channels, 5G is able to support speeds up to 10 Gbps of contiguous and consistent coverage. 5G technologies enable data transport with less than a millisecond of delay and bring peak download speeds of 20 gigabits per second.

The number of use cases for Mobile Internet and IoT are growing quickly and driving the 5G market. Examples include augmented reality, virtual reality, remote computing, eHealth services and autonomous vehicles. As described in the ITU-R IMT 2020 Requirements depicted in **Figure 7**, most of the 5G use cases can be grouped into three usage scenarios including enhanced mobile broadband, massive machine type communications and ultra-reliable and low latency communications.

Connecting private vehicles and public transport with 5G is poised to revolutionize travel, particularly in light of the advent of self-driving vehicles. As the numbers of autonomous vehicles become more and more significant, so does the need for advanced wireless communications systems. Under the umbrella of 5G enabled technologies, a variety of solutions are emerging in the categories of Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications. One of the most significant advantages to transportation offered by 5G, in addition to lower latency, is the possibility to use a multiplicity of communications channels and access points within a single session. This increases connection management flexibility and increases the number and variety of possible service offerings.

With the emergence of automated and driverless vehicles, V2V communication has become one of the most impactful areas of development for 5G. Cars are now able to monitor vehicle and journey factors using sensors, sending and receiving information to and from one another wirelessly. This near real-time exchange of vital information creates a new, large data sets that can be utilized to improve many current transportation challenges, beginning with road safety. For example, vehicles can inform surrounding vehicles in real-time when there has been a high-impact collision, sudden unexpected slow-down or changes in weather conditions. 5G reception can provide a continuous and reliable signal, while developments in network slicing, small cells and mmWave technologies are leveraged to enable these types of solutions.

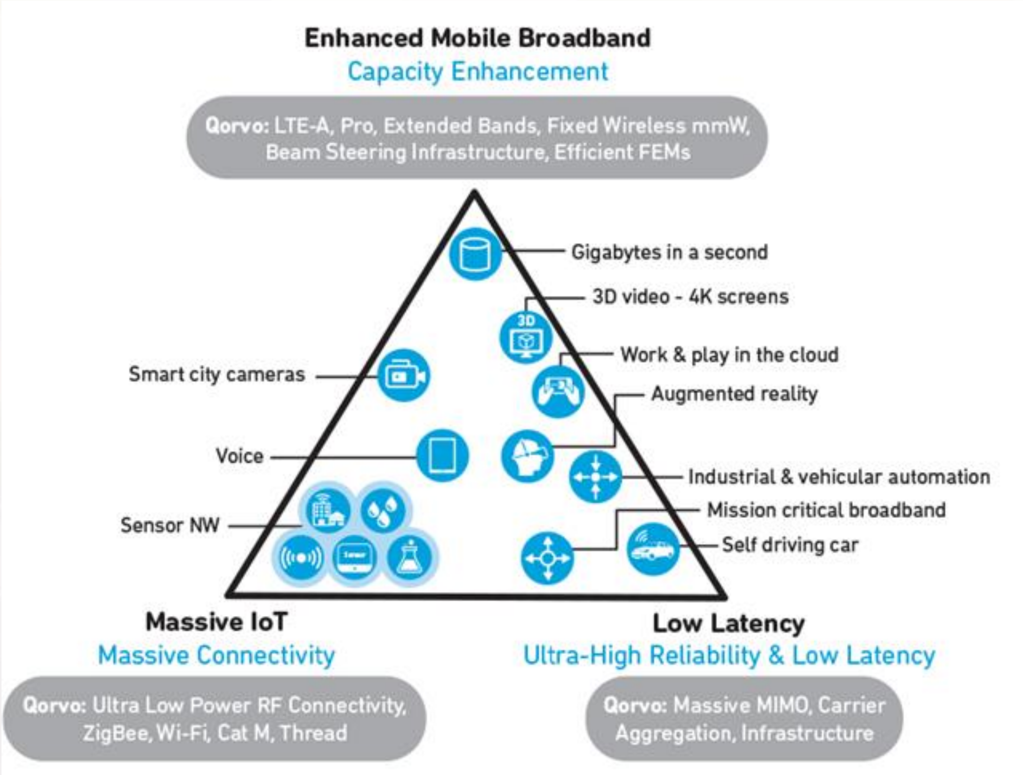

Figure 7: 5G use cases (From: ITU-R IMT 2020 Requirements)

As vehicles interconnect with other vehicles via V2V technology, they will also be able to connect to the infrastructure around them, such as traffic lights, bus stops and even the road itself. This V2I connectivity will allow vehicles themselves to react to the road conditions ahead, thereby increasing safety and reducing travel time. Vehicles will be able to assess the route ahead, avoiding congested areas and planning alternative routes as the journey progresses. Additionally, these systems could offer alternative transportation alternatives by querying resources such as live public transportation timetables and parking availability and assessing the fastest journey in real-time. While, V2V and V2I are heavily focused on driver and passenger safety, efficiency and infrastructure improvements, there are a many aspect about 5G technology that will enable journeys to be more enjoyable and personal by providing a deluge of applications that personally optimize each journey.

One of the emerging architectural platforms making its way into a standard is Fog Computing. Fog Computing is a paradigm designed to improve the speed, performance and security of data transport, while providing significant energy efficiency over more centralized approaches for devices and applications at the network edge. Fog deployment typically targets a specific geographic region. Fog Computing Nodes (FCN) are generally heterogeneous and encompass routers, switches, access points, IoT gateways, etc. Moreover, the Fog framework is specifically designed for applications that require real-time response with low latency, especially heavily interactive applications. To accelerate the adoption of fog computing, the OpenFog consortium was founded in November of 2015 and published a Fog Computing Reference Architecture (OpenFog Architecture) in February 2016. Fog computing serves as a system-level, horizontal architecture that distributes resources and services including computing, storage, control and networking anywhere along the range from the cloud to things, thereby enabling an interoperable FC ecosystem.

The implementation of 5G networks will be the force that facilitates major changes in transportation. 5G networks are able to carry data at speeds unmatched by older networks, ensuring safe and efficient communication between autonomous vehicles, connected cars, trucks, busses, bus-stops, traffic systems and lights. Not only will this set of emerging 5G based technologies make transportation systems safer, more efficient and sustainable, it will also make a tremendous impact on pollution reduction, productivity and overall journey time by creating an eco-system of scale and diversity. New services and business models can be supported with sensors embedded in roads, railways and airfields that communicate to each other and/or with smart vehicles and infrastructure. These are just a fraction of the benefits 5G could bring within the vehicle and transportation sector. As the network infrastructure and enabling technologies advance, they have a potential to dramatically transform and revolutionize transportation.

NEXT STEPS

The SACOG Smart Region Concept of Operations is intended to provide a framework for coordinated ITS projects. This document lends itself to all of SACOG's member agencies to collaborate on ITS projects. This collaboration can be achieved by using this document as a reference for future initiatives. In addition, member agencies can take additional steps to achieve cohesive projects that integrate with the Smart Region. Below is a list of suggested steps for all SACOG member agencies, with a focus on those for whom local implementation plans have not recently been prepared. Additional steps may be considered depending on the nature and complexity of the project:

- **Understand the existing ITS infrastructure**
  This step can be achieved through examining existing inventory documents, GIS maps, databases, and performing field visits. Examining the existing ITS infrastructure provides an understanding of field equipment conditions. This step allows agencies to determine how existing infrastructure can work with new projects. An example of this step could be CMS placement, wherein there are existing CMS along one freeway corridor, and proposed CMS on a freeway that meets with the other. It would be important to look at the placement of the existing CMS. This effort would help determine the locations for new CMS to provide clear and visible messaging for motorists.
- **Notify SACOG partner agencies about plans for a proposed project**
  To the extent this effort isn't already occurring, this step can open conversations for collaboration and integrating with existing infrastructure, in particular for those member agencies located outside the Sacramento metropolitan area, as well as law enforcement and public safety. For example, additional agencies may show interest in participating in STARNET data sharing. Partner agencies may offer solutions from their own experiences in approaching similar projects. There is likely information out there that one agency knows, while another does not, so these conversations can facilitate a wider spread of knowledge among partners. SACOG's Regional ITS Partnership meets monthly and will continue to serve as an effective venue for this collaboration.
- **Promote projects with available funding opportunities**
  Similarly, to the extent this effort isn't already occurring, conversation with other agencies may tie into this step as well, in particular for those member agencies located outside the Sacramento metropolitan area, as well as law enforcement and public safety. It is important to understand what available funding sources are out there, and what projects are most likely to receive funding. This can encourage faster implementation of ITS projects. When looking at the needs of the area, and proposed strategies, it is will be important to consider funding as it relates to project feasibility. The Regional ITS Partnership is an appropriate venue for this collaboration as well.

Additional steps that can be taken directly from this document include:

- **Institutionalizing operational scenarios into standard operations**
  This would require looking to the operational scenarios as a blueprint for the standard operations of an agency. This can allow for a more proactive and coordinated approach to handling different scenarios.
- **Continue to hold monthly ITS meetings and extend an invitation to external, but related, agencies**
  Agencies outside of the realm of ITS or transportation can often be helpful in providing additional feedback. Important agencies that can offer valuable information include (but are not limited to) CHP, law enforcement, and fire and emergency services. These conversations, likely continuing through the Regional ITS Partnership, can be helpful in maintaining consistent communication, planning for events, and preparing for emergencies.
- **Establish regional protocol for the compilation and sorting of regional projects, including maintaining Smart Region GIS**
  Likely using the regional GIS developed as part of this Smart Region project, establish a regional protocol for collecting and dynamically sorting regional agency projects. This somewhat basic information sharing, some of which is expected to occur naturally with adjacent agencies and through the monthly ITS Partnership Meeting, will enable all stakeholders to easily assess others' projects/priorities. The success of this step will largely rely on the investment and importance placed on the on-going data/information maintenance.