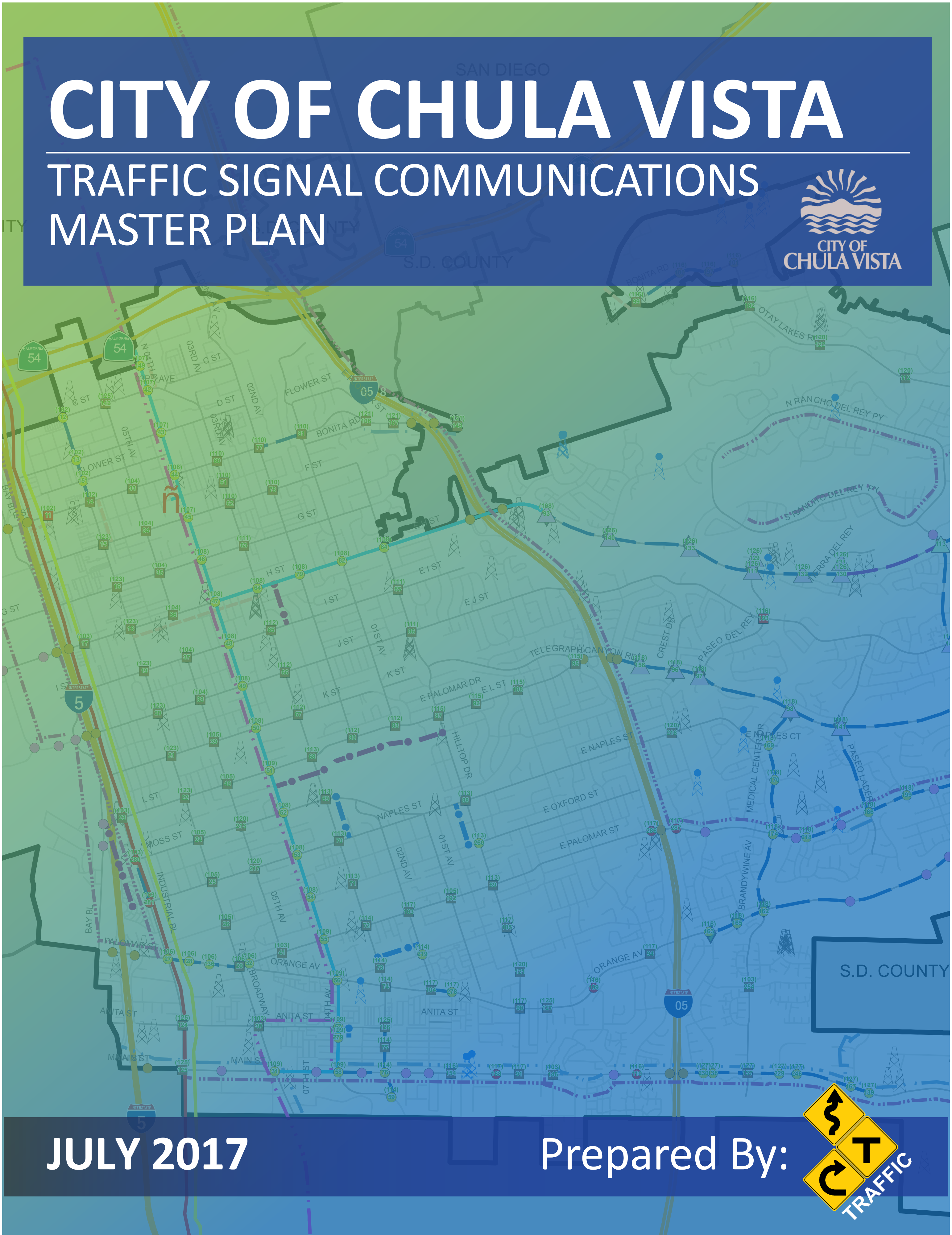
CITY OF CHULA VISTA

TRAFFIC SIGNAL COMMUNICATIONS MASTER PLAN

CITY OF CHULA VISTA

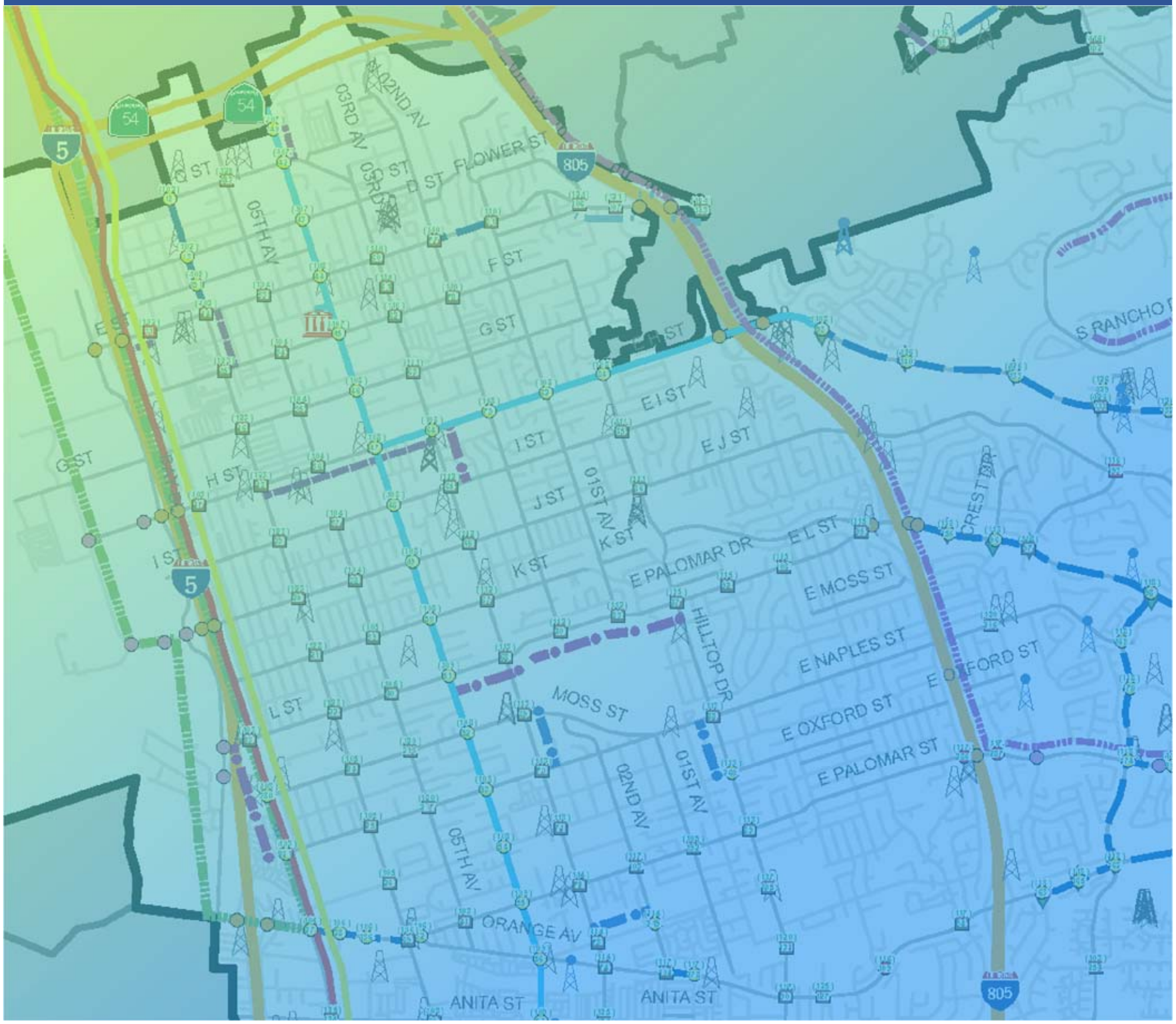


JULY 2017

Prepared By: TRAFFIC

CITY OF CHULA VISTA

Traffic Signal Communications Master Plan



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1	11/29/16	Issued for City Review
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4	6/23/17	Submitted Final Draft
5	7/13/17	Submitted Final Report

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List of Acronyms

AASHTO ... American Association of State Highway and Transportation Officials

ALOS ... Arterial Level of Service

API ... Application Programming Interface

ATC ... Advanced Traffic Controller

ATCMTD ... Advanced Transportation and Congestion Management Technologies Deployment

ATCS ... Adaptive Traffic Control System

ATP ... Active Transportation Program

ATT ... Arterial Travel Time

AV ... Automated Vehicle

BBS ... Battery Backup System

BPS ... Bits Per Second

Caltrans ... California Department of Transportation

CAT ... Category

CCTV ... Closed Circuit Television

CDBG ... Community Development Block Grant

CIP ... Capital Improvement Program

CMU ... Conflict Monitor Unit

COM ... Communications

CVBMP ... Chula Vista Bayfront Master Plan

DAR ... Direct Access Ramp

DIF ... Development Impact Fees

DMS ... Dynamic Message Sign

DSRC ... Dedicated Short Range Communications

EIR ... Environmental Impact Report

EPA ... United States Environmental Protection Agency

EV ... Electric Vehicle

EVP ... Emergency Vehicle Preemption

FAST .... Fixing America's Surface Transportation Act

FES .... Field Ethernet Switch

FWG .... Fiber Working Group

FY... Fiscal Year

GHG .... Green House Gas

GIS .... Geographic Information Systems

GMOC .... Growth Management Oversight Commission

GPS .... Global Positioning System

Hi-Res.. High-Resolution

HSIP.. Highway Safety Improvements Program

IoT .... Internet of Things

IP... Internet Protocol

IR .... Infrared

IT .... Information Technology

ITS .... Intelligent Transportation System

JPO .... Joint Program Office

LED .... Light Emitting Diode

MBPS .... Megabits Per Second

MFES .... Managed Field Ethernet Switch

MTS .... Metropolitan Transit System

NTCIP .... National Transportation Communications for ITS Protocol

POTS .... Plain Old Telephone Service

PTZ .... Pan-Tilt-Zoom

QoS .... Quality of Service

RAMS .... Regional Arterial Management System

ROI .... Return on Investment

RTCM .... Radio Technical Commission for Maritime Services

RTMS .... Remote Traffic Microwave Sensors

RTP .... Regional Transportation Plan

SANDAG .... San Diego Association of Governments

SCATS .... Sydney Coordinated Adaptive Traffic System

SCN .... System Control Number

SFP .... Single Fiber Port

SHSP .... Strategic Highway Safety Plan

SPA .... Sectional Planning Area

SPaT .... Signal Phase and Timing

TDIF .... Transportation Development Impact Fee

TMC .... Traffic Management Center

TMP .... Traffic Monitoring Program

TOD .... Time of Day

TSCC .... Traffic Signal Communications Center

ULOS .... Urban Street Level of Service

USDOT .... United States Department of Transportation

V2I .... Vehicle to Infrastructure

VDSL .... Very High Bit Rate Digital Subscriber Line

VOS .... Volume-Occupancy-Speed

Executive Summary

The City of Chula Vista is preparing for the next generation of technology which will support the City's smart growth and development. At the core of the City's "Smart City" initiatives are investments in Intelligent Transportation Systems (ITS) infrastructure. Through leveraging state-of-the-art communications systems and Internet of Things (IoT) devices the city will have the ability to gather and analyze data to gain insights into infrastructure and travel that will lead to better transportation system management and overall improvement in public services.

The Traffic Signal Communications Master Plan purpose (hereby referred to as Master Plan) is to guide the City's investment and implementation in traffic signal communications systems and ITS technology. Chula Vista is San Diego County's second largest and fastest growing city. The Master Plan is critical to ensure the City 's current and future transportation system needs and objectives are realized through this growth. Most importantly, the implementation of the Master Plan will promote the City's vision of sustainability, economic vitality and high quality of life – through the significant benefits of traffic systems technology and improved traffic management and operations.

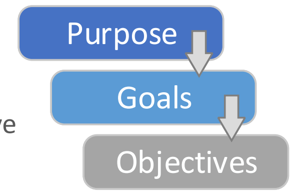
E1 Need

The communications system is the most critical part of a traffic management system and delivers information from City streets and intersections back to the Traffic Management Center (TMC) where the management and operation activities take place. The City of Chula Vista monitors and manages 267 traffic signals, providing safe movement at signalized intersections for vehicles, pedestrians, bicyclists, emergency vehicles, transit, and rail[1]. The City of Chula Vista is the fastest growing City in San Diego County and is expected to add in the order of 100 new traffic signals in the next five to ten years[2].

Like many municipalities in San Diego County, the Chula Vista traffic signal communication system operates legacy equipment and obsolete communication protocol. POTS (Plain Old Telephone Service) leased lines provide the primary communication links between groups of traffic signals and the traffic equipment room in City Hall. There are several limiting factors associated with this antiquated communication architecture: modern devices with desirable capabilities do not support the legacy protocols, the existing communication bandwidth is a fraction of modern systems, operating and maintaining the existing communications and legacy devices is increasingly difficult and expensive, and the City relies on a third-party service provider which is costly[3]. To sum it up, the existing traffic communications system is functionally obsolete and costly. As the City continues to experience rapid growth and development it is critical to plan for new technology that will promote efficient management and operations in the modern traffic environment.

E2 Purpose, Goals and Objectives

The purpose of the Master Plan is to create a detailed inventory of the City's communications systems and to guide the City's future traffic signal communications and ITS technology improvements. An intelligent traffic signal communications system is beneficial in many ways and promotes goals including: increased roadway safety, shortened commute times, travel reliability, reduced greenhouse gasses, economic and sustainable growth, and increased mobility at signalized intersections for all modes of travel including motorists, bicyclists, pedestrians, transit, and emergency vehicles.



The traffic signal communications system is essential for Chula Vista to provide a proactive approach to traffic management and all around better service to the traveling public. The Master Plan provides a framework to strategically achieve the following primary objectives:

- Develop system topology and network architecture for a future-proof city-owned communication platform concept.
- Leverage existing communications infrastructure investments to support new systems and technologies.
- Establish solutions for existing system deficiencies.
- Eliminate 3rd party service for traffic signal communications.
- Identify current and future traffic system needs and leverage new technology to meet the needs.
- Incorporate recommendations into other City planning and development projects.
- Support other City departments communication system needs.
- Identify connections to City initiatives including Smart City and Climate Action that will benefit from the Master Plan.
- Identify potential partnerships with regional public agencies and private entities to advance master plan implementation.
- Establish consistent ITS infrastructure improvements through the various capital improvement channels.
- Develop an implementation prioritization and phasing strategy.
- Estimate order of magnitude costs, assess resources, and system benefits.

E3 Key Recommendations

Key communications systems and ITS element recommendations identified in the Master Plan are summarized below and in the following section.

- The City of Chula Vista future traffic signal communication system network will be based on Ethernet protocol.
- The future network will combine multiple communications medium such as single mode fiber, existing copper plant, point-to-multipoint wireless, and cellular.

- The future “CORE” network will use Layer 3 nodes connecting to each other via single mode fiber links.

E4 Implementation Phasing

The highest priorities include establishing a City-owned traffic signal communication system and implementing Ethernet-compatible systems/network. Existing investments in communication infrastructure, underground systems, signal interconnect cable, and traffic signal cabinets will continue to be utilized. Obsolete legacy network equipment will be upgraded or decommissioned and replaced with new modern communication technologies. The timeframe for each phase of implementation is based on available funding and could be accelerated as additional funds are made available.

Phase 1: City-Owned Infrastructure (Year 1-3)

Phase 1 of the implementation plan includes providing a wholly City-owned traffic signal communication network, converting from Serial to an all Ethernet-based network, upgrading traffic signal controllers to Ethernet protocol, and establishing video monitoring at the City’s highest priority locations. The following summarizes the Phase 1 traffic signal communications network upgrades:

- Upgrade existing fiber optic system to Ethernet communications.
- Convert leased copper lines to City-owned wireless Ethernet radio communications.
- Upgrade City-owned copper lines to Ethernet-over-copper communications.
- Install City-owned wireless Ethernet radio communications at all offline traffic signals.
- Convert leased cellular network for existing Traffic Measurement Devices to City-owned wireless Ethernet radio communications.
- Install video monitoring devices at high priority locations.
- Install fixed Dynamic Message Signs at the Chula Vista Amphitheater.
- Obtain 2 portable Dynamic Message Signs for use during planned or unforeseen major traffic impacting events.
- Install a satellite Traffic Management Center at the City’s Traffic Operations Maintenance Facility.
- Upgrade all traffic signal equipment to Ethernet-enabled devices Citywide.
- Implement Layer 3 communication hubs at strategic locations.

Phase 2: Infrastructure and Priority Corridors Upgrade (Year 4-6)

Phase 2 of the Implementation Plan prioritizes fiber optic communications. Strategic signalized intersections along priority corridors throughout the City will be upgraded to include type 2070 ATC traffic signal controllers and closed circuit televisions (CCTV) cameras for remote video monitoring. The following summarizes the Phase 2 traffic signal communications network upgrades:

- Upgrade existing empty communications conduit and install fiber optic cable.

- Install conduit and fiber optic cable to resolve communications gaps in the network and create redundant ring topology.
- Upgrade traffic signal equipment on primary fiber optic ring route with fiber devices.
- Upgrade traffic signal equipment on priority corridors with new 2070 controllers and CCTV cameras.

Phase 3: Citywide Buildout (Year 7-10)

Buildout of the traffic signal communications network will be completed in Phase 3. Remaining signalized intersections will be upgraded with type 2070 ATC traffic signal controllers and closed-circuit television (CCTV) cameras for remote video monitoring.

E5 Order of Magnitude Cost Estimate

A summary of the costs for the deployment of the Master Plan, broken down by the implementation phase, is shown on **Table ES-1**.

Table ES-0-1 Citywide Master Plan Deployment Cost Estimate

PHASE	DESCRIPTION	TOTAL
1	City-Owned Infrastructure	$4,794,750
2	Infrastructure and Priority Corridor Upgrades	$7,092,075
3	Citywide Buildout	$3,949,500
	GRAND TOTAL	**$15,836,325**

Note: Each phase will be implemented in stages as funding becomes available.

The order of magnitude cost estimate for the Master Plan implementation is $15,836,325.

E6 Cost and Benefit Analysis

The annual benefit-cost ratio for implementing Phase 1 is 65:1. This indicates that improvements would yield benefits of $65 for every dollar spent. With cost savings exceeding the State and National benefit-cost ratio range of 20 to 60:1 return on investment (ROI) for Phase 1 alone, the monetary investments identified in the Master Plan are poised to be recaptured many times over for both economic and social benefit.

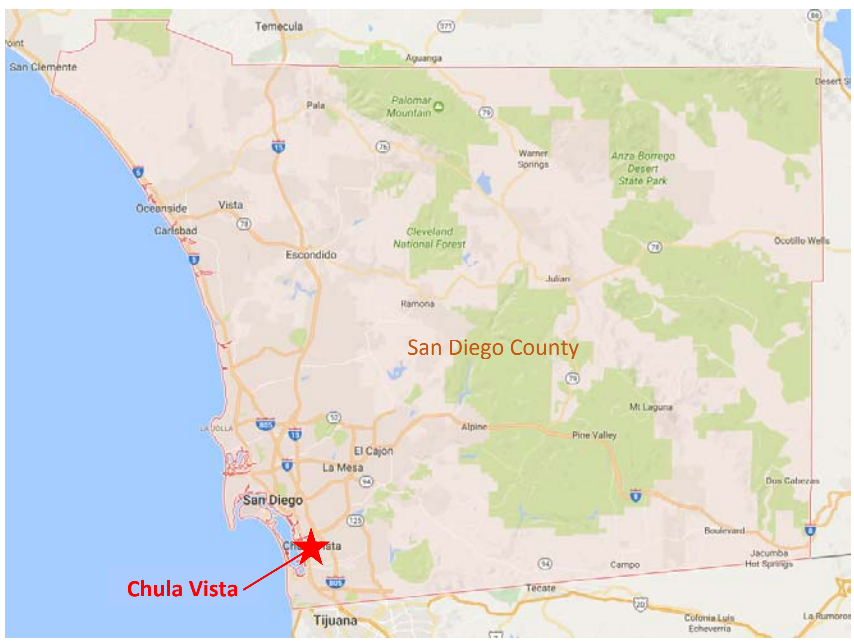
1 Introduction

The City of Chula Vista Traffic Signal Communications Master Plan establishes the planning framework for implementing state-of-the-art communications technology and Intelligent Transportation Systems (ITS) elements to meet the City's immediate and long-term traffic system needs. The City has placed great emphasis on immediate and long-range planning in its continued effort to strike a balance between quality of life and growth. The Master Plan is a central element to the City's overall planning framework and establishes a proactive approach to better serve the public through state-of-the-art traffic systems technology.

The Master Plan was initiated to address two overarching needs: (1) the immediate need to replace the existing obsolete systems that inhibit staff's ability to efficiently manage the traffic signal system and (2) address the long term need to establish a future-proof platform that supports growth and enables the City to implement and utilize future transportation systems technology. The Master Plan provides concepts, assessments, and illustrations in one comprehensive guiding document for staff's use in preparing the future City traffic signal communication system and ITS infrastructure.

1.1 City Setting

The City of Chula Vista has a population of over 260,000 people[1], covers an area of 52.1 square miles[2], is the 2nd largest City in San Diego County[3], and is the 14th largest City in the State of California[4]. Chula Vista is also the fastest growing City in the San Diego Region with large areas of planned development. To give the City's growth context, the City's General Plan anticipates a population of over 300,000 residents by 2030, and an additional 100 new traffic signals.



1.2 City Initiatives

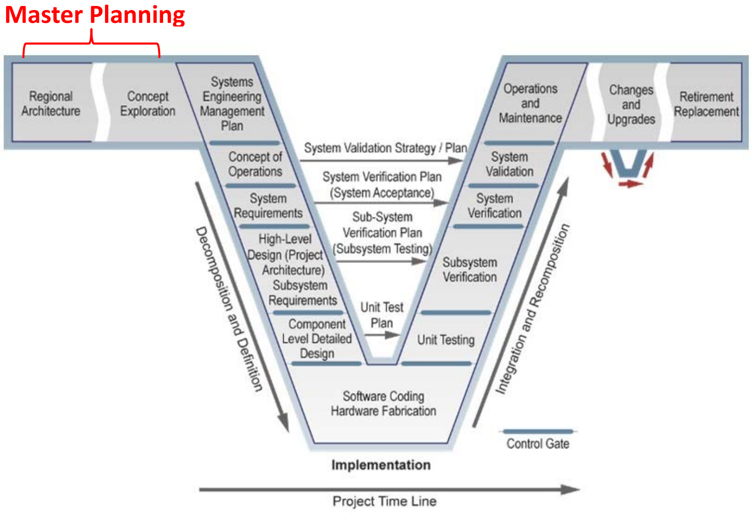
The City promotes the orderly management of growth in a manner that maintains a balance between quality of life, the environment and economic stability by applying the General Plan and related supporting plans. The City is a recognized leader in conservation and renewable energy implementing policies that have led Chula Vista to become a smarter city, with development practices now delivering many Smart City initiatives. A sample of Chula Vista's Smart City initiatives include:

- The **Bayfront Smart City** which brings the latest in infrastructure technology for maximum energy efficiency and sustainability outcomes to the largest waterfront development on the West Coast[5].
- One of the densest networks of **Electric Vehicle (EV)** charging stations in the Country[6].
- Constructed and opened a new state-of-the-art **Traffic Management Center** and **Traffic Signal Communication Center** in January 2017.
- Implementation of a new state-of-the-art **Adaptive Traffic Control System** (ATCS).
- The **ACT Chula Vista** citizen web portal connecting citizens with each other and City services creating a web-based connected community platform[7].
- Competed for the USDOT's Smart City Challenge in 2016 which became the impetus for Chula Vista being selected as an "Autonomous Vehicle Proving Ground" in January 2017 – one of ten sites chosen by the USDOT to collaborate and test the practicality of autonomous cars on public roads.
- Received the 2014 EPA Center for Corporate Leadership, Climate Leadership Award for exemplary climate actions.

The Master Plan connects into and supports many existing forward reaching initiatives in the City's planning structure including:

- City of Chula Vista General Plan.
- Chula Vista Bayfront Master Plan.
- City of Chula Vista Climate Action Plan.
- City of Chula Vista Clean Transportation Energy Roadmap.
- City of Chula Vista Strategic Plan.
- City of Chula Vista City Operations Sustainability Plan.
- City of Chula Vista Growth Management Program.
- City of Chula Vista Neighborhood Traffic and Pedestrian Safety Program.
- City of Chula Vista Pedestrian Master Plan.
- City of Chula Vista Bikeway Master Plan.

1.3 Consistency with Regional, State, and National Architectures and Plans



The "V" Diagram is the standard way to represent the systems engineering process for ITS projects. Following this process reduces risk, controls cost and schedule, improves quality, and results in a system that meets the user needs[8].

The Master Plan is the earliest planning stage (pre-design) of the systems engineering process and presents high-level concepts and architecture and supports initial needs identification. The Master Plan lays the groundwork for capital improvement programming, prioritization, and budgeting for future identified projects through subsequent parts of the systems engineering process.

1.3.1 San Diego Region Intelligent Transportation Systems (ITS) Strategic Plan

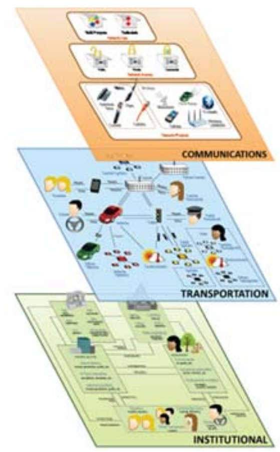
The San Diego Region ITS Strategic Plan provides a unified vision for regional ITS investment strategies that regional transportation agencies prioritized for funding and implementation[9]. The ITS Strategic Plan provides policy guidance and articulates the common vision for the employment of ITS technologies to improve mobility, safety, efficiency, and reliability throughout the region and is a supporting document to **San Diego Forward** (The Regional Plan) and the **SANDAG 2050 Regional Transportation Plan (RTP)**[10]. The Master Plan will advance the regional goals to the next level in Chula Vista by identifying specific ITS technologies, deployment strategies, and the resources required.

1.3.2 California Strategic Highway Safety Plan (SHSP)

STRATEGIC HIGHWAY SAFETY PLAN SHSP Create a Culture of Safety in California

The California Strategic Highway Safety Plan (SHSP) identifies signal timing and ITS tools as appropriate safety countermeasures for intersection crashes[11]. The **California Local Roadway Safety Manual** also identifies improved signal timing, coordination, and operation as a safety benefit to address locations that have a crash history at multiple signalized intersections[12]. The Master Plan recommends systems necessary for implementing traffic signal control strategies, including coordinated traffic signal operations. This will maximize throughput, minimize stops and reduce delay on roadways. In turn, there will be fewer intersection red-light violations, a reduction in aggressive driver behavior, and a decrease in intersection crashes.

1.3.3 National ITS Architecture



The National ITS Architecture provides a common framework for planning, defining, and integrating ITS. It is a mature architecture that reflects the contributions of a broad cross-section of the ITS community (e.g., transportation practitioners, systems engineers, system developers, technology specialists). It is comprised of three primary layers: communications, transportation, and institutional which set the building block for ITS development[13].

The Master Plan addresses the communication layer of the National Architecture. Communications systems are the wireline and wireless systems and equipment that provide paths and connections to transmit information. The City relies on the communications system to support management and operation of the many functional aspects of the City's transportation system.

1.4 Purpose and Goals

The purpose of the Master Plan is to guide the replacement of existing obsolete systems that inhibit staff's ability to efficiently manage the traffic signal system and to establish a platform for the City to implement and utilize future transportation systems technology. The plan represents a significant opportunity for the City of Chula Vista to advance traffic signal communications systems and supporting elements to the technological forefront. An intelligent traffic signal communication system is beneficial in many ways and promotes: increased roadway safety, shortened commute times, travel reliability, reduced greenhouse gasses, and economic and sustainable growth. The Master Plan will open doors to opportunities including: access to grant funding, coordination with various projects and developments, cost savings on leased communications for numerous City needs, providing a future proof platform, and advancing related Smart City and Climate Action initiatives. The Master Plan ultimately improves mobility through robust communications and enhanced traffic signal management and operations for all modes of transportation including motorists, bicyclists, pedestrians, transit, and emergency vehicles.

1.5 Objectives

The traffic signal communication system is essential for Chula Vista to provide a proactive approach to traffic management and all around better service to the traveling public. The plan provides a framework to strategically achieve the following primary objectives:

- Develop system topology and network architecture for a future-proof city-owned communication platform concept.
- Leverage existing communications infrastructure investments to support new systems and technologies.
- Establish resolutions for existing system deficiencies.

- Eliminate 3rd party service for traffic signal communications.
- Identify current and future traffic system needs and leverage new technology to meet the needs.
- Incorporate recommendations into other City planning and development projects.
- Support other City departments communication system needs.
- Identify connections to City initiatives including Smart City and Climate Action that will benefit from the Master Plan.
- Identify potential partnerships with regional public agencies and private entities to advance master plan implementation.
- Establish consistent ITS infrastructure improvements through the various capital improvement channels.
- Develop an implementation prioritization and phasing strategy.
- Estimate order of magnitude costs, assess resources, and system benefits.

1.6 Document Organization

The remainder of this document is organized into three sections as described below:

Existing Systems Assessment

Presents the extensive research and corresponding inventories completed for existing traffic systems throughout the City including: communications systems, central systems, field elements and traffic operations, and staff organization. The results of the existing systems assessment are presented on system architecture maps and schematics in the Appendix.

Needs Assessment

This section is divided into two primary subsections: existing system deficiencies and future roadway network needs. The existing system deficiencies and needs build on the existing systems assessment. The City's future transportation network plans are also presented to identify where the traffic signal communications infrastructure will be required. The results of the existing deficiency and future transportation network research are summarized on figures and maps included in the section.

Future System Architecture and ITS Elements

This section presents the network and ITS elements, standardization, topology, physical and logical requirements to achieve the future communication system concept. Several architecture examples are provided to demonstrate system connectivity and resiliency. This section also presents the communication system relation to Chula Vista Smart City transportation initiatives. A schematic detailing the future traffic system communications architecture concept is provided in the Appendix.

Implementation Phasing and Cost-Benefit Analysis

Presents a strategic implementation phasing plan that includes deployment prioritization and phasing. Order of magnitude cost estimates for technical solutions to communications deficiencies are presented for each phase, and the phased future traffic signal communication map concept is provided. This section also presents an analysis of the costs and benefits associated with implementation of the Master Plan recommendations by deployment phases. The timeframe for each implementation phase is dependent on available funding and is subject to acceleration as additional funds are made available.

2 Existing Systems Assessment

The basis for planning the concept of the future communication system architecture is laid upon the foundation of the existing traffic signal and communication system infrastructure. This section documents the results of extensive research and inventories of the City's existing traffic systems including: communications, central systems, field elements, operations, and staff. Several sources of information were utilized to obtain information including:

- Geographic Information Systems (GIS).
- Laser fiche as-built records.
- Accounting systems.
- QuicNet and SCATS systems.
- Field reviews.
- Interviews with city staff.

Documentation was obtained from various city departments including: Public Works/Engineering, GIS, Information Technology (IT), Development Services, and Planning. Shapefiles with attribute tables detailing the number and location for existing traffic signals, conduit, and wireless towers was provided by the City's Geographic Information Services (GIS) Department. A digital library comprising 910 researched plans and documents of the City's traffic systems was created. The various information sources were compared and verified with City traffic signal maintenance staff to produce an accurate map of existing traffic systems Citywide. At the time of this report, 267 traffic signals are owned and operated by the City of Chula Vista.

A Geographical Information System (GIS) database and map of the existing systems infrastructure was created and is provided in **Appendix A** and a schematic detailing the existing traffic system communications architecture is provided in **Appendix B**. Detailed review information is presented throughout the remainder of this section.

2.1 Traffic Communications Systems

The City of Chula Vista's traffic communications system is extensive, connecting all the existing traffic signals and traffic data collection systems in the City, and is comprised of numerous media and network devices. Traffic communication system documentation was researched to determine location and status of:

- Single-mode fiber optic network.
- Third-party owned leased line wire based analog network.
- City-owned copper wire based analog network.
- Serial wireless radio communications network.

The communications system includes a combination of twisted pair copper wired based media, fiber optic cable media, and Serial digital wireless radios. Third-party owned and serviced Plain Old Telephone Service (POTS) leased lines provide the primary communication links between traffic systems and the City's existing Traffic Signal Communication Center (TSCC) located at City Hall. The following subsections provide summaries of the existing traffic communications systems and network architecture.

2.1.1 Single-mode Fiber Optic Network

Single-mode fiber optic cable provides communications between the TSCC and 25 traffic signals located along Fourth Avenue, H Street, and Main Street. Fiber strand counts are summarized in **Table 2-1**.

Table 2-1 Existing Single-mode Fiber Optic Strand Counts

STREET	(NORTH/EAST) LIMIT	(SOUTH/WEST) LIMIT	CABLE
Fourth Avenue	(N) Brisbane Street	(S) Main Street	288-strand SMFOC
Main Street	(E) Main Street	(W) Broadway	288-strand SMFOC
Davidson Street	(E) Fourth Avenue	(W) Guava Avenue	288-strand SMFOC
H Street	(E) Hidden Vista Drive	(W) Fourth Avenue	36-strand SMFOC

2.1.2 Leased Line and City-Owned Copper Wire Based Analog Network

Accounting systems that contained information on the City's third-party owned leased line communications for various traffic systems throughout Chula Vista were researched. Billing information identified circuit numbers that corresponded with the City's TSCC and the individual traffic system telephone drop locations. The location information was cross-checked and verified with the System Control Number (SCN) address reference table provided by the City's traffic signal maintenance department and the traffic signal controller list generated by the City's QuicNet 4+ central traffic management system. Billing statements indicate approximately $75,000 is spent annually on leased line communications[1].

Nearly 90% of the City's 267 traffic signals communicate with the TSCC through a third-party owned POTS leased line network. The existing AT&T lease line telephone drops provide communication links between the TSCC and individual traffic signals or groups of traffic signals, interconnected by the City-owned copper wire based analog multi-drop network.

The original leased lines were first installed approximately 30 years ago by Pacific Bell Telephone Company (PacBell) in the western portion of the City. As the City continued to develop, City-owned twisted pair copper interconnect was installed intermittently with developments and capital improvements. The western portion of Chula Vista, between the I-5 and I-805, is the oldest part of the City and contains a minimal amount of City-owned twisted pair interconnect. The areas east of I-805 are newer and contain more City-owned twisted pair interconnect. All the existing copper wire based interconnect links operate on legacy Serial 1,200 bps analog modems and lack direct connections to the City's TSCC, and thus require utilization of leased line telephone drop communications. The existing network is obsolete and is incapable of supporting modern ITS technologies.

2.1.3 Serial Wireless Radio Communications

Several traffic signal locations in the City utilize Serial wireless radios for communications due to a lack of copper wire or fiber infrastructure to provide direct connection to the TSCC. Wireless radio communication is 900 MHZ Serial (EIA-232) digital, low bandwidth. Existing wireless radio interconnect locations are summarized in **Table 2-2**.

Table 2-2 Existing Serial Wireless Radio Interconnect Locations

STREET	(NORTH/EAST) LIMIT	(SOUTH/WEST) LIMIT
Third Avenue	(N) Moss Street	(S) Naples Street
Fourth Avenue	(N) Anita Street	(S) Montgomery School Crossing
Quintard Street	(E) Second Avenue	(W) Third Avenue
Hilltop Drive	(N) Naples Street	(S) Oxford Street

2.1.4 Cell Towers

There are City-owned and privately-owned cell towers located throughout the City. The number and location were determined from shapefiles provided by the City's GIS Department. The cell towers are not currently used for traffic-related systems.

2.2 Central Systems

The City's central systems are housed in City Hall and include:

- Traffic Signal Communication Center (TSCC)
- Traffic Management Center (TMC)
- QuicNet 4+ Regional Arterial Management System (RAMS)
- Sydney Coordinated Adaptive Traffic System (SCATS)

As-built documentation was unavailable for several of the traffic systems housed within the City's existing TSCC. Limited existing documentation was supplemented with on-site investigations.

2.2.1 Traffic Signal Communications Center and Traffic Management Center

The TSCC was constructed with City Hall in 2004 and quickly became a dual-purpose data center and Traffic Management Center (TMC). At 9 feet by 17 feet, the TSCC was not designed to be used as a TMC and over time, the room became congested and disorganized as new equipment and systems were installed[2]. TSCC equipment includes:

- AT&T telephone service lines termination panel with multiple demarcation points.
- 288-strand single-mode fiber optic cable line.

- Splice enclosure rack mount.
- Traffic signal test cabinet.
- Two equipment racks housing analog modems.
- Two Digi 16-port Serial communications servers.
- QuicNet 4+ Server
- SCATS Server
- Battery back-up system.
- Cisco 10 Base-T/100 Base-Tx Ethernet switch.
- Type I enclosure breaker panel serving the existing TSCC room, IT room, and new TMC room.

The City executed a design-build contract with STC Traffic to remodel the TSCC into a distinct data center and build a new TMC. The project was completed in early 2017. **Figures 2-1** and **2-2** below show the TSCC and TMC before and after construction.

Figure 2-1 TSCC Before and After

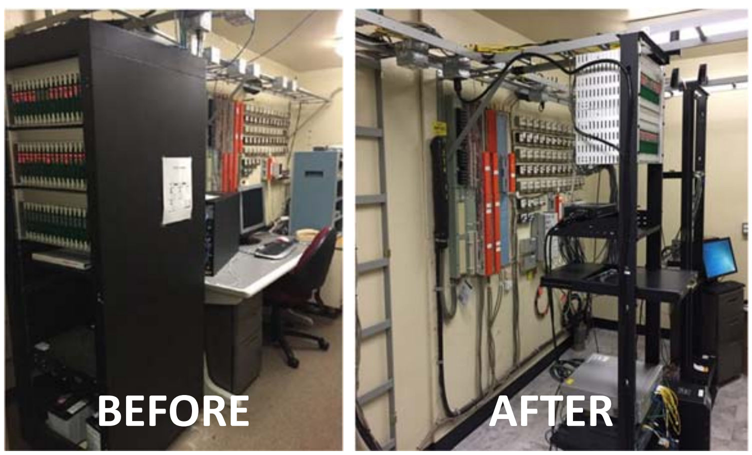
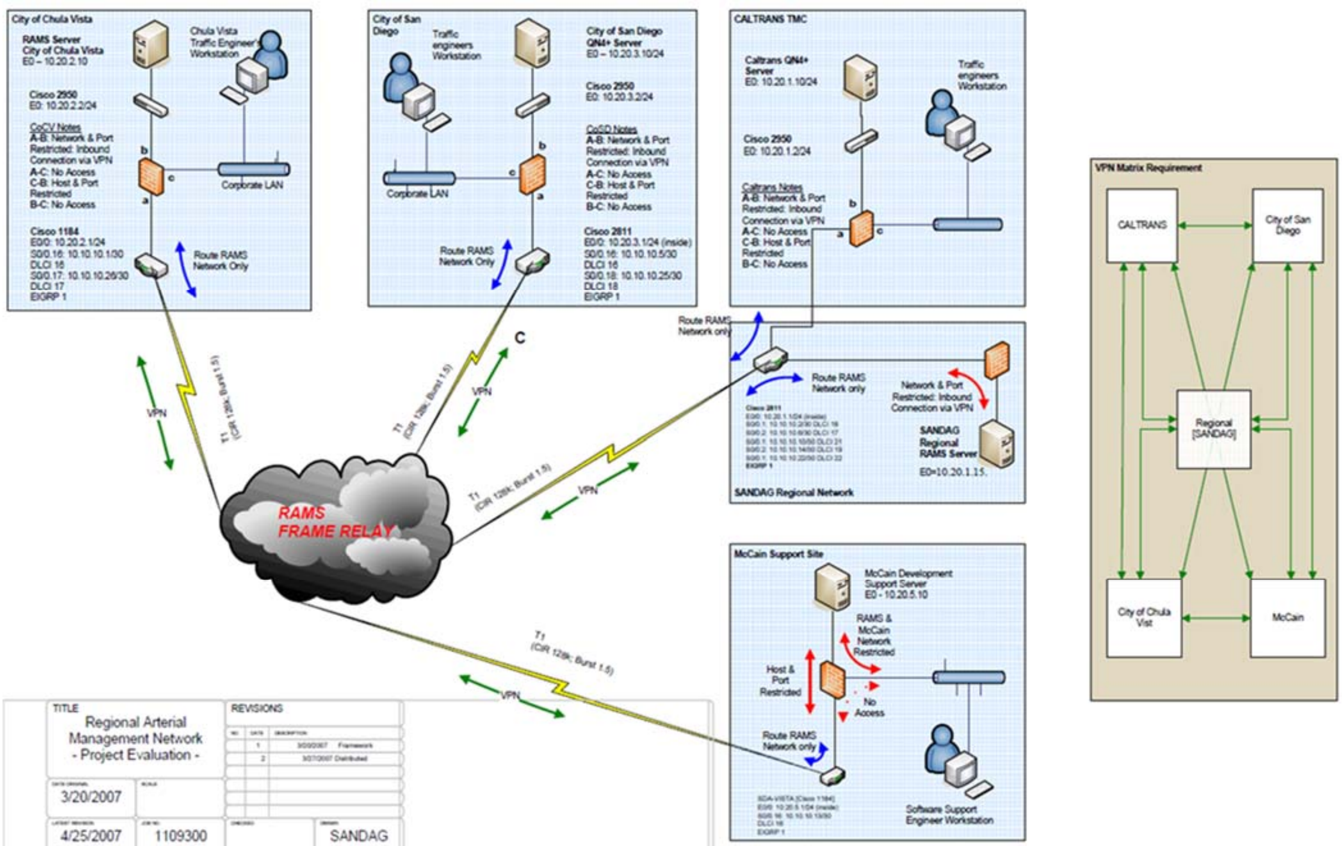


Figure 2-2 TMC Before and After

2.2.2 Central Traffic Management System

The City utilizes the QuicNet 4+ Regional Arterial Management Systems (RAMS) central control software for traffic management. Implemented in 2006, RAMS enables sharing of traffic signal operation information across jurisdictions in San Diego County through the QuicNet 4+ software application. Communications between agencies is accomplished over a T1 leased line and connectivity for the City is illustrated in **Figure 2-3**. The RAMS systems are currently being upgraded to Transparity as part of the system maintenance program. A new fiber optic line has been installed at the City's TMC and communications will be 2 Mbps Ethernet over fiber when Transparity is active.

Figure 2-3 RAMS Network

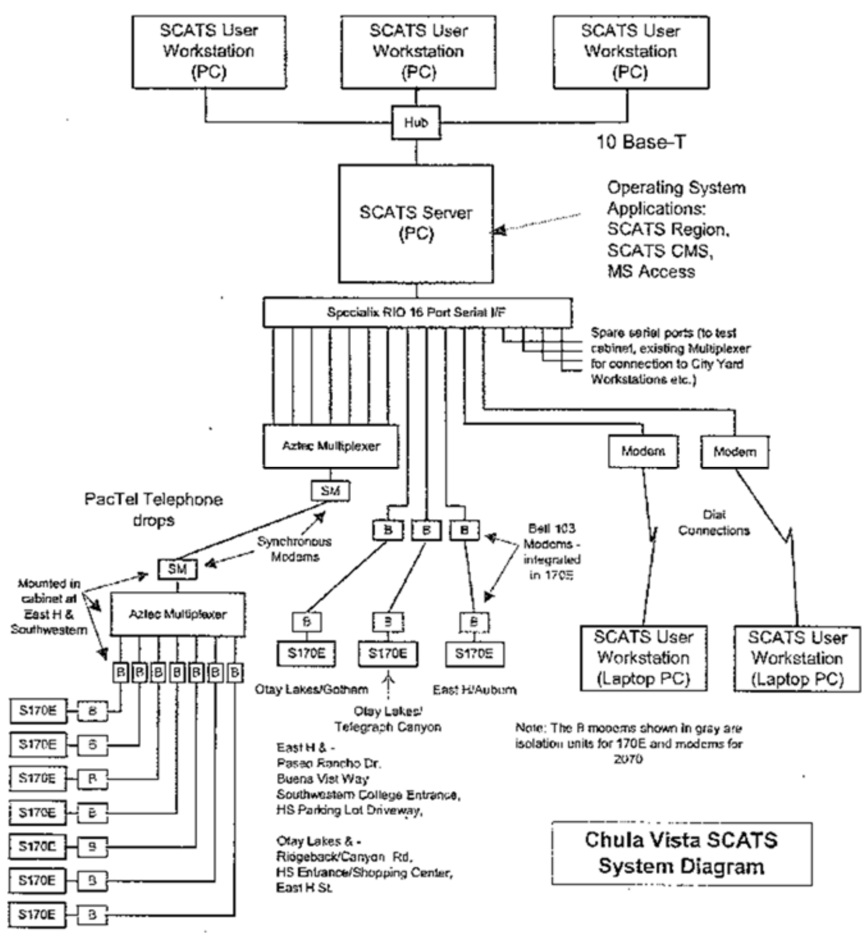


2.2.3 Adaptive Signal Control

The City of Chula Vista installed the Sydney Coordinated Adaptive Traffic System (SCATS) in May 2003. The system objectives include selecting cycle lengths, splits, and offsets to minimize stops during light demand, minimize delays during normal demand, and maximize throughput during heavy demand. The SCATS system includes twelve intersections along portions of East H Street and Otay Lakes Road[3]. The system runs on a dedicated server located in the TSCC. The server and user workstation are connected via a hub and 10/100 Base-T LAN. A 16-channel Serial interface unit communicates with the intersections through data multiplexers and three low speed modems. Seven low speed channels from the 16-port Serial interface connect to the multiplexer located at Chula Vista City Hall. A composite signal from this multiplexer connects to a modem configured for 2400 bps synchronous operation. The voice frequency side of the modem connects with a changeover switch to the telephone drop cabinet third-party lease line at the East H Street and Southwestern College Entrance intersection and provides a composite signal to a multiplexer. The multiplexer decodes the seven low speed intersection signals and connects to the intersection modems and a changeover switches the communications line connections to the configuration required for SCATS[4].

Field elements include 2070 controllers with TransCore software and the modem and multiplexer equipment. System elements in the TSCC include a Windows NT operating system based PC server, SCATS intersection control software version 5, Serial interface hardware and software, modem and multiplexer equipment, an equipment rack, and a user work station. The SCATS network is shown in **Figure 2-4**. The SCATS system is no longer operational due to the SCATS server failure and a replacement adaptive traffic signal control system is currently being deployed.

Figure 2-4 SCATS Network



2.3 Field Elements and Traffic Operations

The ITS communication and central systems previously described are utilized to manage and operate various connected devices in the field. These include traffic signal cabinets and controllers that operate timing and coordination, emergency vehicle preemption systems, grade crossing preemption, transit signal priority, and data acquisition systems.

2.3.1 Cabinets and Controllers

The most common signal cabinet and current standard installation in the City is the type 332 controller cabinet. Most of the traffic signal controllers in Chula Vista are type 170 or Type 170E running 233 intersection control programs. As previously described in Section 2.2.3 there are 12 traffic signals that have custom-built 2070 controllers that run SCATS intersection control software version 5.

2.3.2 Traffic Signal Timing and Coordination

Many traffic signals throughout the City run Time of Day (TOD) plans with coordination patterns typically scheduled during the morning, midday, and evening peak periods along arterials and secondary roadways. **Table 2-3** contains a list of the 22 coordinated corridors in the City. The corridors are illustrated geographically on **Figure 2-5**.

Table 2-3 Existing Coordinated Corridors

STREET	(NORTH/EAST) LIMIT	(SOUTH/WEST) LIMIT
Bonita Road	(E) Billy Casper Way	(W) Willow Street
Broadway	(N) C Street	(S) H Street
Broadway	(N) H Street	(S) Palomar Street
E Street	(E) Bonita Road	(W) Woodlawn Avenue
East H Street	(E) Otay Lakes Road	(W) Hidden Vista Drive
Fifth Avenue	(N) F Street	(S) G Street
Fourth Avenue	(N) Brisbane St	(S) Main Street
H Street	(E) Hilltop Dr	(W) Broadway
Hilltop Drive	(N) I Street	(S) J Street
L Street	(E) Nacion Avenue	Broadway
Main Street	(E) I-805	(W) Industrial Blvd
Main Street	(E) Nirvana Avenue	(W) I-805
Olympic Parkway	(E) Eastlake Parkway	(W) Heritage Road
Orange Avenue	(E) Max Avenue	(W) Fourth Avenue
Orange Avenue/Olympic Parkway	(E) Brandywine Avenue	(W) Melrose Avenue
Otay Lakes Road	(E) Lane Avenue	(W) La Media Road
Otay Lakes Road	(N) Bonita Vista High School Drwy	(S) East H Street

STREET	(NORTH/EAST) LIMIT	(SOUTH/WEST) LIMIT
Otay Lakes Road	(N) East H Street	(S) Telegraph Canyon Road
Palomar Street	(E) Orange Avenue	(W) Industrial Boulevard
Palomar Street	(E) Hilltop Drive	(W) Fourth Avenue
Telegraph Canyon Road	(E) Otay Lakes Road	(W) Canyon Plaza Driveway
Third Avenue	(N) H Street	(S) Main Street

2.3.3 Grade Crossing Preemption

The Blue Line Trolley route, operated by the San Diego Metropolitan Transit System (MTS) has 3 station stops in Chula Vista: Bayfront/ E Street, H Street, and Palomar Street. The Blue Line runs parallel to Industrial Blvd and there are 7 preempted traffic signals. The grade crossing preemption systems were recently upgraded to operate advance preemption and supervisory circuits. This preemption operation is more complex than traditional preemption operation and requires more complex controller programming and railroad to traffic signal interconnect.

2.3.4 Transit Signal Priority

The South Bay *Rapid* project includes a 21-mile bus route that will run between the Otay Mesa Port of Entry and Downtown San Diego via National City and eastern Chula Vista. Eight stations in eastern Chula Vista and Otay Mesa, a Direct Access Ramp (DAR) on East Palomar Street at I-805, and a nearly six-mile dedicated transit lane in the median of East Palomar Street and along Eastlake Parkway are planned along the route. All phases of the South Bay *Rapid* project are currently in construction including 12 of the 15 total stations, arterial transit-only lanes on East Palomar Street, Transit Signal Priority (TSP), and enhanced customer amenities[5].

2.3.5 Emergency Vehicle Preemption

Emergency Vehicle Preemption (EVP) technology overrides typical traffic signal operations to provide priority for approaching emergency responder vehicles including firetrucks and ambulances. The typical emergency vehicle preemption build throughout Chula Vista includes an infrared-based system with varying models of Opticom phase selectors and infrared system emitters and detectors. Preemption devices throughout the City are typically older and range in age from 5 years to 15 years old.

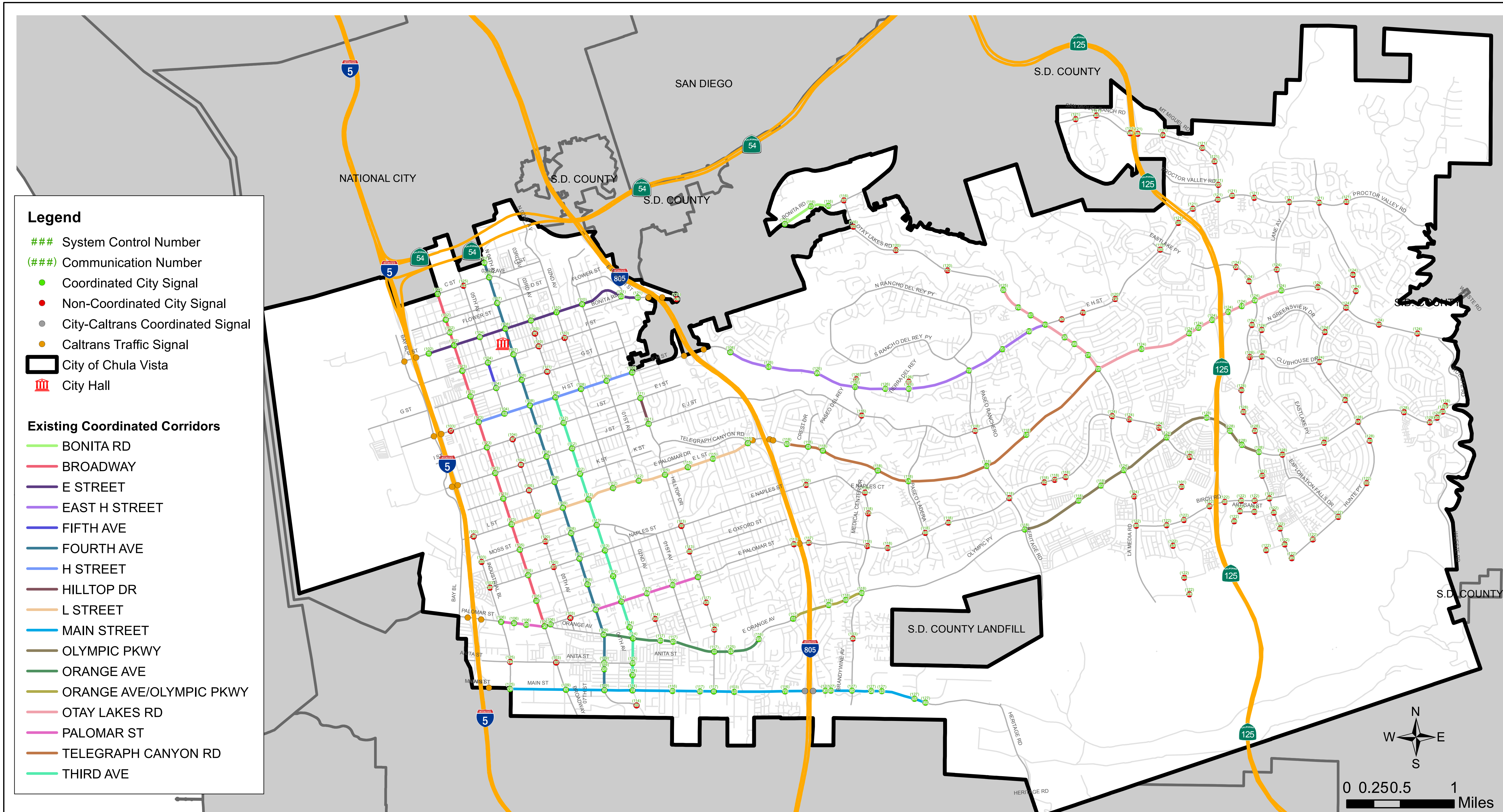


Figure 2-5 Existing Coordinated Corridors

2.3.6 Data Acquisition Systems

Traffic operations are monitored by City staff regularly and assessed annually by the City's Growth Management Oversight Commission (GMOC). Data acquisition systems including a small number of Traffic Measurement Devices and are utilized to provide real-time and historical traffic data. Accurate data is imperative to analyzing operational efficiencies and ensuring traffic threshold standards are met.

2.3.6.1 Traffic Measurement Devices

The City of Chula Vista's Growth Management Program seeks to maintain quality of life by monitoring threshold standards for various public facilities and service through the City's Traffic Monitoring Program (TMP). Traffic thresholds are monitored for Arterial Level of Service (ALOS) and Urban Street Level of Service (ULOS) standards. To acquire necessary traffic data for monitoring and assessment purposes, traffic measurement devices including volume data collection and speed monitoring systems are located throughout Chula Vista. Remote Traffic Microwave Sensors (RTMS) are located at 28 permanent count stations Citywide. 18 in-pavement wireless Sensys detectors are located along Olympic Parkway, East H Street, and Telegraph Canyon Road for arterial travel time (ATT) volume, occupancy, and speed (VOS) data and bicycle activity. **Table 2-4** below summarizes traffic measurement device locations by type. Communications to the City's TSCC is accomplished through a third-party owned cellular network using older 2G technology and data is hosted by an outside party server. Maintenance and operation of the system is increasingly expensive and expansion is cost prohibitive. The system is becoming obsolete and more modern and affordable systems are available on the market.

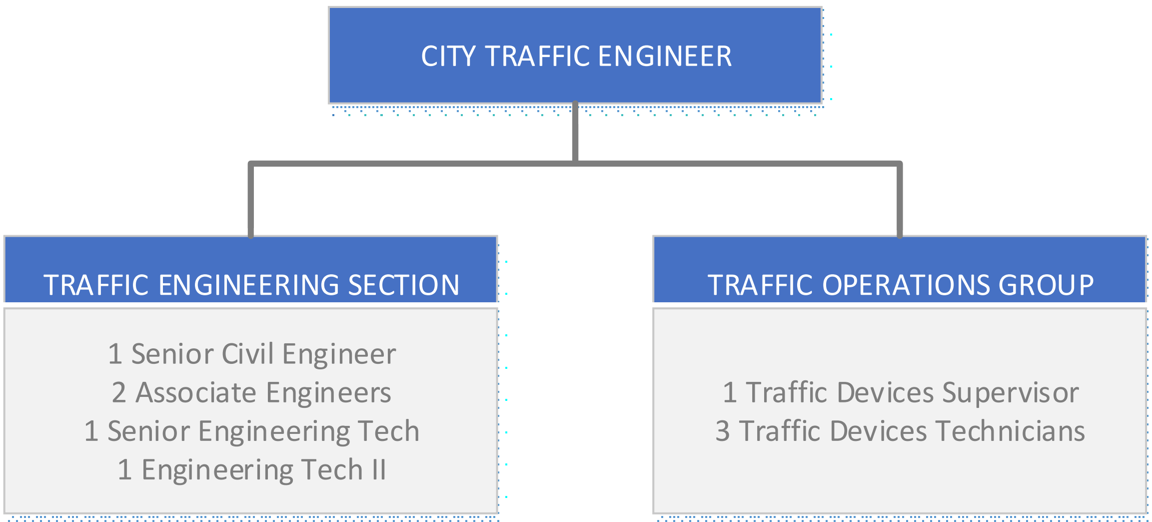
Table 2-4 Traffic Measurement Devices Location Summary

RTMS		SENSYS	
STREET	**LOCATION**	**STREET**	**LOCATION**
Birch Rd	East of Eastlake Pkwy	Birch Rd	Magdalena
Birch Rd	Between Magdalena Ave and SR 125	East H St	Paso Del Rey
Eastlake Pkwy	North of Olympic Pkwy	East H St	Del Rey Blvd
Eastlake Pkwy	Between Olympic Pkwy and Birch Rd	East H St	Terra Nova Dr
Eastlake Pkwy	South of Clubhouse	East H St	Hidden Valley
Eastlake Pkwy	Between Otay Lakes Rd and Greensgate Dr	Olympic Pkwy	Heritage Rd
Exploration Falls	South of Olympic Pkwy	Olympic Pkwy	Brandywine Ave
Hunte Pkwy	North of Otay Lakes Rd	Olympic Pkwy	Concord Wy
Hunte Pkwy	Between Otay Lakes Rd and Greesview	Olympic Pkwy	Oleander Ave
Hunte Pkwy	Between S Greesview and Olympic Pkwy	Otay Lakes Rd	Rutgers Ave
Hunte Pkwy	Between Olympic Pkwy and Evening Star	Telegraph Canyon Rd	La Medina Rd
Hunte Pkwy	East of Eastlake Pkwy	Telegraph Canyon Rd	Buena Vista
La Media Rd	Between Olympic Pkwy and Birch Rd	Telegraph Canyon Rd	Paseo Ranchero
La Media Rd	South of Olympic Pkwy	Telegraph Canyon Rd	Paseo Ladera
Lane Ave	Between Mackenzie Creek and Otay Lakes Rd	Telegraph Canyon Rd	Medical Center
Magdalena Ave	South of Birch Rd	Telegraph Canyon Rd	Paseo Del Rey
Magdalena Ave	North of Birch Rd	Telegraph Canyon Rd	Oleander
Olympic Pkwy	Between Hunte Pkwy and Olympic Vista	Telegraph Canyon Rd	Canyon Plaza Ctr
Olympic Pkwy	West of Hunte Pkwy		
Olympic Pkwy	East of La Media		
Otay Lakes Rd	Between Hunte Pkwy and Woods		
Otay Lakes Rd	Between Woods and Wueste Rd		
Otay Lakes Rd	Between Eastlake Pkwy and Lane Ave		
Otay Lakes Rd	Between Lane Ave and Hunte Pkwy		
East Palomar St	South of Olympic Pkwy		
Proctor Valley Rd	Between Duncan Ranch Rd and Agua Vista		
Winding Walk	Between Olympic Pkwy and Evening Star		
Wueste Rd	Between Otay Lakes Rd and Olympic Pkwy		

2.4 Traffic Operations Staff

The most important resource of the City traffic system are the people who manage, operate, and maintain it. Chula Vista employs staff dedicated to the operation and maintenance of the City's traffic system including the Traffic Engineering Section and Traffic Operations Group. Staffing organization is illustrated in **Figure 2-6** and discussed in the following subsections.

Figure 2-6 Traffic Systems Staff Organization Chart



2.4.1 Traffic Engineering Section

The Traffic Engineering Section is part of the City's Department of Engineering and Capital Projects. Traffic engineering and operations staff report to the City Traffic Engineer. Traffic Engineering section responsibilities include[6]:

- Development, monitoring, and implementation of traffic improvements in the City.
- Assist on all developments and review construction area traffic control plans.
- Perform field surveys of high accident and high congestion locations.
- Investigate requests from the public, City Council, City Manager, Mayor, and/or community groups for traffic improvements, and initiate remedial and corrective traffic improvements.
- Address traffic safety issues in cooperation with the Chula Vista Police Department.
- Serve as communication link between residents, City staff, and City Council via the Safety Commission.
- Involvement in the Neighborhood Traffic and Pedestrian Safety Program to improve safety for pedestrians, bicyclists, and motoring public within Chula Vista.
- Coordinate with regional agencies including SANDAG, MTS, Caltrans, and the Port of San Diego.
- Develop, monitor, and implement traffic signal timing.
- TMC operation.
- Operation and management of the traffic signal communications network.

2.4.2 Traffic Signal Maintenance Group

Traffic systems maintenance is provided by the Traffic Operations Section under the City's Engineering and Capital Projects Department. Traffic device technicians perform annual preventative maintenance and repairs on both emergency and as-needed basis for traffic signal systems and street lights throughout Chula Vista[7]. Traffic operations staff report to the City Traffic Engineer.

2.5 Communications System Topology and Architecture

The traffic systems research and documentation were documented in a Geographic Information System (GIS) database and presented graphically with a corresponding map. ESRI software ArcMap 10.2.2 was utilized and a dynamic layer set with attribute tables were created and include all inventory information researched for inclusion. Shapefiles for traffic signals, conduit, and cellular towers were provided by the City's GIS department. Existing attribute tables for the shapefiles were supplemented with information obtained from digitized improvement plans and additional City-provided documentation. **Table 2-5** summarizes the dynamic layers and inventory information. Examples of the GIS attribute tables that correspond with the dynamic layers are provided in **Figures 2-7** through **2-10**.

Table 2-5 Summary of Inventory Information for Existing Conditions Dynamic Layer Set

DYNAMIC LAYER	INVENTORY INFORMATION
Telephone Drop Traffic Signals	Intersection, SCN, Communication Number, Drop Number
Offline Telephone Drop Traffic Signals	Intersection, SCN, Communication Number, Drop Number
Adaptive Traffic Signals	Intersection, System Type
Existing Traffic Signals	Intersection, Operation, Status, SCN, Communication Number, Drop Number, Drawing Number, Signal Modification Date
Existing Caltrans Traffic Signals	Intersection
Traffic Measurement Device	Street, Location Description, Type, IP Address, Download Date, 7.4.2, AP, Repeater, Cards, TT, VOS, Bike, Controller Location, Bike Lane Designation, Bike Detection Cards, Bike Detection Sensors
City-Owned Wireless Towers	Own Status, CA SENO, Applicant, Project Type, Global ID
Private Wireless Towers	Own Status, CA SENO, Applicant, Project Type, Global ID
Existing Copper	Street, Interconnect Type, Conduit Size, As-Built Date
Existing Wireless Traffic Interconnect	Street, Intersection, Communication Type, Brand, Activity
Existing Fiber	Street, Interconnect Type, Conduit Size, As-Built Date, # of Fibers
Existing Empty Conduit	Street, Conduit Size, As-Built Date
MTS Fiber	Interconnect Type, Conduit Size
Caltrans Fiber	Interconnect Type, Conduit Size

DYNAMIC LAYER	INVENTORY INFORMATION
Port of San Diego Fiber	Interconnect Type, Conduit Size
City of San Diego Fiber	Interconnect Type, Maintenance Date

2.5.1 Existing Traffic Systems Topology

A Geographic Information System (GIS) database and map was created detailing specifics of communication systems build and location. The resulting map illustrates the topology of traffic systems in the City. Existing traffic systems conditions are mapped on **Figure 2-11** and a full size 24x36 fold out plan is provided in **Appendix A**.

2.5.2 Existing Traffic Systems Communications Architecture

The existing traffic systems communications network is based on low speed multi-drop Serial communications technology over various communications mediums and is comprised of:

- Traffic Signal Communications Center located at Chula Vista City Hall.
- Single-mode fiber optic lines based digital multi-drop network.
- City-owned copper wire based analog multi-drop network.
- Leased line analog multi-drop network.
- Serial wireless radio communications network.

The primary communications system, for approximately 90% of the traffic signals in the City of Chula Vista, is based upon 3rd party leased telephone lines. **Table 2-6** provides a summary of the traffic signals by communication type. A schematic detailing the City of Chula Vista's existing traffic systems communications architecture is provided in **Appendix B** as a full size 24x36 fold out plan.

Table 2-6 Existing Traffic Signal Communications Summary

COMMUNICATION TYPE	DESCRIPTION	# OF INTERSECTIONS
Fiber Optic Cable	Single-mode fiber optic cable • *Ring 1: IFS fiber modems* • *Ring 2: VLINK fiber modems* • *Ring 3: VLINK fiber modems*	24 *4* *14* *6*
Leased Copper Lines	Analog modems	91
City-Owned Copper Plant to Leased Copper Lines	Analog multi-drop modems SCATS adaptive traffic signals	123 12
Wireless Interconnect	Serial wireless radio connections	4
Offline	Communications Infrastructure Gap Telephone Drop Repair Needed	11 2

Figure 2-7 Existing Traffic Signals Attribute Table

Table

Traffic Signals

OBJECTID_1 *	Shape *	FID_1	INTERSECTION	STATUS	QN_COMM	SCN	Drop_
205	Point	75	HILLTOP DR&I ST	Existing	(111)	85	5
206	Point	76	THIRD AV&G ST	Existing	(111)	63	1
184	Point	52	THIRD AV&I ST	Existing	(112)	65	2
185	Point	53	THIRD AV&J ST	Existing	(112)	66	3
186	Point	54	THIRD AV&K ST	Existing	(112)	67	4
284	Point	35	SECOND AV&L ST	Existing	(112)	80	5
285	Point	36	FIRST AV&L ST	Existing	(112)	83	6
228	Point	46	THIRD AV&MOSS ST	Existing	(113)	69	2
232	Point	87	HILLTOP DR&NAPLES ST	Existing	(113)	88	5
241	Point	115	THIRD AV&NAPLES ST	Existing	(113)	70	3
246	Point	120	THIRD AV&OXFORD ST	Existing	(113)	71	4
260	Point	134	HILLTOP DR&PALOMAR ST	Existing	(113)	89	6
276	Point	259	HILLTOP DR &OXFORD ST	Existing	(113)	260	7
283	Point	34	THIRD AV&L ST	Existing	(113)	68	1
238	Point	112	FOURTH AV&BEYER WY	Existing	(114)	59	6

226 (0 out of 363 Selected)

Traffic Signals

Figure 2-8 Existing Copper Interconnect Cable Attribute Table

Table

Existing Copper

OBJECTID *	Shape *	Street	Conduit Size	Conduit Size 2	Interconnect Type	As-Built Date
7	Polyline	BROADWAY	1 1/4"		3PR 20	<Null>
8	Polyline	BROADWAY	1 1/4"		3PR 20	<Null>
13	Polyline	EAST H	2"		3PR 20	11/4/1994
14	Polyline	EAST H ST	2"		3PR 20	11/4/1994
15	Polyline	PASEO DEL REY	2"		3PR 20	11/29/1995
16	Polyline	TELEGRAPH CANYON	2"		3PR 20	3/22/2002
17	Polyline	BEYER WAY	2"		6PR20	3/12/2012
18	Polyline	MAIN ST	3"		6PR20	3/13/2012
19	Polyline	OTAY LAKES RD	2"		3PR20	<Null>
20	Polyline	E ST	2"		6PR20	2/12/2013
21	Polyline	TEELGRAPH CANYON RD	2"		3PR20	3/22/2002
22	Polyline	TELEGRAPH CANYON RD	2"		3PR20	3/22/2002
23	Polyline	3RD AV	2"		6PR20	1/28/2010
24	Polyline	3RD AV	2"		6PR20	1/28/2010
29	Polyline	MAIN ST	3"		6PR22	2/21/2004

12 (0 out of 165 Selected)

Existing Copper

Figure 2-9 Existing Fiber Optic Cable Attribute Table

Existing Fiber

OBJECTID *	Shape *	Location	Conduit Size	Interconnect Type	As Built Date	Shape_Length
1	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1336.474443
2	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1271.488334
3	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1325.463722
9	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1317.130619
10	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1323.519307
11	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1425.082032
12	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1322.547269
13	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/22/2003	636.949538
14	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1321.253985
15	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1320.949815
16	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1325.700937
17	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1324.397145
18	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1325.634529
19	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1318.784806
20	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1321.346428
21	Polyline	04TH AV	1 1/2"	FIBER 1-288 SMFO	8/21/2003	1320.717512

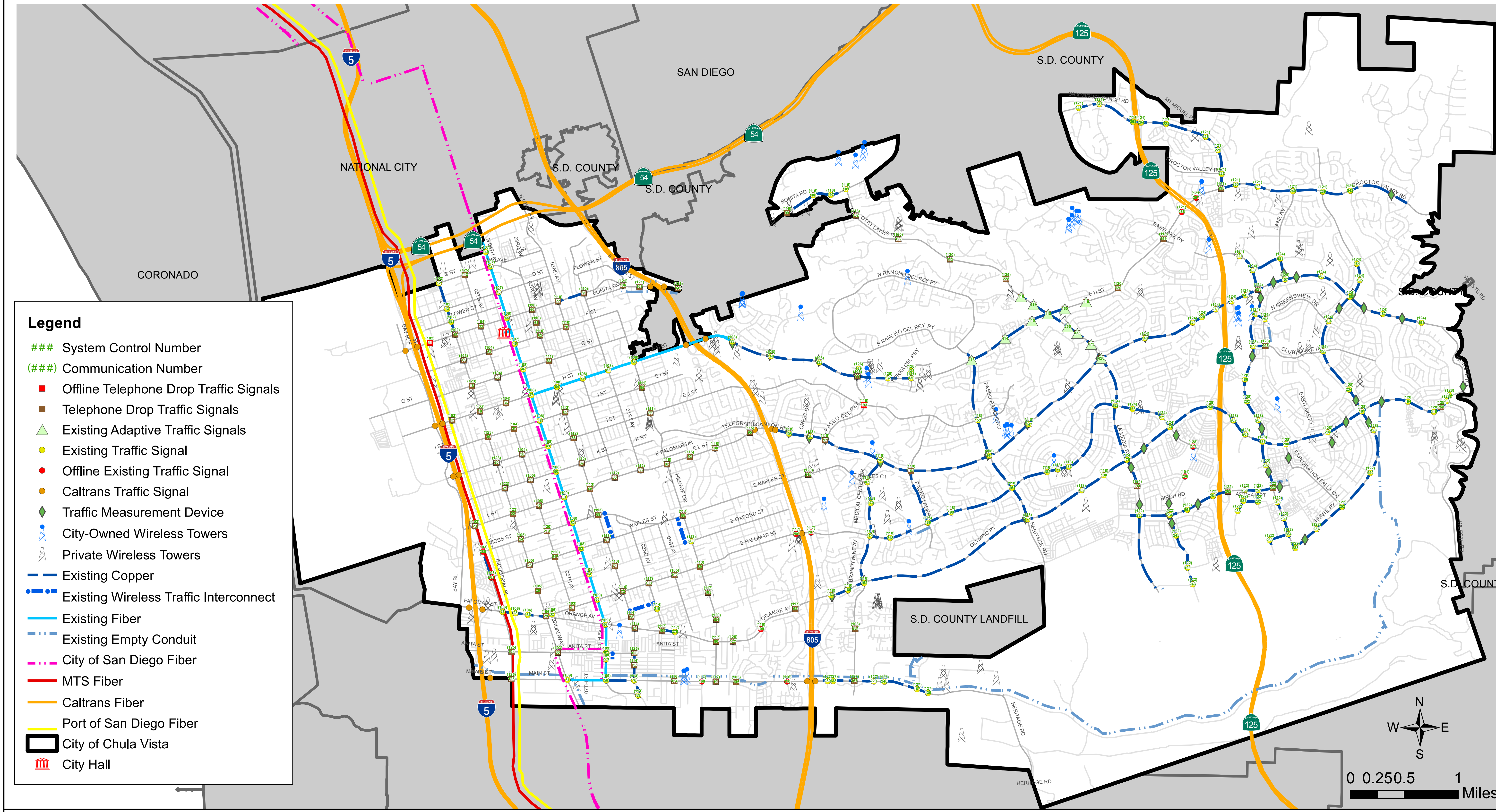
(0 out of 28 Selected)

Figure 2-10 Existing Wireless Traffic Interconnect Attribute Table

Existing Wireless Traffic Interconnect

OBJECTID *	Shape *	Street	Extent	Communication Type	Brand
1	Polyline	3rd Avenue	Moss St to Naples St	Ethernet to Serial	Iteris
2	Polyline	4th Avenue	Montgomery School Xing to Anita St	SMFO to Serial	Encom 5100
3	Polyline	Quintard St	2nd Ave to 3rd Ave	Serial	Encom 5100
4	Polyline	Hilltop Dr	Oxford St to Naples St	Serial	Encom 5200R

(0 out of 4 Selected)



CITY OF CHULA VISTA

Figure 2-11 Existing Traffic Systems Communications Network

TRAFFIC

2.5.3 Regional Communications Infrastructure

Existing communications facilities for regional agencies including the San Diego Association of Governments (SANDAG), San Diego Metropolitan Transit System (MTS), California Department of Transportation (Caltrans) District 11, and the Port of San Diego were obtained from the regional Fiber Working Group (FWG) documentation. Existing and future Port of San Diego fiber locations were researched from the Bayfront Master Plan. The Port of San Diego is currently developing a fiber master plan that will complete a fiber optic ring around the San Diego Bay area. The architecture is built based on a core ring concept that will provide high-speed network entry points for the entire area. SANDAG is upgrading the RAMS system connectivity between each agency in the region to a new fiber optic lease connection with 2 Mbps speed. Fiber optic communications routes for each regional agency is mapped on the Master Plan map and assigned to separate unique dynamic layers within the GIS geodatabase.

3 Needs Assessment

The traffic systems communications needs assessment is based on two primary criteria: existing system deficiencies that require more immediate attention and the needs of the long-term future transportation network. Existing system deficiencies and needs have been identified through an extensive review of the existing conditions including the traffic communications system, central systems, ITS elements, and traffic operations. The City's future transportation network was researched to identify the new infrastructure needs and subsequently prioritize opportunities to improve the traffic communication system. New roads and traffic signals provide opportunities to expand, modernize, or build new communications system technology and infrastructure that meet both immediate and future needs. The communications system needs include considerations for speed, bandwidth, reliability, redundancy, networking capabilities, gaps in communication due to infrastructure and/ or media deficiencies, and new locations requiring service. The following sections present the existing system deficiency identification and future roadway network assessment.

3.1 Stakeholder Outreach

Outreach and coordination meetings were conducted with several other City departments to acquire additional information and documentation on existing and future traffic systems in the City. The City's Geographic Information System (GIS) Department provided relevant GIS shapefiles and information. The Information Technology (IT) Department provided information on communications connectivity within the City's Traffic Signal Communications Center (TSCC) and existing and future system support requirements. Staff from the City's Development Services Department and Economic Development Department provided documentation and information for both in-construction and future improvement projects and master plans throughout the City that will affect traffic systems in Chula Vista. Additionally, SANDAG's 2050 Regional Transportation Plan (RTP) Revenue Constrained Plan for Arterial Projects was researched.

3.2 Deficiency Identification

Communications deficiencies have been identified for traffic communications, central systems, field elements, and traffic operations based upon analysis of the existing communications systems conditions. Existing communications media and protocols, both City-owned and leased, currently limit the City's ability to monitor and manage traffic systems in real-time. Deficiencies and needs were identified based on the capabilities of the existing elements and the functionality necessary to efficiently and effectively operate the various systems and operations.

3.2.1 Traffic Communications System Deficiencies

Communications system deficiencies were identified and are listed as follows.

- Existing single-mode fiber optic network utilizes low speed (1,200 bps) Serial communications.

- Existing wireless radio communications are Serial and have low bandwidth capabilities.
- Extensive gaps in City-owned communication infrastructure due to missing physical connections centrally and/ or locally. Only 24 of the City's 267 existing traffic signals have a physical link to the TSCC.
- Leased communications are costly, reliant on the third-party owner for communications repairs, and have limited communications capabilities such as low-speeds, low-bandwidth, and are analog-based. Approximately 90% of the City's existing traffic signals communicate on leased lines, limiting the entire traffic signal communications network to analog.
- Operation and maintenance costs for the existing leased line telecommunications network is expensive, currently costing the City approximately $75,000 per year, and incapable for supporting existing and future traffic systems and ITS applications.
- Two traffic signals are offline and unable to communicate with the City's TSCC through leased line communications due to the third-party owner's inability to make adequate repairs to the network.
- Video detection feeds are unable to be viewed remotely due to physical gaps in communication infrastructure to the TSCC and bandwidth limitations associated with leased line communications and/ or Serial wireless radio communications.
- Existing traffic signal communications system bandwidth is unable to accommodate current and future high bandwidth required by ITS applications such as real-time video monitoring of the traffic on the city streets.
- Modern devices with desired capabilities do not support the legacy communication protocols.

3.2.2 Central Systems Deficiencies

The City remodeled and built a new TSCC data center and Traffic Management Center through a separate design-build task with STC Traffic. The project was completed in early 2017 and resolved the primary central systems deficiencies. Remaining central system deficiencies were identified as follows.

- The QuicNet4+ Regional Arterial Management System (RAMS) currently utilized is outdated and does not offer the functionality provided in modern systems that are becoming industry standard. It is also unable to communicate with Advanced Traffic Controllers (ATC).
- The Sydney Coordinated Adaptive Traffic System (SCATS) is outdated and subject to down time due to the legacy protocols, low-speed (1,200 bps) connection, and bandwidth limitations associated with leased line communications. The SCATS system is no longer operational.

The two remaining central system deficiencies are being resolved through implementation of two new state-of-the-art systems in 2017, (1) a new Transparity RAMS system and (2) a new central traffic management system (ATMS.now) and SynchroGreen™ Adaptive Traffic Control System (ATCS).

3.2.3 Field Elements and Traffic Operations Deficiencies

The City uses multiple systems and strategies to manage traffic operations throughout Chula Vista including traffic signal timing and coordination, grade crossing preemption, emergency vehicle preemption, transit signal priority, and data acquisition. Each system has been reviewed and deficiencies identified include:

- There are 22 existing coordinated corridors throughout the City. Many have inconsistent coordination plans. This is a symptom of a lack of reliable communications to traffic signals to monitor and verify that signal timing is as designed and TOD plans are providing efficient and effective traffic progression.
- Type 170 controllers are outdated and do not provide modern communication protocols or functionality required to perform advanced traffic operations.
- Emergency Vehicle Preemption equipment is antiquated (up to 15 years old), Infrared-based, relies on line-of-sight, and is susceptible to illegal emitters. Unauthorized preemption drastically impacts coordinated corridors, as recovery can take a significant amount of time, causing unnecessary impacts to traffic signal operations on critical corridors throughout Chula Vista.
- Traffic measurement devices currently communicate through a third-party owned cellular network and the traffic data is hosted through an outside party server.
- Traffic signals lack stand-alone battery back-up units for emergency power during power outages.
- Field elements lack the ability to communicate with the element, view the element status, and remotely manage and control the element.
- City staff does not have the communication system necessary to monitor and control traffic in real time through video and data acquisition.

3.2.4 Communications Gap Identification

Gaps in communications infrastructure were identified through analysis of the Master Plan GIS map, which geographically presents the existing traffic systems. Although the City currently has established communications to approximately 95% of the 267 existing traffic signals, only 9% are communicating on City-owned infrastructure and the remaining traffic signals communicate via leased lines. The high operating and maintenance costs associated with these leased lines, as well as the limited communication capabilities due to obsolete technology, makes the existing communications network an impractical and unsustainable model for the City of Chula Vista's existing and future transportation system needs.

Communications gap identification includes considerations for gaps between traffic signals locally and gaps between traffic signals and the TMC. Based on the existing communications system in Chula Vista, gaps were categorized as follows:

- Gaps due to lack of infrastructure.
- Gaps due to leased infrastructure.
- Gaps due to combination of leased and City-owned infrastructure.

3.2.4.1 Infrastructure Gaps

Gaps due to a lack of infrastructure include signalized locations with no existing City-owned or leased communications infrastructure. There are 13 offline traffic signals in the City that cannot be monitored remotely from the TMC and City staff must be dispatched to verify signal operations in the field. This is an inefficient use of both City time and resources. Of the 13 offline traffic signals, 11 are caused by gaps in communication infrastructure and 2 are leased infrastructure locations that require repairs.

3.2.4.2 Leased Gaps

Gaps due to leased infrastructure include signalized intersections that communicate with the TMC through a third-party owned POTS leased network. There are 102 telephone drop traffic signals, including 11 SCATS signals, in the City with the majority located in the downtown area between I-5 and I-805.

3.2.4.3 Combination Infrastructure and Leased Gaps

Communications gaps that are caused by a combination of leased and City-owned infrastructure include traffic signals that are interconnected by City-owned twisted pair copper wire to a traffic signal communicating on leased lines. These signals are currently connected to telephone drops due to a lack of a direct communications link to the City's TMC. There are 124 traffic signals, including 1 SCATS signal, on the City-owned copper wire based analog multi-drop network.

Table 3-1 provides a summary of the traffic signal communication system deficiencies and **Figure 3-1** presents the City's communications gaps[1].

Table 3-1 Traffic Signal Communications Infrastructure and Deficiencies Summary

Number	DESCRIPTION	QUANTITY
-	City of Chula Vista Total	267
1	Analog Fiber Optic Communication	24
2	Serial Wireless Radio Communication	4
3	Leased Copper-Based Communication	102
4	City-Owned Infrastructure on Leased Copper-Based Communication	124
5	No Communication Due to Infrastructure Gap	11
6	No Communication Due to Leased Infrastructure Repair	2
7	Analog Video Detection	155
8	Lack of Remote CCTV Monitoring	267
9	Lack of Limited Service and/or Post-Preemption Sequence	5
10	IR-Based Emergency Vehicle Preemption	267
11	Leased Cellular-Based Communications	46*
12	Type 170 Controllers	255
13	Lack of Stand-Alone Battery Back-Up	267

*Traffic Measurement Devices are located nearby signalized intersections

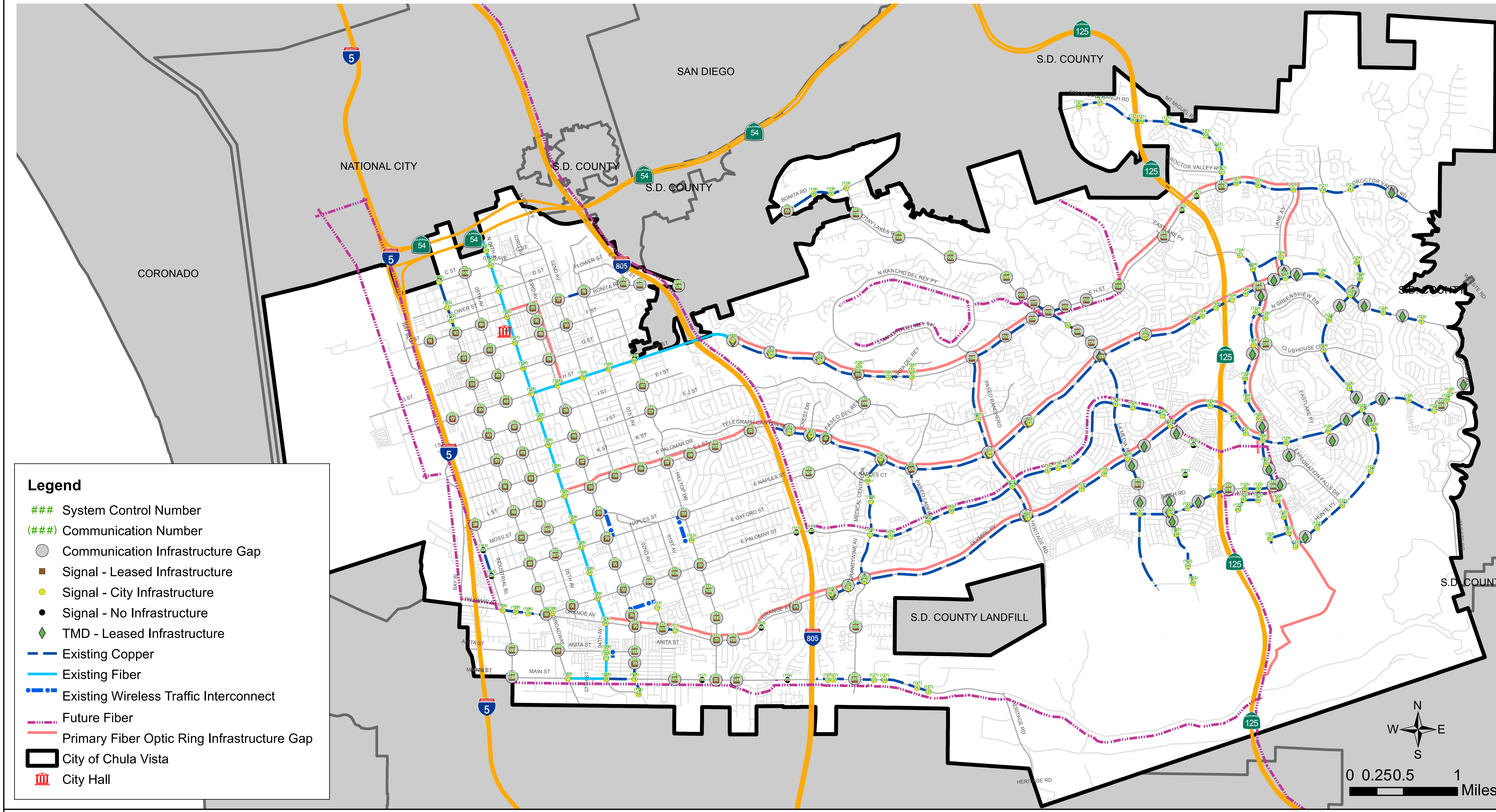


Figure 3-1 Communication Gaps

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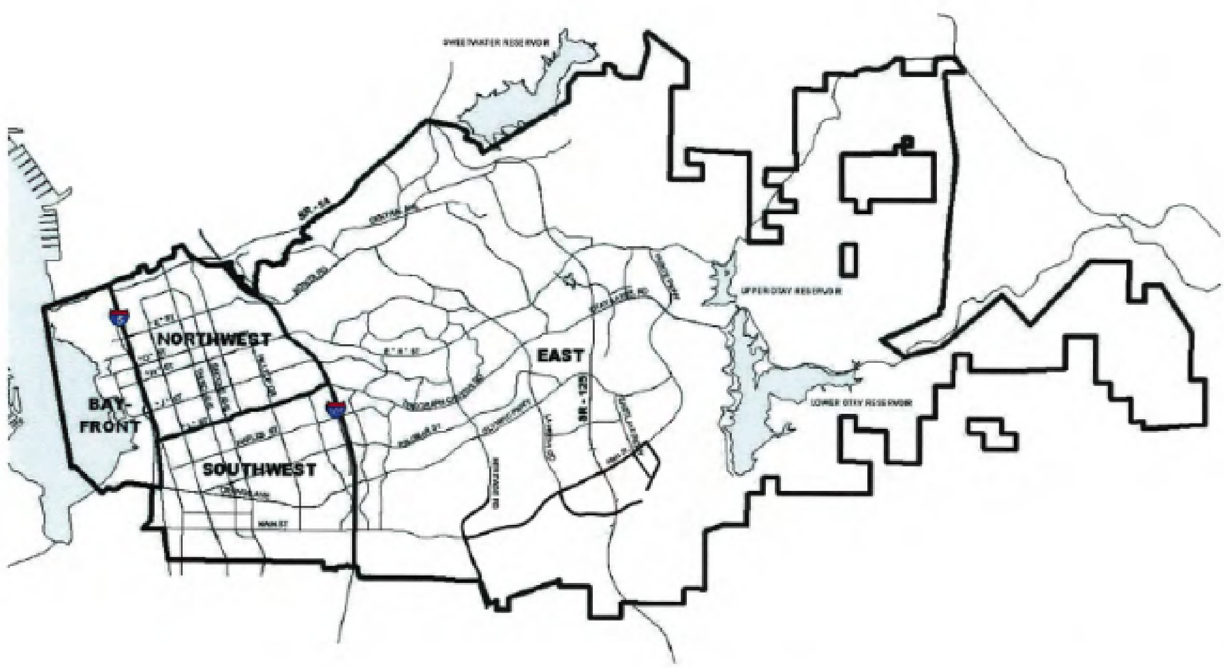
3.3 Future Roadway Projects

Relevant information for future roadway projects throughout Chula Vista was researched in documentation provided by the City's Public Works, Engineering and Development Services Departments. The documents provided information on new traffic signals, new roadways, and planned roadway widenings. The documents researched include:

- Otay Ranch Villages Sectional Planning Area (SPA) Plans.
- University Villages Project Environmental Impact Report (EIR).
- Bayfront Master Plan.
- Chula Vista Main Street Streetscape Master Plan.
- Urban Core Specific Plan.

The City of Chula Vista General Plan organizes the City into a hierarchy of geographic areas for policy purposes. From the largest to the smallest, the areas include: Planning Area, Subarea, District, and Focus Area. Chula Vista's four Planning Areas are: Bayfront, Northwest, Southwest, and East. Each planning area has an Area Plan that is incorporated into the Land Use and Transportation Element. Research was conducted for planned projects that would impact Chula Vista's future roadway network.

Chula Vista Planning Areas



3.3.1 Future Traffic Signals

Research of the above documentation identified 96 traffic signals that are planned for future construction. The future traffic signals were documented on a dynamic layer in GIS with the attribute table detailing the intersection location. The following are the developments associated with the future traffic signals.

- The Chula Vista Bayfront Master Plan (CVMBP) is a joint master plan by the Port of San Diego, City of Chula Vista, and Pacifica Companies to develop a 500-plus acre public area along the San Diego Bay. Seven new traffic signals will be installed in the Bayfront area[2].
- The Chula Vista Main Street Streetscape Master Plan develops a Complete Street plan for Main Street between Industrial Boulevard and the I-805. The roadway plan identifies 6 new signalized intersections along Main Street between Jacqua Street and Otay Valley Road/ Maple Drive[3].
- The Eastern area of the City has developed thousands of acres of formerly undeveloped land since the mid-1970s. The area comprises six master planned communities including: Sunbow, Rancho del Rey, Eastlake, Rolling Hills Ranch, San Miguel Ranch, and Otay Ranch. Five of the six communities are either built-out or nearing completion. Otay Ranch is in the development process and is the largest master planned community in Chula Vista with 83 planned new traffic signals[4].

3.3.2 Future Traffic Communications Systems

The City plans to construct several new traffic system communications paths. The following describes the future paths by communications medium.

3.3.2.1 Future Copper Wire Interconnect

New copper wire based interconnect will be installed to close the communications infrastructure gap between East H Street/ Tierra Del Rey and East H Street/Paseo Ranchero on the future adaptive traffic signals project identified in Section 3.3.3[5].

3.3.2.2 Future Single-mode Fiber Interconnect

New fiber routes will be constructed in conjunction with the following projects:

- The South Bay Rapid project installs new City-owned conduit and single-mode fiber optic cable along portions of I-805, East Palomar Street, Eastlake Parkway, Birch Road, and SR-125.
- The Main Street Fiber Optic Project installs new conduit and fiber, with City-owned inner-duct and dedicated fiber, along Main Street from Industrial Boulevard to SR-125.
- In the Rancho Del Rey area, new conduit and single-mode fiber optic cable will be installed along portions of North Rancho Del Rey Parkway, South Rancho Del Rey Parkway, Ridgeback Road, Otay Lakes Road, East H Street, and Corral Canyon Road.

3.3.2.3 Future Wireless Interconnect

New wireless interconnect will be installed at the following locations:

- Industrial Boulevard and L Street (Drop) to Industrial Boulevard and Naples Street.
- 4th Avenue and L Street (Existing Fiber) to Hilltop Drive and L Street.
- 3rd Avenue and H Street (Existing Fiber) to 3rd Avenue and I Street.

3.3.3 Future Adaptive Traffic Control System

Grant funding from the Highway Safety Improvement Program (HSIP) will implement an Adaptive Traffic Control System (ATCS) at 28 signalized intersections on East H Street, Paseo Ranchero, Otay Lakes Road, and Telegraph Canyon Road. Twelve of the 28 project signals are existing SCATS signals that are being replaced with the new ATSC system and 16 are non-adaptive signals. The traffic signal communications will be upgraded to an Ethernet/IP network. The SynchroGreen™ ATCS system was selected and implementation is anticipated in mid to late 2017.

3.3.4 Future Coordinated Corridors

Four new traffic signal coordination networks are planned, in addition to the 22 existing corridors on the streets listed below and shown on **Figure 3-2**.

- East H Street: Bonita Vista High School Driveway to Eastlake Drive.
- Eastlake Parkway: Greensgate Drive to Commercial Driveway.
- East Palomar Street: I-805 to Olympic Parkway.
- Otay Lakes Road: Allen School Lane to Bonita Vista Middle School Driveway.

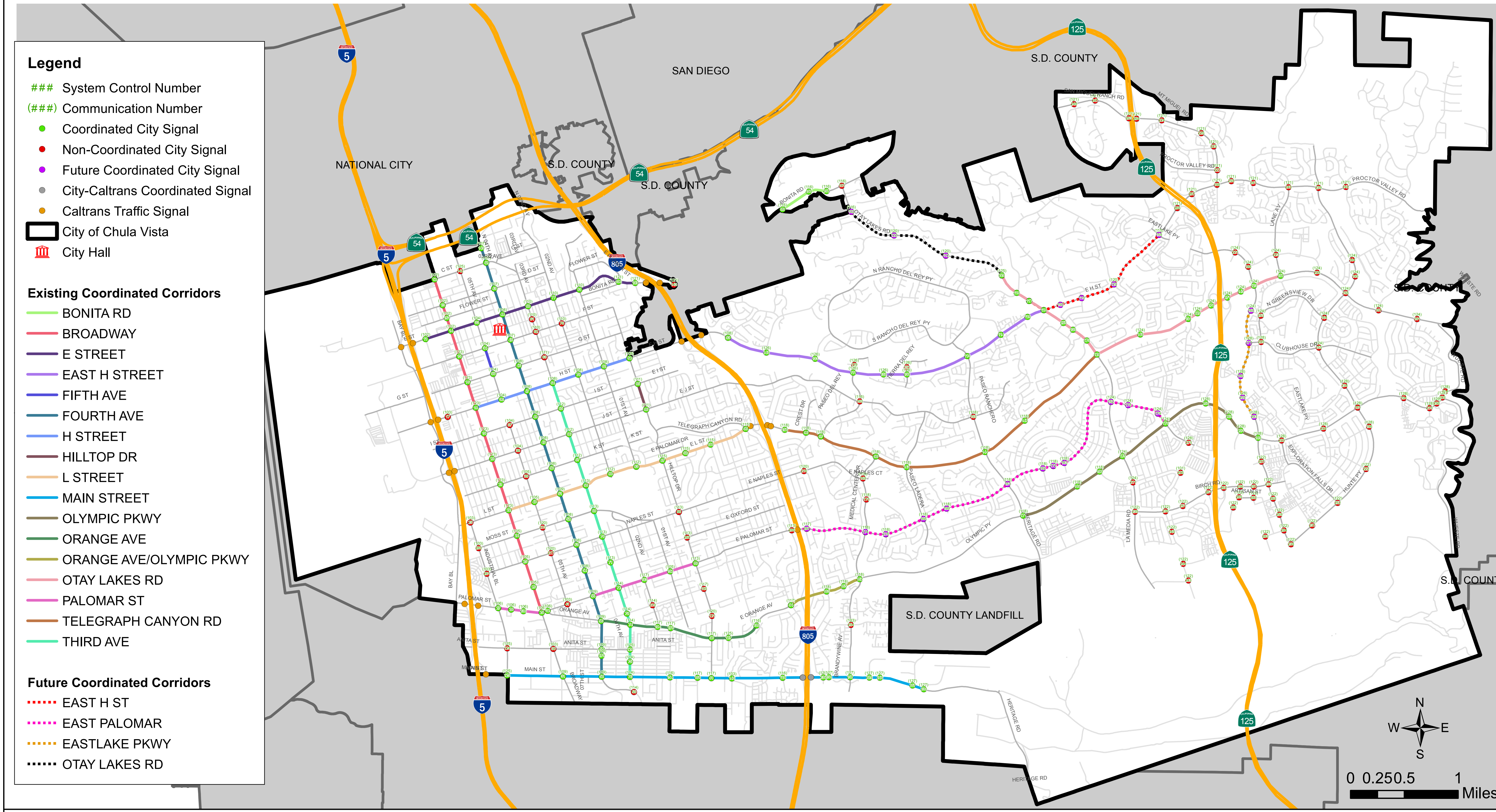


Figure 3-2 Future Coordinated Corridors

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3.3.5 Future Roadways

The Otay Ranch Villages Sectional Planning Area (SPA) plans and documentation provided by the City's Public Works and Engineering Departments were researched for future roadway construction. The new roadways are anticipated in the East subarea for Otay Ranch Villages 3, 8 East, 8 West, 9, and 10. A dynamic layer in GIS documents the location, street names, and associated project in the attribute table.

3.3.6 Future Roadway Widening

Specific Plans and Master Plans throughout the City were researched to identify future roadway widening projects which can provide potential opportunities to expand the traffic communications systems infrastructure. The Chula Vista Urban Core Specific Plan Mobility Element Section 3 outlined Future Conditions and Street Improvement Opportunities including:

- **Widening of E Street between Woodlawn Avenue and I-5** to serve traffic needs, reduce queues in the westbound direction, and improve operations at the I-5 Northbound ramp at Woodlawn Avenue.
- **Widening of H Street from 3rd Avenue to Broadway** to accommodate buildout traffic, improve segment operations, and reach the ultimate classification of H Street per the General Plan.
- **Widening of Broadway between E Street and F Street** to accommodate a consistent configuration along Broadway between C Street and L Street including a raised medians and bike lanes.

Appendix C contains the complete list of future transportation projects and traffic signals within the City.

3.4 SANDAG 2050 RTP

The SANDAG 2050 Regional Transportation Plan (RTP) was referenced to gather information on future roadway projects that are planned to be constructed over the next 33 years. RTP Appendix A (2050 RTP Projects, Costs, and Phasing) was researched to obtain additional information for each respective project. Due to funding limitations and uncertainties, only arterial projects contained in the revenue constrained plan were inventoried. Within the City of Chula Vista, two projects have been identified and summarized in Table A.8 (Phased Arterial Projects – Revenue Constrained Plan) including:

- **Willow Street Bridge Project**: Replace and widen the existing bridge, including shoulders, on Willow Street from Bonita Road to Sweetwater Road. This project is currently in construction.
- **North Fourth Avenue and Brisbane Street Project**: Widen Fourth Avenue to add an additional lane on the east side of the roadway.

The Future Road Network for the City of Chula Vista is illustrated in **Figure 3-3**.

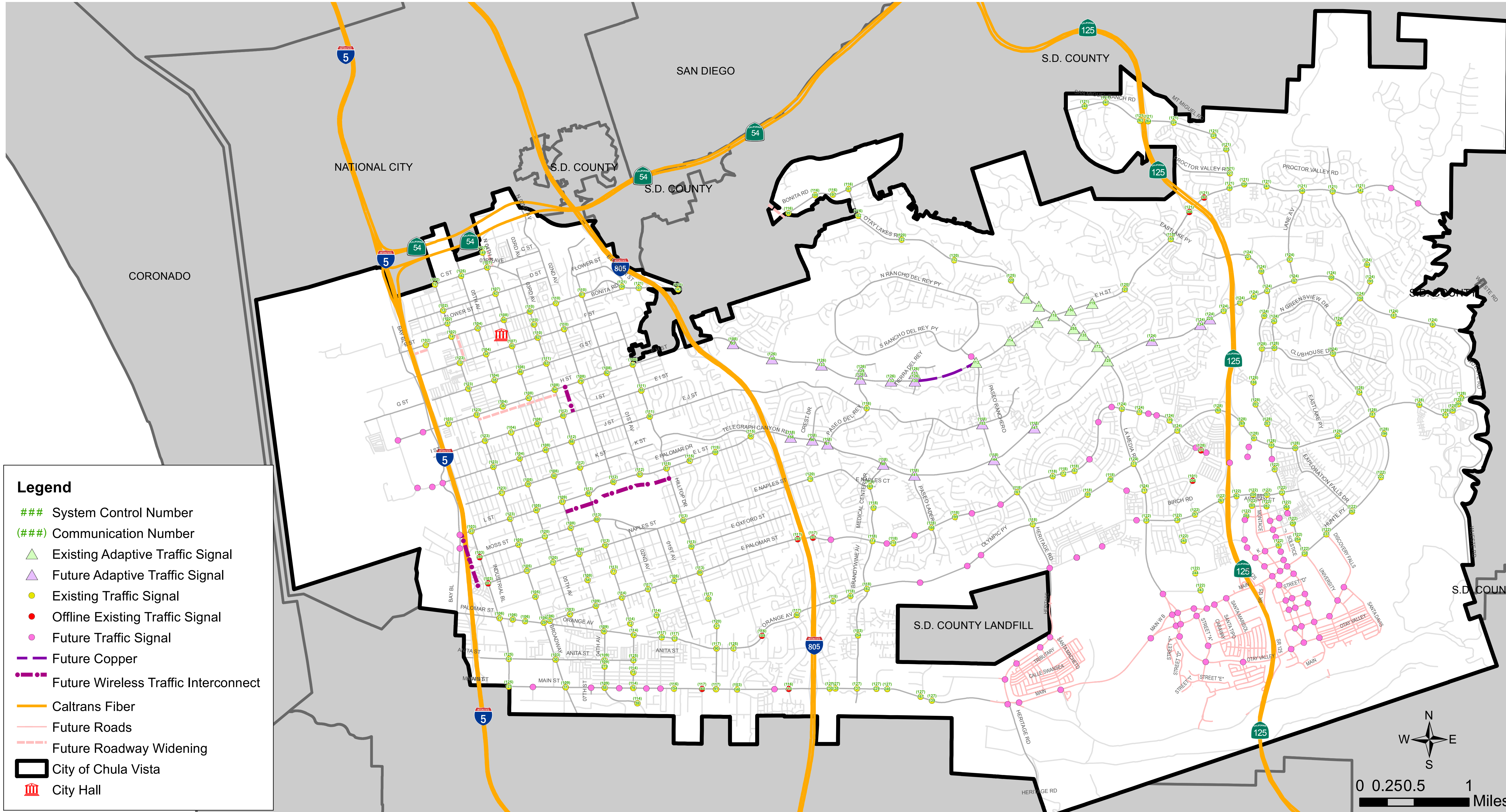

Figure 3-3 Future Roadway Network

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4 Future System Architecture and ITS Elements

The future City traffic signal communication system architecture will link all system elements creating one ubiquitous network on which all devices will communicate. The Master Plan architecture is conceived as a reliable and future-proof network that will meet any City transportation system need. This section presents the network and ITS elements, standardization, topology, physical and logical requirements to achieve the future communication system concept. Several architecture examples are provided to demonstrate system connectivity and resiliency. This section also presents the communication system relation to Chula Vista Smart City transportation initiatives. A schematic detailing the future traffic system communications architecture concept is provided in **Appendix D**.

4.1 Future Network Standardization

Today's "continuously connected" devices like smart phones, tablets and personal computers use Ethernet protocol to connect with each other and the internet. The world's communication systems are based on the Ethernet protocol. There are no more separate data networks or voice networks as there were during 1980's. Nowadays one common Ethernet network utilizing Internet Protocol (IP) efficiently handles both voice and data.

Since Ethernet networks are ubiquitous the cost of communications equipment has continuously declined while the communications capabilities increase. The "Internet of Things" (IoT) applications will cause even further decline in Ethernet equipment price. Additionally, there are plenty of knowledgeable network engineers and technicians to support these new networks.

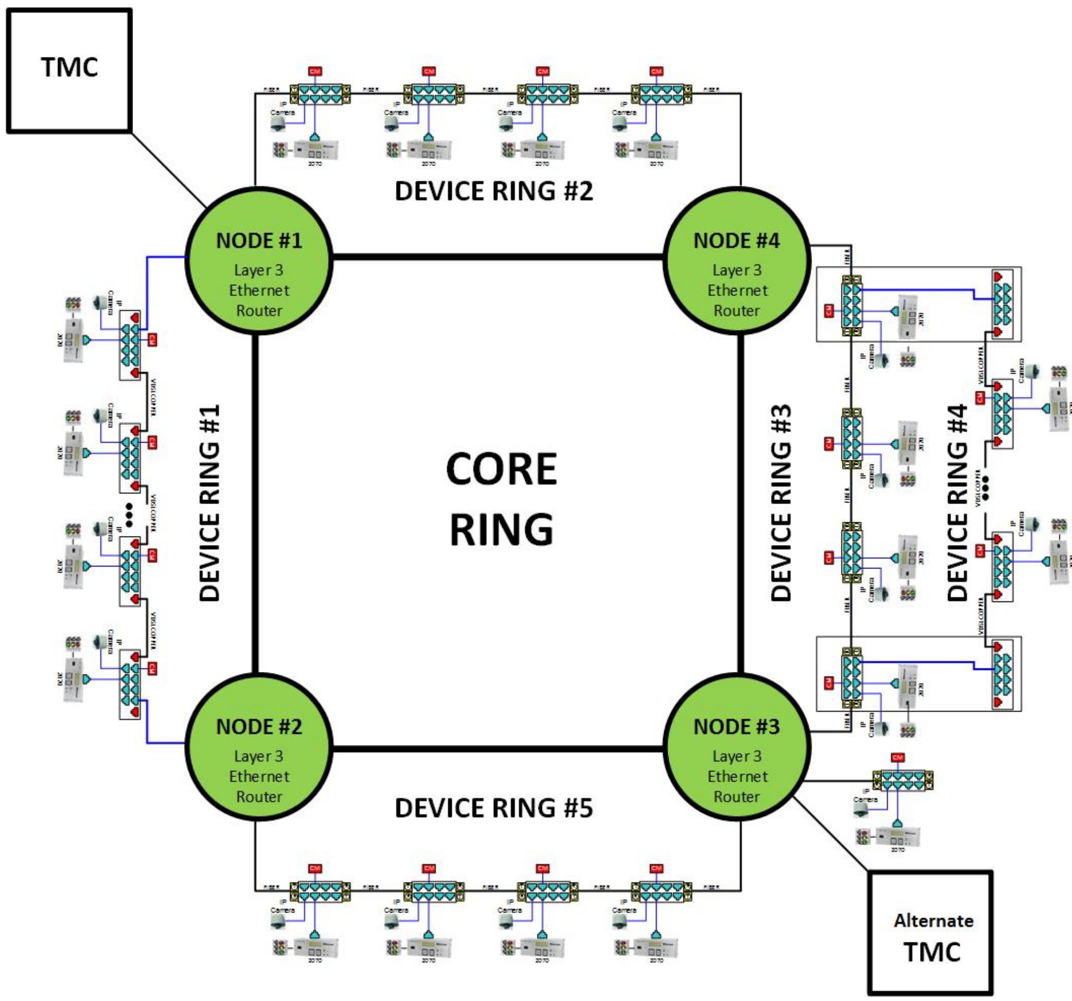
The newer traffic, transportation, and ITS devices are either standardized on Ethernet interface or offer Ethernet interface as an option. Yet to be invented future devices will most likely support Ethernet interface. Ethernet provides a "future proof" network for the foreseeable future.

- The City of Chula Vista future traffic signal communication system network will be based on Ethernet protocol.
- The future network will combine multiple communications medium such as single mode fiber, existing copper plant, point-to-multipoint wireless, and cellular.
- The future "CORE" network will use Layer 3 nodes connecting to each other via single mode fiber links.

The future Ethernet/ IP protocol network shall be designed as a two-tiered network. Tier 1 will utilize the Layer 3 node equipment connected to each other in a ring network fashion using 10 Gbps or higher speed links. Tier 2 will utilize the Layer 2 Managed Field Ethernet Switches (MFES) such as VDSL switches, field Ethernet switches, and wireless broadband radios also connected to each other in a ring network fashion at various speed links, depending on the equipment on that link. ITS devices such as traffic controllers, conflict monitors, CCTV cameras, Dynamic Message Signs (DMS), vehicle detectors, transit and emergency vehicle pre-emption devices, etc. will connect to the copper ports of Layer 2 MFES.

The network architecture topology example is shown in **Figure 4-1**. The main feature of the future traffic signal communication system is its self-healing capability. The MFES's, equipped with either dual fiber ports or dual VDSL ports, will connect to each other in a daisy chain fashion and to the Layer 3 nodes eliminating single point of failure and providing unattended, automatic self-healing capability.

Figure 4-1 Future CORE Ring Network Topology Example



At every traffic system location, the self-healing ring technology will be utilized as much as financially possible. When implemented, the City will have a state-of-the-art, future proof network that will be easily expandable to serve the city across diverse geography and services. The City of Chula Vista traffic signal communication system will simultaneously support multiple different ITS applications including:

- Existing and future traffic controllers.
- CCTV cameras.

- Conflict monitors.
- Dynamic message signs.
- Highway advisory radios.
- Vehicle detection systems, (radar, video, etc.).
- Emergency vehicle pre-emption systems.
- Bluetooth and/or Wi-Fi based travel time systems.
- Upcoming Vehicle to Infrastructure (V2I) systems and “Autonomous Vehicle” systems.

In addition to the above ITS applications, the future traffic signal communication system will support

- All future “Smart City” related applications.
- All future Wi-Fi communications anywhere in the City including the “Chula Vista Smart Bayfront” project.

The network will also support:

- Public message billboards and public messaging systems.
- Voice, video, streamed video services, and video conferencing among departments.
- Any future Ethernet based communication devices and/ or services.

At the City’s discretion, the network will be able to provide bandwidth and/ or ports sharing capability to different City departments. The same network could also provide bandwidth to private enterprises.

4.2 Future Network Architecture Examples

Figure 4-2 shows one Layer 2 fiber switch based self-healing ring and four Layer 2 VDSL switch (copper) based self-healing rings. Each Layer 2 switch ring starts from a Layer 3 Ethernet router and terminates on a different Layer 3 Ethernet router. The Layer 3 ring starts at the TMC from the Layer 3 Ethernet router NODE TMC-1 and goes through NODE A, NODE B, NODE C and returns to the TMC and terminates on a different Layer 3 router NODE TMC-2. This topology eliminates any single point of failure, fiber cut or a node failure and the self-healing capability is the main principle of the future network design concept.

Figure 4-3 shows one Layer 2 fiber switch based self-healing ring starting from a Layer 3 Ethernet router NODE A and terminating on a different Layer 3 Ethernet router NODE C. In this topology if a Layer 2 fiber switch fails, the fiber switches left of the failure point will communicate to NODE A and the fiber switches right of the failure point will communicate to NODE C. All the devices attached to Layer 2 switches will recover communications to the TMC automatically. Only the devices attached to the failed switch will lose communications to the TMC. If a fiber link fails, the devices attached to that switch will recover communications to the TMC via the other port.

In addition, to illustrate the “dual homing” concept, a Layer 2 fiber switch is connected to both NODE A and NODE B and a second Layer 2 fiber switch is connected to both NODE B and NODE C. If one fiber link fails for a Layer 2 fiber switch, it will still communicate to the TMC via the other NODE.

Figure 4-2 Future Fiber and Copper Rings Network Topology Example

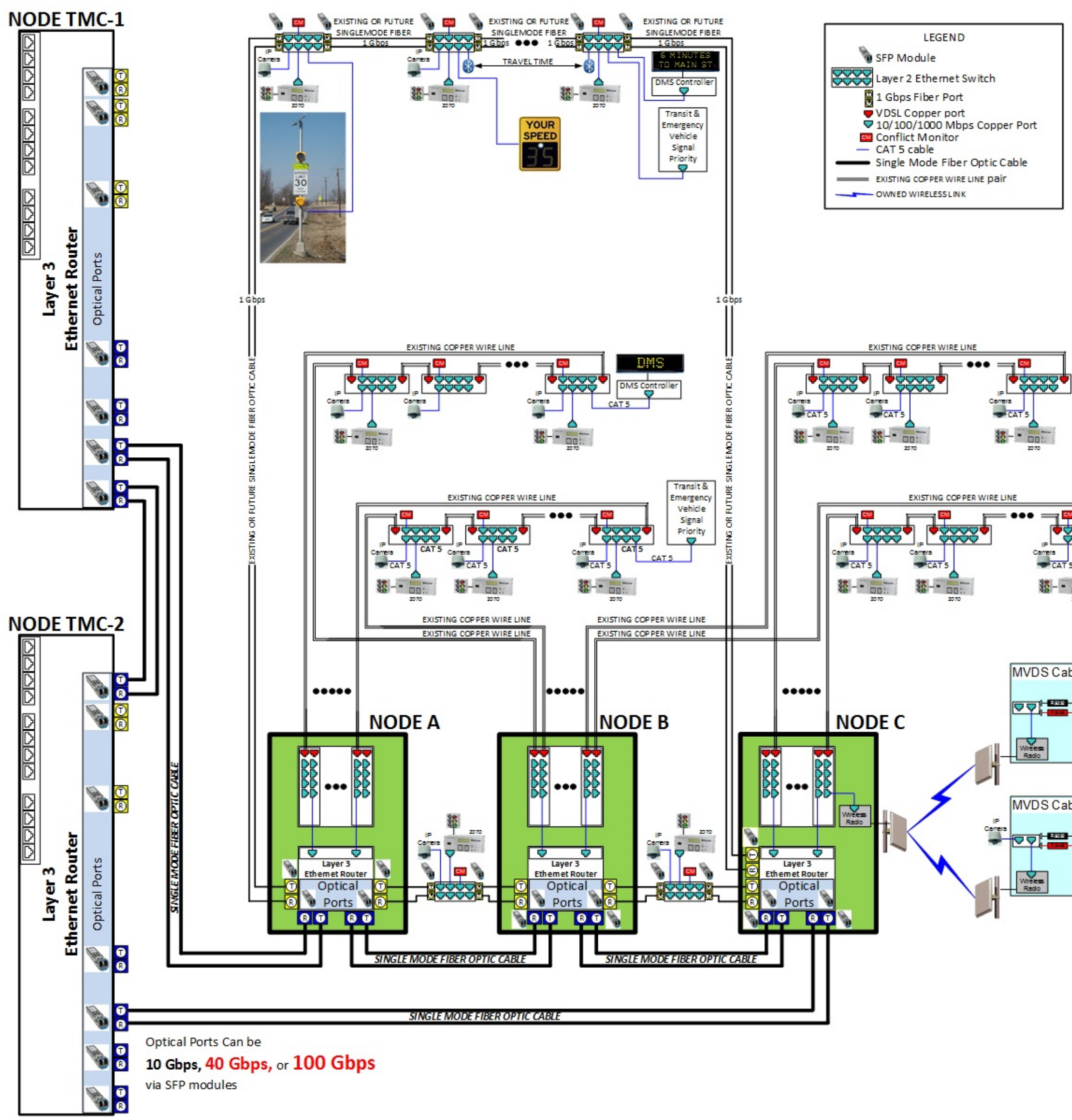


Figure 4-3 Future Fiber Switch Ring Topology Example

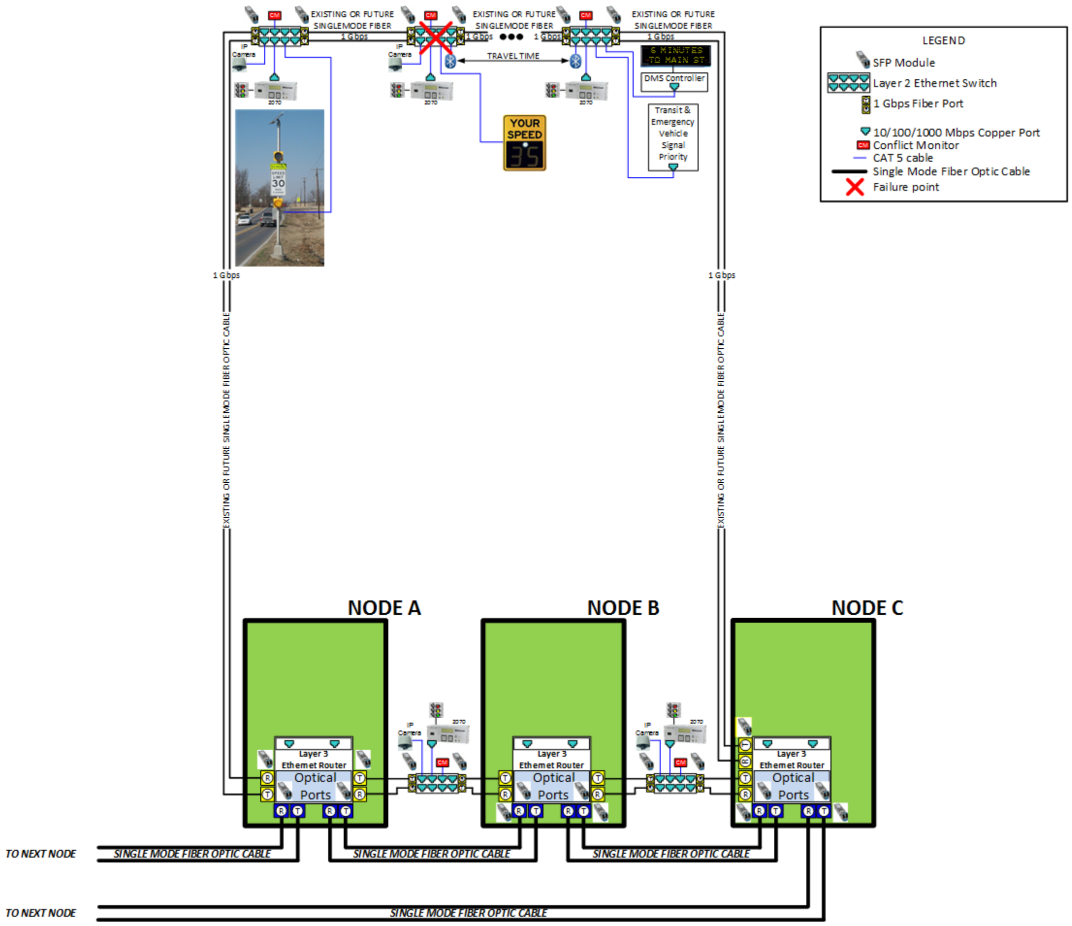


Figure 4-4 shows one Layer 2 VDSL switch (copper) based self-healing ring start from a Layer 3 Ethernet router NODE A and terminate on a different Layer 3 Ethernet router NODE B. In this topology if a Layer 2 VDSL switch fails, the VDSL switches left of the failure point will communicate to NODE A and the VDSL switches right of the failure point will communicate to NODE B. All the devices attached to Layer 2 VDSL switches will automatically recover communications to the TMC. Only the devices attached to the failed VDSL switch will lose communications to the TMC. If a VDSL link fails, the devices attached to that switch will recover communications to the TMC via the other port.

Figure 4-4 Future VDSL Copper Switch Ring Network Topology Example

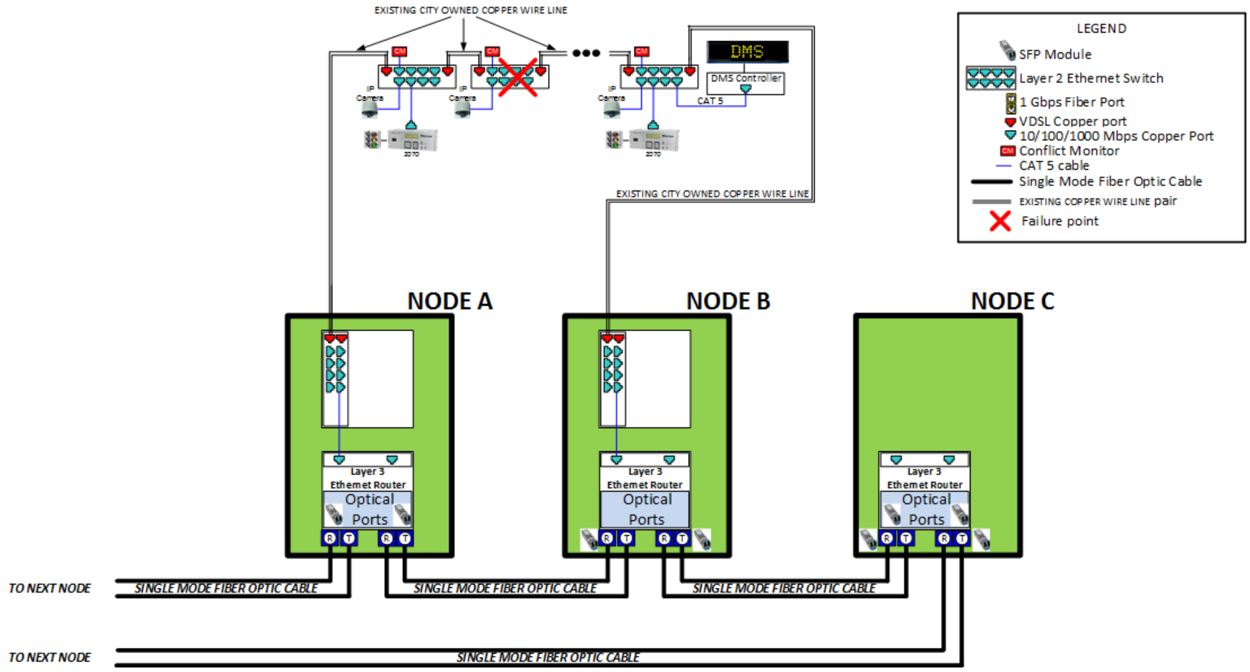


Figure 4-5 shows one Layer 2 fiber switch based self-healing ring starting from the Layer 3 Ethernet router NODE A and terminating on the Layer 3 Ethernet router NODE C. Figure 4-5 also shows a second self-healing ring composed of Layer 2 VDSL switches, starting from the Layer 2 fiber switch, Switch #1 on the left and terminating on a different Layer 2 switch, Switch #2 on the right. Fiber Layer 2 switch, Switch #1 and VDSL switch, Switch #3 are collocated on the left and Fiber Layer 2 switch, Switch #2 and VDSL switch, Switch #4 are collocated on the right. Fiber and VDSL switches connect to each other via a short CAT 5 cable inside the traffic controller cabinet.

In this topology if a Layer 2 switch (fiber or VDSL) fails, both the fiber switches based ring and the VDSL switches based ring will automatically recover communications to the TMC via either Switch #1 or Switch #2. Only the devices attached to the failed Layer 2 switch (fiber or VDSL) will lose communications to the TMC. If a link (fiber or copper) fails, the devices attached to that switch will recover communications to the TMC via the other port.

Figure 4-5 Future VDSL Copper Switch Ring to Fiber Switch Ring Topology

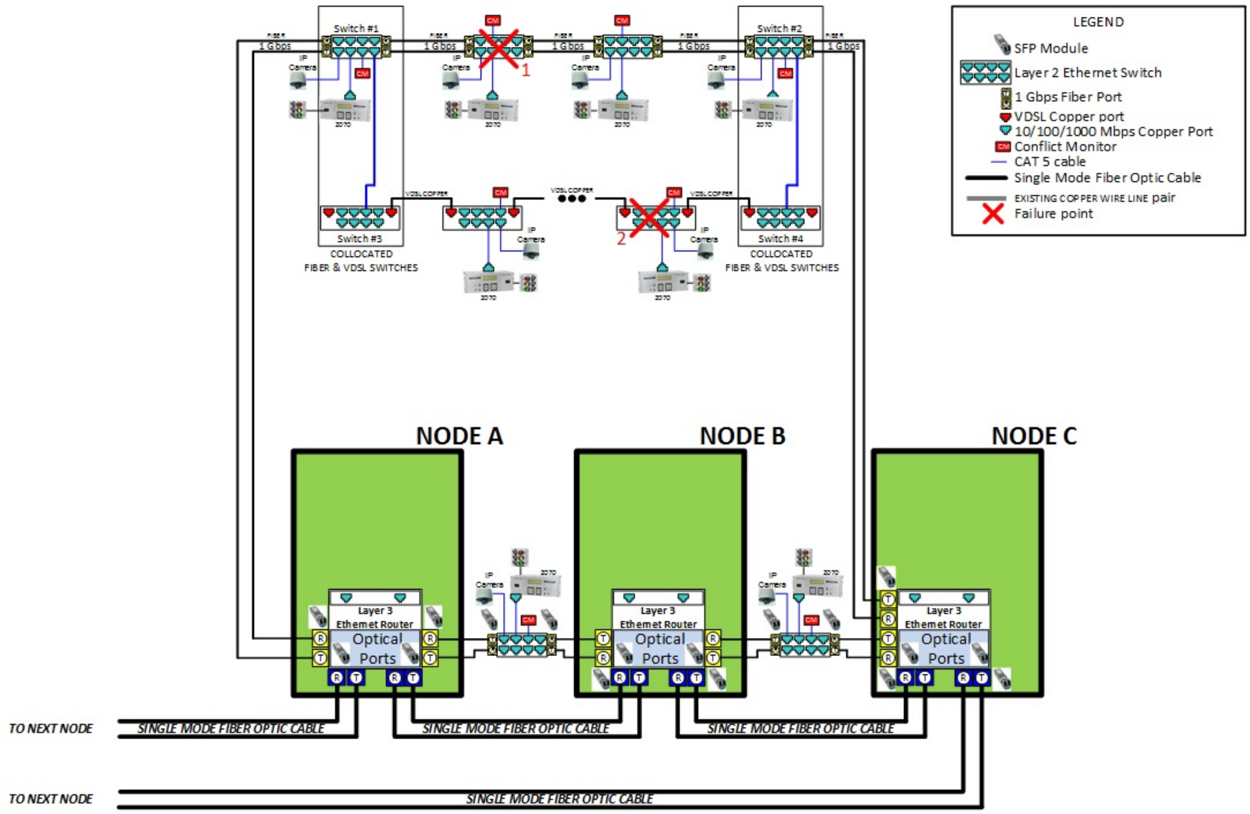


Figure 4-6 shows isolated signals that are not on fiber routes on the city-owned copper wire routes, and signals that are on the city-owned copper wire routes but with no direct connection to a Layer 3 router. These isolated signals will use a 4G wireless router (also called a cellular modem) and communicate to the TMC over the 4G cellular service provider owned IoT service.

Those signals that are on the city-owned copper wire routes but with no direct connection to a Layer 3 router will also communicate to the TMC using a 4G wireless router collocated with the “head-end” Layer 2 VDSL switch over the same 4G cellular service provider owned IoT service.

In this topology, if a 4G router fails, only that single signal or the whole VDSL line is lost. If the IoT router, or the Firewall at the TMC or the link to the IoT service from the TMC fails, the communication to the 4G routers will be recovered via the second IoT link from NODE B.

Figure 4-6 Future IoT over Cellular Wireless Network Topology Example

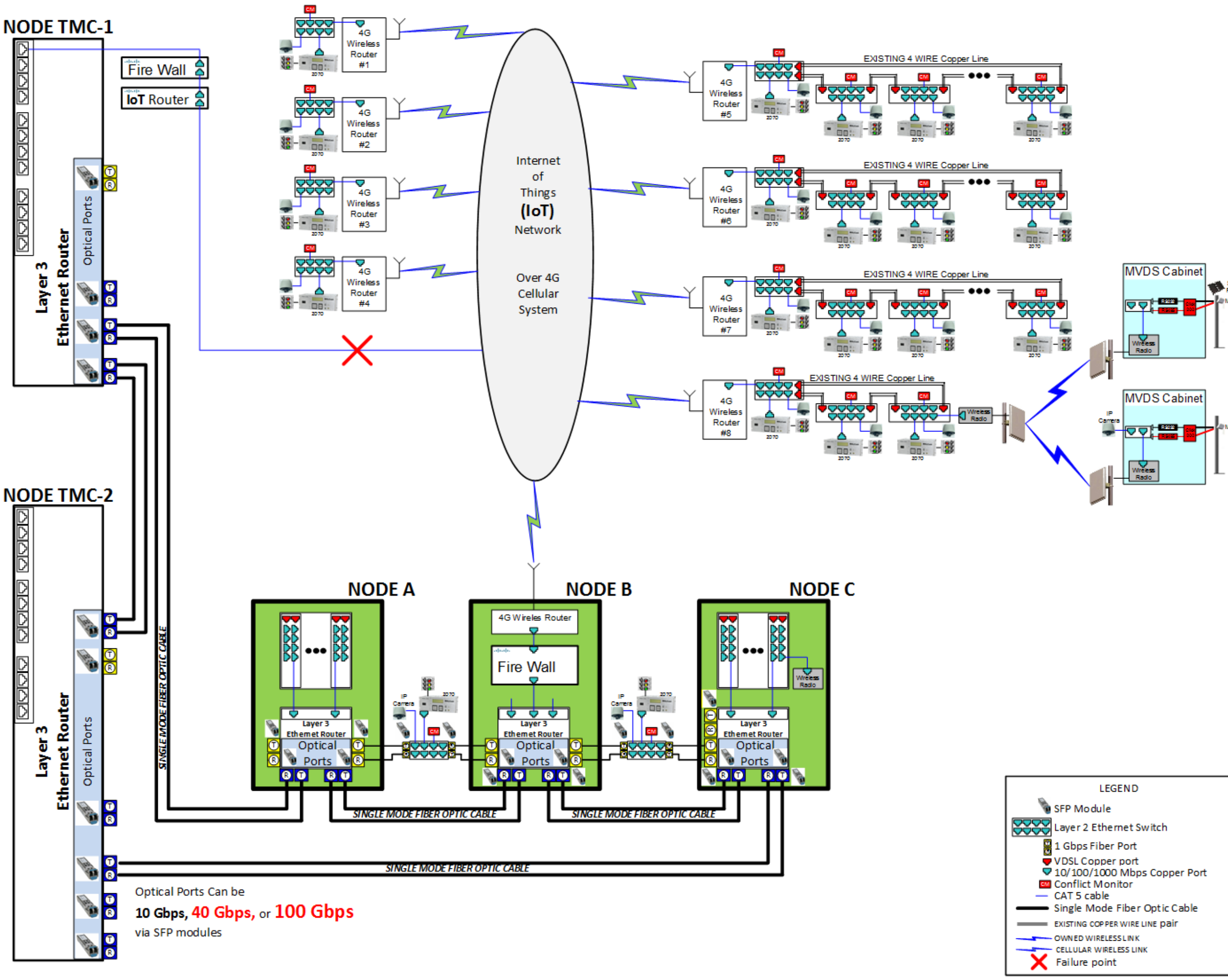


Figure 4-7 shows three different owned wireless network topology examples utilizing 802.11 ac (or the latest technology) wireless radios with integrated and external antennas. The same self-healing scenarios explained in prior cases also apply. If a remote radio or the wireless link from that remote radio location fails, only that location loses communications to the TMC. If a master radio fails, all the locations communicating with the master radio fails. Where geographically possible, mesh wireless links should be used.

Figure 4-7 Future Owned Wireless Network Topology Example

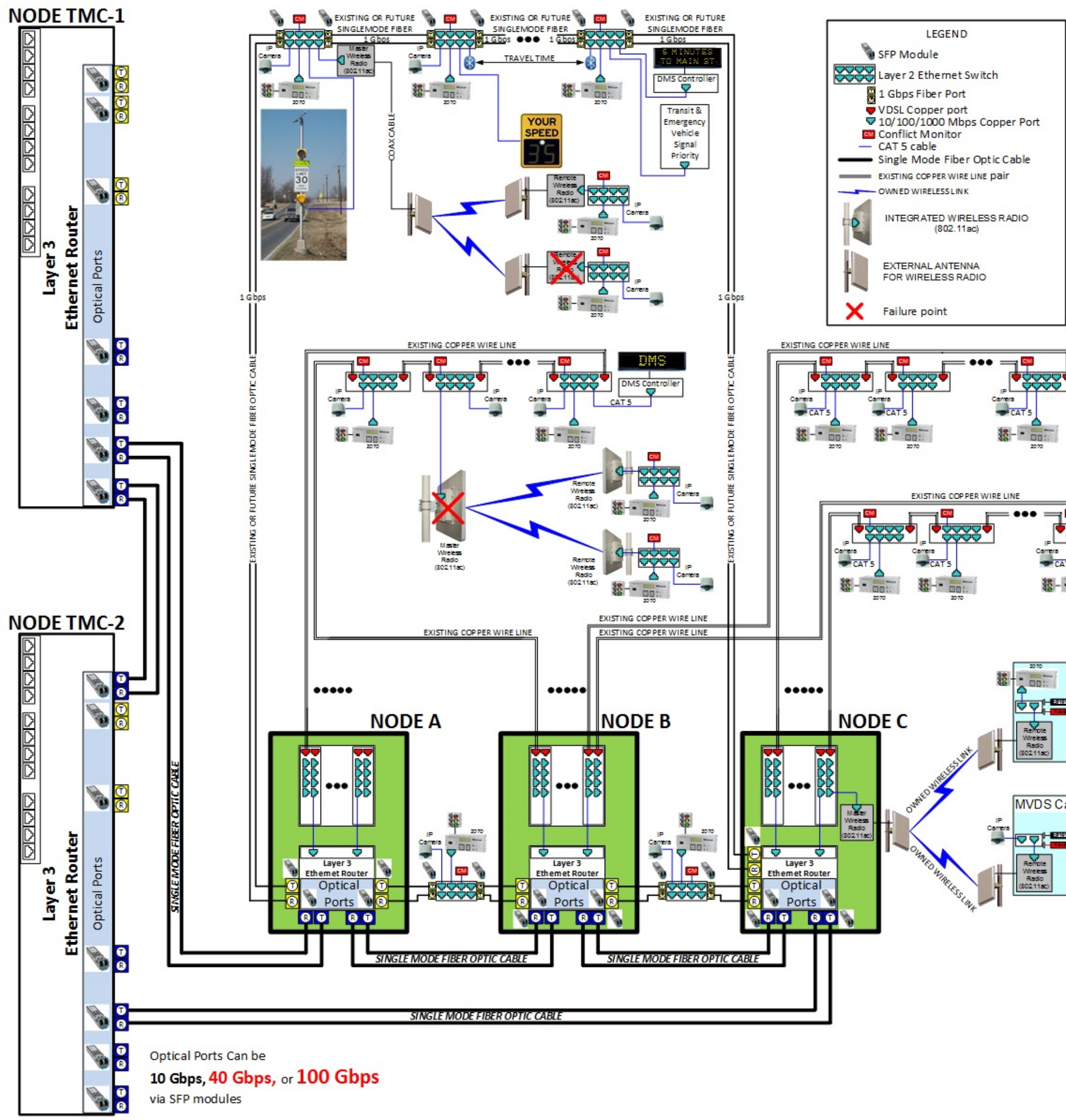
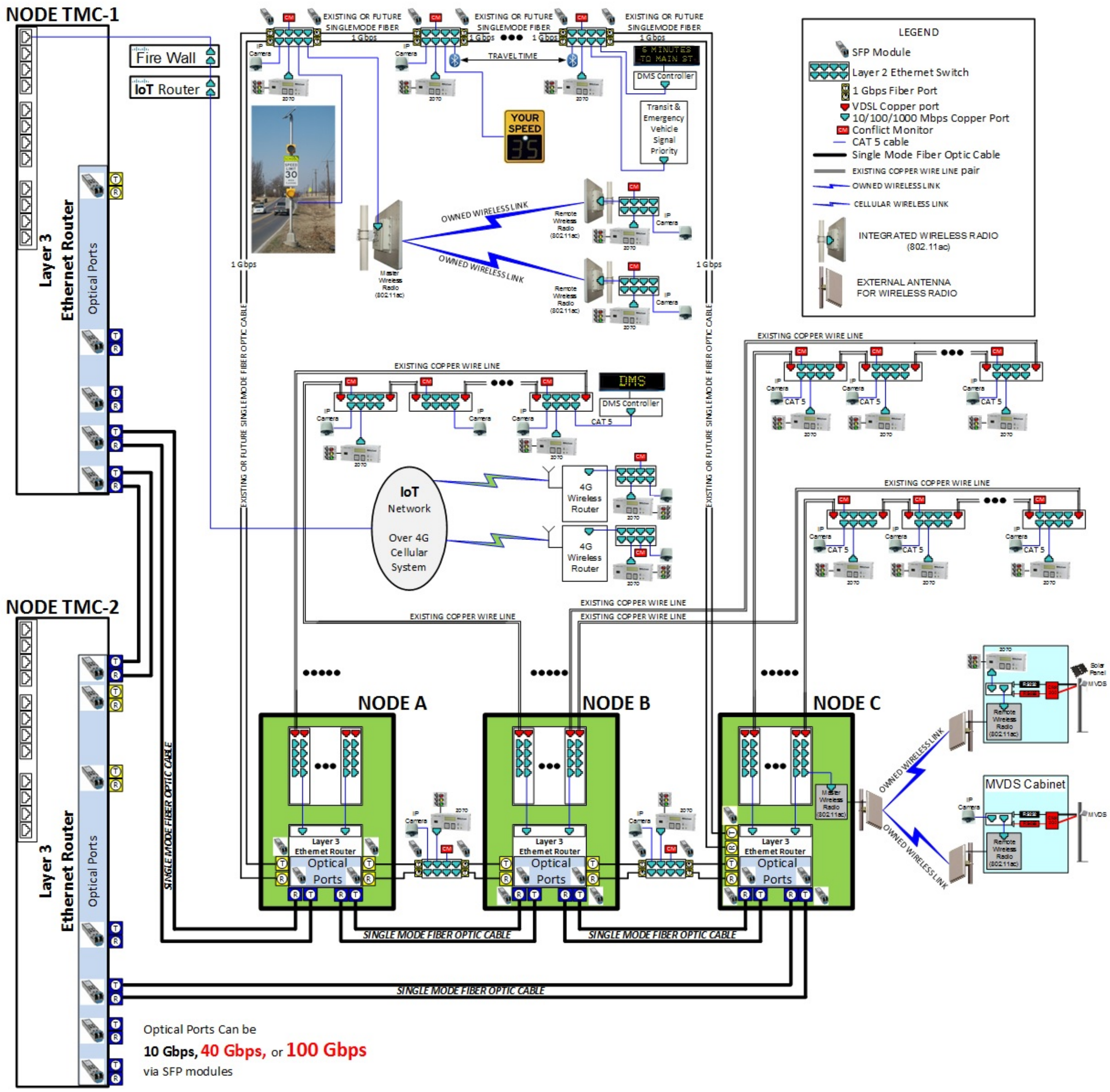


Figure 4-8 Future Redundant and Self-Healing Ring Architecture



4.2.1 TSCC Communication Ports

All the Digi boards at the TSCC will be removed, discarded and replaced with "Virtual Com Port" software provided by Digi. The Virtual Com Port software allows the existing traffic controller software that was communicating with the existing 170E controllers over its Serial port to communicate over the new Ethernet network without any hardware or firmware changes to the 170E controller in the field. Only a new Digi N2S-170 Card will be installed in the modem slot of the 170E controller.

4.2.2 Bandwidth Requirements

The vast bandwidth of a modern Ethernet network dramatically increases accessibility to all ITS devices and applications within the traffic signal network, including streaming video from CCTV cameras and emerging technologies such as Connected Vehicles and Smart City applications. While the initial upgrade to Ethernet will effectively over-provision the capacity requirements of existing technology, the use of managed network switches allows for resource reservation control mechanisms ensuring Quality of Service (QoS) can be delivered to critical applications and/or devices.

4.2.2.1 Traffic Signal Cabinet Assemblies and Components

The assemblies and components of a traffic signal cabinet were originally developed under the restrictions of legacy communication networks where bandwidth was a scarce resource. These utilize a minimal portion of the overall bandwidth available in an Ethernet network. A single IP surveillance camera consumes several orders of magnitude more bandwidth than bandwidth consumed by all the traffic controllers within the same network. However, cumulative impact of thousands of devices can overload the network. The traffic control devices consuming minimal bandwidth include:

- Traffic Controller Unit
- Conflict Monitor Unit
- Preemption Phase Selector
- Battery Backup Unit

4.2.2.2 IP Surveillance Cameras

Real time video streaming over IP is the chief consumer of network bandwidth in a traffic signal communication network. Live video is paramount to the effective management of signal operations at individual intersections and along arterial routes. Video detection cameras and Pan-Tilt-Zoom (PTZ) cameras are commonly used to monitor the flow of the traffic. The bandwidth utilized by cameras ranges from 0.5 to 5 bps per camera[1]. The following parameters affect the actual bandwidth consumed by an IP video camera system and one must consider the following factors:

- Video encoding algorithm, like H.265 (AVC), H.264, MPEG-4, MPEG-2, Motion JPEG.
- Resolution.
- Frames per second.
- Number of Cameras.

4.2.2.3 Dynamic Message Signs

Dynamic Message Signs (DMS) provide travelers with real-time or advanced notice information for traffic conditions, roadway incidents, construction, community events, and other alerts. LED signs are most common and are energy-efficient, bright, and highly legible. Character size and number of lines differ among manufacturers and signs are capable of multi-colored and graphical displays, providing the City with advertisement placement opportunities. Signs can be managed remotely utilizing the traffic systems communications network. DMS include portable and fixed sign deployments or installations.

Portable DMS are mounted to a trailer with hydraulic lift mechanisms and positioned on the side of a roadway prior to diversion points or connecting roadways. Portable DMS are self-powered utilizing solar panels or batteries and the messages are typically changed remotely from the TMC utilizing wireless or cellular communications. The City currently owns two portable DMS signs that are used exclusively by the Chula Vista Police Department. Two additional portable DMS signs are recommended for City Traffic Operations staff use.

Fixed DMS are larger overhead signs that are mounted to a fixed pole and positioned at central areas of interest to provide the greatest benefit for shared travel information. Fixed DMS utilize a local power source and can communicate with the TMC through the cable based traffic systems communications network. It is recommended that the City install fixed DMS signs in advance of freeway ramps and at the Chula Vista Amphitheater.

Both portable and fixed DMS should be used to share traffic information related, but not limited to: recurring congestion, traffic incidents, special events, construction, maintenance activities, road closures, detour routes, etc. To ensure security, rights for device use, including both view and control, should be assigned to prevent unauthorized access.

4.2.2.4 Demand for Real-Time Data

Future transportation management systems will exchange traffic data with a multitude of independent and/or integrated mobility applications that will allow travelers and system operators to make informed decisions. Smartphone applications like, Waze, HERE WeGo, Inrix Traffic, etc. are now connecting to traffic management systems to exchange data. The data exchange is typically provided through a separate internet connection at the TMC.

4.2.3 IP Addressing Scheme

Since the future traffic signal communications network devices are going to be IP based, each device in the network must have at least one IP address. IP addresses are in the form of First Octet. Second Octet. Third Octet. Fourth Octet. An example IP address is 192.168.1.123. The future IP scheme for the City of Chula Vista Master Plan is as follows.

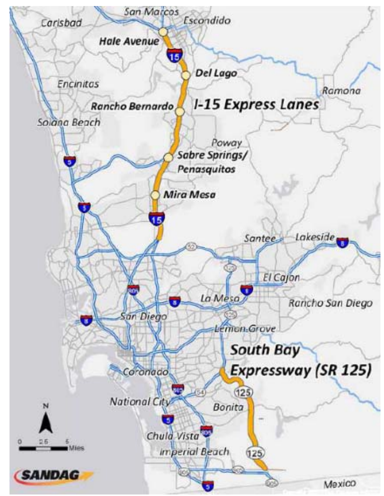
- First Octet = ABC.
- Second Octet = XYZ.
- Third octet = Device ID organized by associated hub and location east or west of I-805.
- Fourth Octet = Intersection ID organized by corridor and direction, east to west or north to south.

The IP addressing scheme is provided to the City in a separate document due the sensitivity of the information.

4.3 Smart City Chula Vista

The City is implementing a vision of a 21st century Smart City that includes building a robust, technically advanced transportation network that connects the City both geographically and on the information superhighway. The Master Plan is compatible with Chula Vista's Smart City initiatives and advances several Smart Infrastructure applications including: video, lighting, parking, transportation, public transportation and shuttles, zero emissions vehicles, environmental sensors, and public safety. The ITS improvements will reduce congestion throughout the City, advance the City's Climate Action Plan goals, and promote sustainability.

4.3.1 Automated Vehicle Proving Grounds

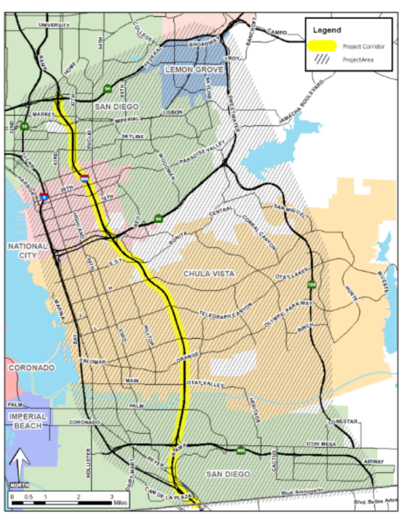


In January 2017, the U.S. Department of Transportation (US DOT) designated 10 Automated Vehicle (AV) proving ground pilot sites to encourage testing and information sharing for AV technologies across a variety of climates, entity types, speed zones, and concentration. SANDAG, Caltrans, and City of Chula Vista were jointly selected in response to the US DOT pilot program application solicitation[2].

The San Diego region has three proving ground environments: the I-15 Express Lanes from SR-163 to SR-78, the SR-125 South Bay Express Way from East Chula Vista to the United States-Mexico border, and the City of Chula Vista. The local network of streets and roadways in Chula Vista will be used as a testbed for AV technology[3].

4.3.2 I-805 Active Traffic and Demand Management

The City of Chula Vista is a stakeholder in the Active Traffic and Demand Management (ATDM) program which will be deployed on the I-805 South corridor from SR-94 to the United States-Mexico border. This heavily-utilized commuter corridor provides access to and from National City, Chula Vista, San Diego, and



beyond. The ATDM project seeks to utilize technology and interagency communications to optimize and maintain trip reliability, increase throughput, minimize delay, promote institutional coordination, and increase technical integration across all modes and jurisdictions. Travel information will be collected, processed, and shared with roadway users to enhance planning for timely arrival at destinations. Twenty-five different ATDMS strategies have been identified in the ATDM Concept of Operations with deployment categorized by timeframe: Short Term (1-3 Years), Medium Term (4-7 Years), and Long Term (8-10 Years). The strategies outlined will be enhanced by the additional operational functions the City currently has and/or is improving including: travel time monitoring on Telegraph Canyon Road and implementation of the new Adaptive Traffic Signal Control system.

4.3.3 Connected Vehicle Technology

Connected vehicle applications have many benefits including increased roadway safety with the potential to greatly reduce or eliminate collisions, improve mobility and roadway capacity, environmental sustainability, and infrastructure management. Connections between vehicles and infrastructure (V2I) is a critical element of the connected vehicle environment and requires infrastructure preparation on the part of public agencies that own and operate transportation systems. V2I deployments have emerged over the past several years with the most prevalent issued by AASHTO; the National Connected Vehicle Signal Phase and Timing (SPaT) challenge. The goal of the SPaT challenge is to deploy roadside Dedicated Short Range Communications (DSRC) radio infrastructure to broadcast SPaT data on at least 1 corridor or street network in all 50 states by January 2020[4].

Connected vehicle technology requires reliable, secure, fast communication with low latency that is not vulnerable to environmental conditions or multipath transmissions, and has wide interoperability. DSRC is the most standardized and tested connected vehicle communication technology. The FHWA is currently proposing a mandate for DSRC to be built into all new vehicles by 2022[5]. Other wireless communications technology alternatives to DSRC have emerged including cellular and cellular hybrid.

The most likely near term (say 5 year) deployment of V2I in the City would be associated with a pilot demonstration deployment. If connected vehicle technology is mandated by the FHWA to be built into new vehicles there would be a significant interest on the part of transportation agencies to widely deploy connected vehicle communications technology in infrastructure. The infrastructure side of the V2I communication link requires a roadside unit (RSU), compatible traffic signal hardware, and communication systems. The most limiting factor with connected vehicle technology deployment is cost, both cost to vehicle manufacturers and transportation infrastructure owners and operators. Opportunities in the form of federal aid funds will likely become available in the future to deploy these communications systems.

The recommendations made in this Master Plan will support the service requirements of future V2I network traffic. The communication system architecture concept includes an over provision of bandwidth, is distributed throughout City, and utilizes NTCIP-complaint hardware and Ethernet communications protocols for a V2I ready infrastructure platform.

4.3.3.1 Predictive Traffic Signals

Advancements in V2I communications include traffic signal and in-vehicle systems that can utilize SPaT information to communicate information to the driver. Several in-vehicle information systems and smart phone applications for predictive traffic signal technology have already been developed and deployed. Generally, information from traffic signal controllers and/ or the central traffic management system is collected and communicated to a third-party data aggregation provider. SPaT data is processed through algorithms and predicted traffic signal red or green state and red times are pushed through an internet connection, typically cellular communications, to display in-vehicle or on the driver's smartphone. This type of information can enhance the way a motorist makes decisions when approaching signals based on the signal state, travel speed, and time. These features ultimately reduce idling, stop-and-go traffic, pollution, and red-light violation collisions.

Third-party data aggregation providers, such as Traffic Technology Systems (TTS) and Connected Signals, Inc. have deployed predictive traffic signal technology in cooperation with automotive manufacturers. TTS is teamed with Audi to deploy an in-dash subscription service which provides a countdown for red lights, 4 second alert before a red-light change, and a heads-up display when a vehicle approaches a signal that is about to change phases. The agency's central traffic management system connects to the TTS system "cloud" to transmit SPaT data. The TTS receives the SPaT data and then sends the predictive information to the OEM backend system which sends it to the vehicle. This system has been successfully demonstrated in Las Vegas, NV and active deployments are planned throughout the US[6]. The City of Chula Vista is currently considering a partnership agreement with TTS.

Connected Signals developed the EnLighten application to provide predictive traffic signal information for BMW vehicles through an in-dash subscription service as well as to drivers that do not own compatible vehicles through their smartphone application. Countdown information is displayed when stopped at a red light and a chime alert sounds seconds prior to the light turning green. Connected Signals utilizes a device on the agency premises to connect to the internet and central traffic management system for receiving SPAT data. The Connected Signals cloud receives the SPaT data and then sends the predictive information to the user's smart phone or in-vehicle system. EnLighten is currently available in Portland

and Eugene, Oregon with testing in progress in the City of San Jose in cooperation with BMW and the U.S. Department of Energy's Argonne National Laboratory[7].

4.3.4 Intelligent Street Lighting

Networked street lighting control systems reduce costs associated with operating and maintaining street lights. The City of Chula Vista was the first in the region to implement LED lighting technology Citywide and is currently working with multiple vendors to install and test street lights, as part of a pilot, with communication and sensor technologies that create a smart grid street light system. The system can also be leveraged to capture high-density time-stamped real-time and historical event data, using the Internet of Things (IoT) cloud storage, for a variety of Smart City applications including vehicle traffic, pedestrian traffic, and parking. Travel data includes vehicle speed, direction, lane use, volumes, pedestrian activity, and parking utilization. This information will enable the City of Chula Vista to more accurately:

- Identify recurring traffic, flow issues, high-incident areas, traffic violation patterns.
- Perform more extensive 'before and after' analyses to illustrate changes in driver behavior.
- Identify sidewalk and crosswalk utilization to enhance pedestrian safety.
- Develop strategic demand-based parking pricing based on parking usage and vacancy periods.
- Provide better parking enforcement for overstay, no-parking zone, and loading zone violations.

The City of San Diego has recently partnered with Current, powered by GE, to deploy 3,200 sensor nodes on City street lights to create a multi-application City IoT network. The nodes can perform a variety of applications including vehicle, pedestrian, and bicycle monitoring, parking availability, air quality sensing, and gunshot detection. The data from the sensor nodes will be processed and stored on a cloud-based server. The deployment of the nodes is slated to begin August 2017 and be completed in July 2018[8].

4.3.5 Advanced Transportation Controllers (ATC)

Chula Vista currently uses "Type 170" traffic signal controllers that are built on an old technology platform with limited processing, memory, program, and communications functionality. These legacy controllers are incapable of collecting High-Resolution (Hi-Res) controller data required for advanced traffic measurement and monitoring. The 2070 ATC controller platform will enable collection and reporting of High-Resolution (Hi-Res) controller data. Industry advancements in Hi-Res data processing provide multiple ITS-related applications pertaining to autonomous vehicles, connected vehicles, connected infrastructure, and Smart City technologies. The Intelligent Transportation Systems Joint Program Office (ITS JPO) has provided research data across all modes for these technologies and has outlined how the data collected is being used by public and private organizations[9].

4.3.6 Future Technology Applications

Table 4-1 provides a summary of the various data types and ITS usage applications that the City of Chula Vista may seek to implement in the future to advance the Smart City Chula Vista vision and increase overall travel safety and efficiency throughout the City.

Table 4-1 ITS Data Applications Summary

ITS DATA TYPE	DATA UTILIZED	AGENCY USES
SPaT	Signal status, signal timing, timing plans, detection	Red light running detection, signal retiming studies, arterial performance measures
Trajectory	Vehicle Location, Speed, Heading	Model development and refinement, new development impact studies, ride sharing applications, vehicle type and route comparisons
Parking Space Availability	Parking lot location, number of spaces, available spaces, size of spaces by vehicle type	Planning and system use analysis, parking applications, traveler information
Safety Messages	Vehicle size, current location, speed, heading, acceleration status, brake system status	V2V and V2I deployment testing and evaluation
Infrastructure Alerts	Infrastructure-to-Vehicle	In-vehicle messaging for variable speed limit signs, dynamic message signs, work zone alerts, tolling rates, and red light running
License Plate Recognition	License plate data	Arterial performance measures, travel time analysis, signal retiming studies
Automated Shuttle	Synchronized scheduling	Self-driving testing, Transit Signal Priority testing, obstacle bypass testing

5 Implementation Phasing Plan

The existing traffic systems communications network is comprised of numerous network devices and communications media including fiber optic cable, twisted pair copper wire cable, Serial wireless radios, and third-party owned leased copper lines, telephone drops, and cellular service. The analog network is antiquated and incapable of supporting the City's future ITS technology investments due to limited communications capacity. Implementing one seamless state-of-the-art communications network capable of meeting the City's existing and future traffic system needs requires a strategically phased approach.

The highest priorities include establishing a City-owned traffic signal communication system and implementing Ethernet-compatible systems/network. The existing analog lease lines generate high recurring costs and are incapable of serving modern traffic system technology. Existing investments in communication infrastructure, underground systems, signal interconnect cable, and traffic signal cabinets will continue to be utilized. Obsolete legacy network equipment will be upgraded or decommissioned and replaced with new modern communication technologies. Converting existing technologies to Ethernet-based communications through upgrades is the most cost-effective and rapid deployment approach, enabling improvements across wider areas.

Implementation of Master Plan recommendations is divided into three phases over a ten-year period. Deployment for each phase is dependent on availability of funds and accelerated deployment is advantageous for financial, operational, and management purposes. The City should seek grant funding and other opportunities to more quickly complete all implementation phases within 5 years.

5.1 Phase 1: City-Owned Infrastructure (Year 1-3)

Phase 1 of the implementation plan includes providing a wholly City-owned traffic signal communication network, converting from Serial to an all Ethernet-based network, upgrading traffic signal controllers to Ethernet protocol, and establishing video monitoring at the City's highest priority locations. Implementation for Phase 1 is prioritized by proximity to City Hall as well as by street network hierarchy. The downtown area, closest to City Hall, contains the greatest number of signalized intersections operating on costly third-party owned leased communications. The traffic signals in this area are spaced close together and are ideal for implementation of broadband Ethernet wireless radios, which provide cost-effective and rapid communications deployment. Traffic signal equipment will be upgraded to Ethernet-enabled devices and Layer 3 communication hubs will be installed at strategic locations. The following summarizes the Phase 1 traffic signal communications network upgrades:

- Upgrade the existing fiber optic system to Ethernet communications.
- Convert leased copper lines to City-owned wireless Ethernet radio communications.
- Upgrade City-owned copper lines to Ethernet-over-copper communications.
- Install City-owned wireless Ethernet radio communications at all offline traffic signals.

- Convert the leased cellular network for existing Traffic Measurement Devices to City-owned wireless Ethernet radio communications.
- Install video monitoring devices at high priority locations.
- Install fixed Dynamic Message Signs approaching the Chula Vista Amphitheater.
- Obtain 2 portable Dynamic Message Signs for use during planned or unforeseen major traffic impacting events.
- Install a satellite Traffic Management Center at the City's Traffic Operations Maintenance Facility.
- Upgrade all traffic signal equipment to Ethernet-enabled devices Citywide.
- Implement Layer 3 communication hubs at strategic locations.

A summary of the Phase 1 improvements is illustrated in **Figure 5-1**.

5.2 Phase 2: Infrastructure and Priority Corridors Upgrade (Year 4-6)

Phase 2 of the Implementation Plan prioritizes fiber optic communications. Existing communications conduit that has been previously installed throughout Chula Vista will be upgraded to include new fiber optic cable installations. New conduit and fiber optic cable will be installed to resolve all remaining communications gaps and create redundancy. Strategic signalized intersections along priority corridors throughout the City will be upgraded to include type 2070 ATC traffic signal controllers and closed circuit televisions (CCTV) cameras for remote video monitoring. The following summarizes the Phase 2 traffic signal communications network upgrades:

- Upgrade existing empty communications conduit and install fiber optic cable.
- Install conduit and fiber optic cable to resolve communications gaps in the network and create redundant ring topology.
- Upgrade traffic signal equipment on primary fiber optic ring route with fiber devices.
- Upgrade traffic signal equipment on priority corridors with new 2070 ATC controllers and CCTV cameras.

A summary of the Phase 2 improvements is illustrated in **Figure 5-2**.

5.3 Phase 3: Citywide Buildout (Year 7-10)

Buildout of the traffic signal communications network will be completed in Phase 3. Remaining signalized intersections will be upgraded with type 2070 ATC traffic signal controllers and closed-circuit television (CCTV) cameras for remote video monitoring. Signalized intersections with existing analog video detection will be upgraded with analog to Ethernet video encoders to enable remote viewing of the video feeds. A summary of the Phase 3 improvements is illustrated in **Figure 5-3**.

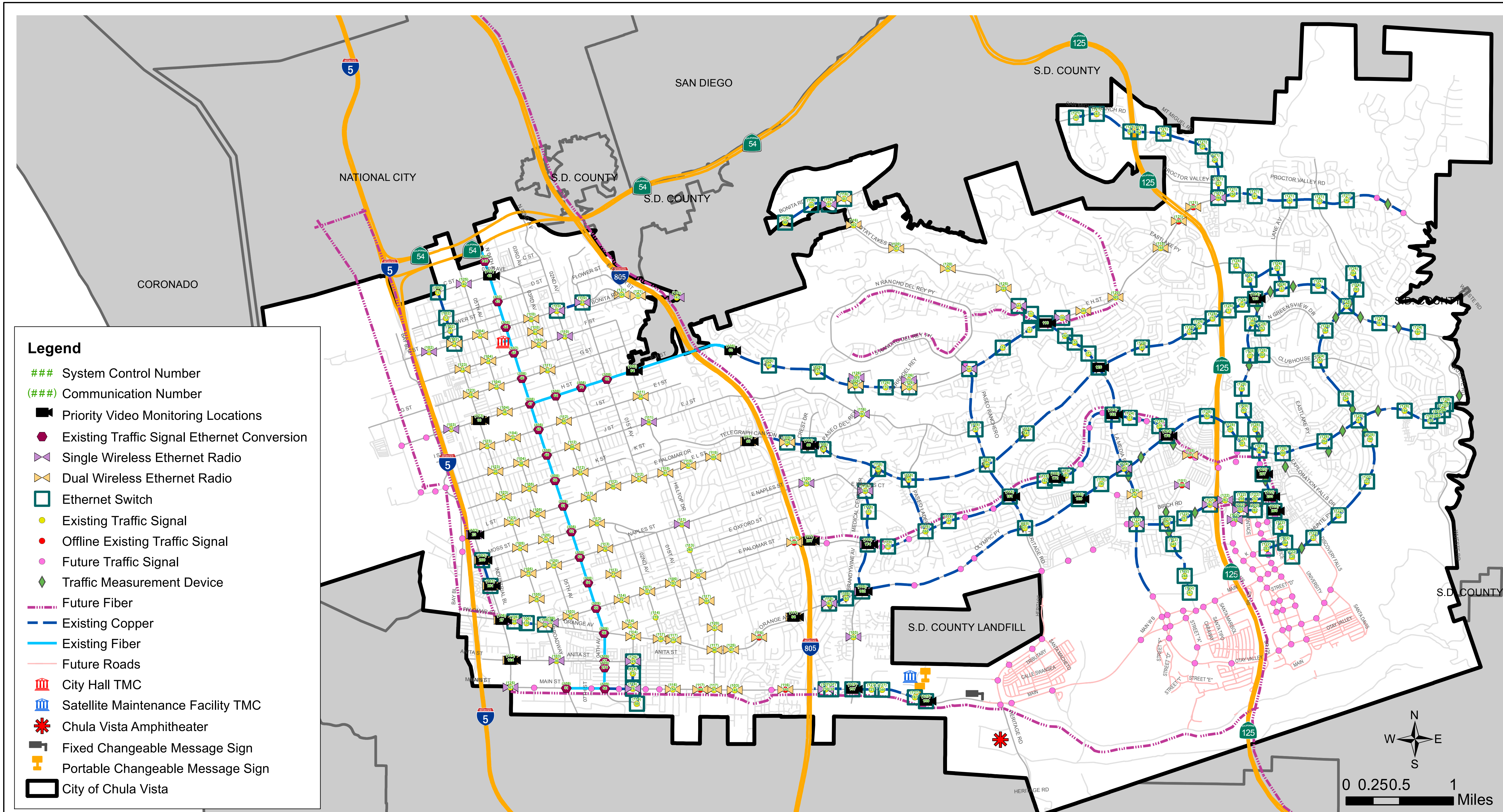


Figure 5-1 Phase 1 Improvements

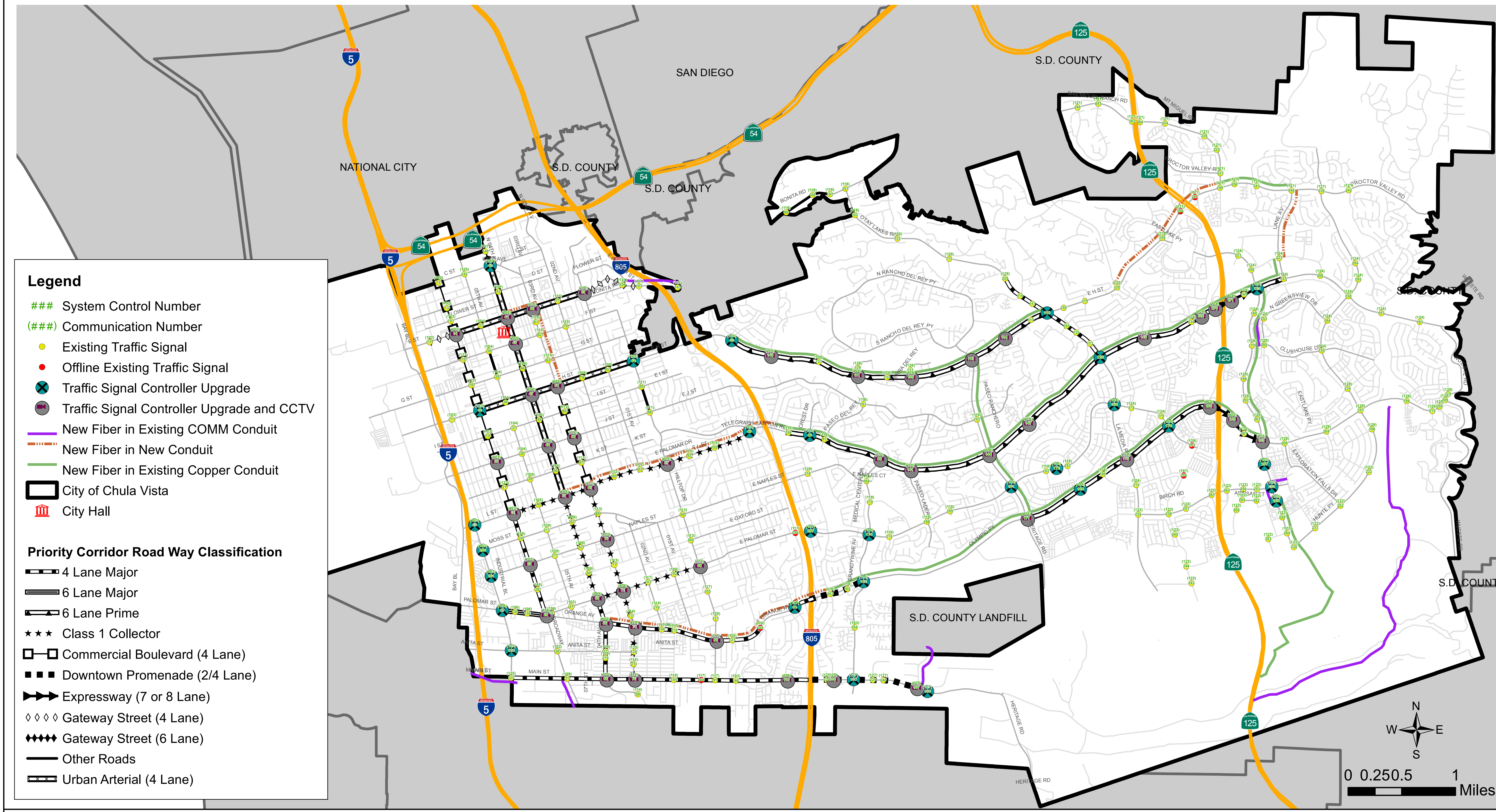


Figure 5-2 Phase 2 Improvements

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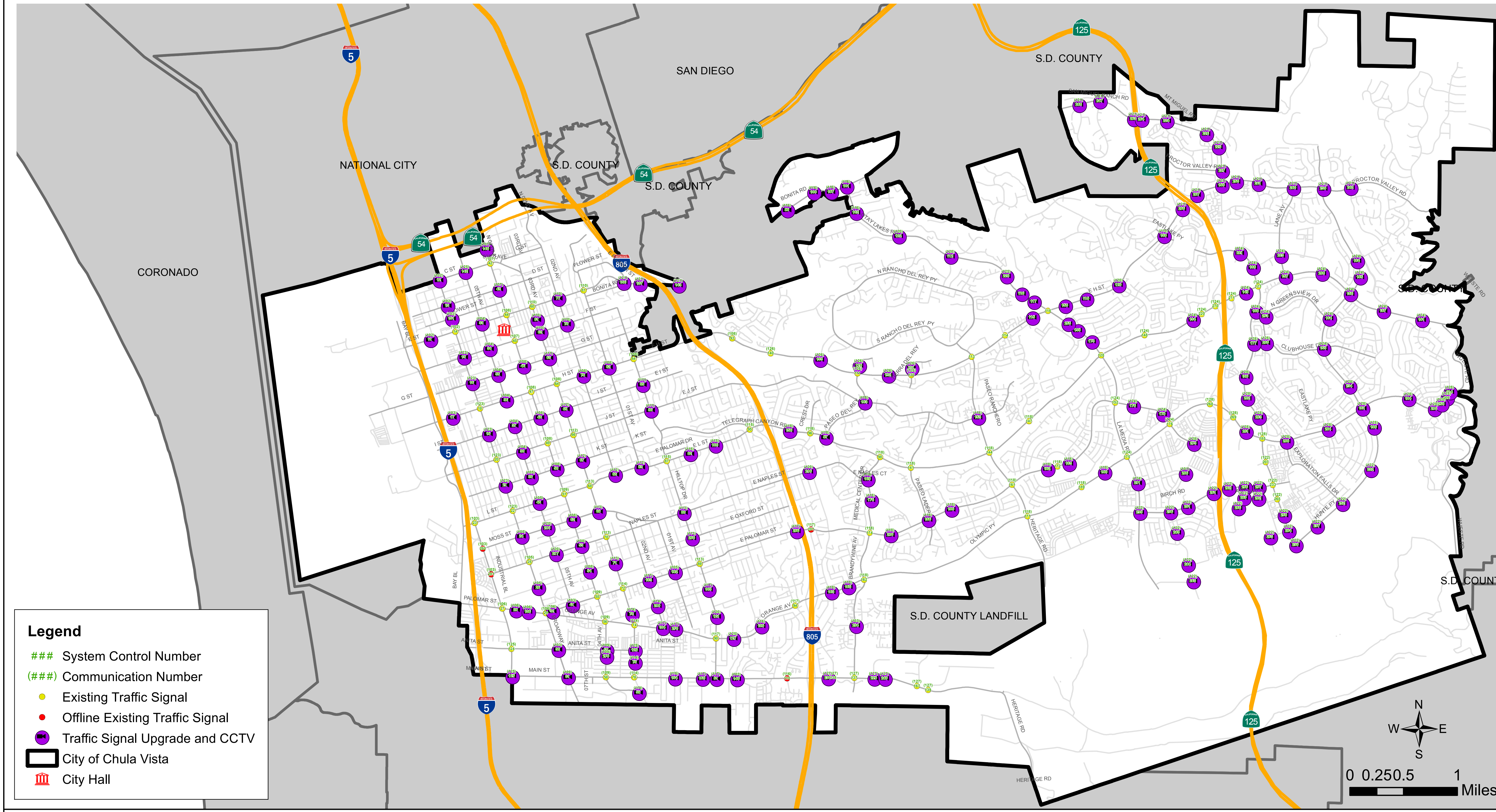

Figure 5-3 Phase 3 Improvements

5.4 Cell Towers

The City owns cell towers throughout Chula Vista that may be utilized for the traffic systems communications network. The implementation phasing plan does not consider use of the towers and focuses on cable based and point to point wireless communications. The towers may provide opportunities to reach areas not easily accessible by cable based systems. The towers could host broadband wireless and/or cellular radios to close gaps in City-owned infrastructure and/or support future ITS technology applications. Tower use would be determined on a case-by-case basis in engineering design phases.

5.5 Long-Term System Considerations

Additional long-term system considerations are included to provide a more robust and reliable traffic signal communication network. These improvements are not part of the three-phase implementation plan but are recommended should additional funding become available. As opportunities arise, new fiber optic conduit and cable should be installed in place of broadband Ethernet wireless radios and fiber optic communication media should be installed in addition to the City-owned copper plant. Major signalized intersections should be upgraded to include stand-alone battery back-up systems, Global Positioning System (GPS) emergency vehicle preemption (EVP) systems, Ethernet-enabled conflict monitor units (CMU), and Power Cycle Relay Switches.

Table 5-1 Long-Term System Improvement Order of Magnitude Costs

IMPROVEMENT	UNIT COST
Trunk SMFOC Cable	$5/LF
Breakout SMFOC Cable	$2/LF
Fiber Optic Vault	$2,500/Each
Splice Closure	$2,000/Each
Fiber Distribution Unit	$2,000/Each
Standalone Battery Back-Up System	$5,000 /Intersection
GPS based Emergency Vehicle Preemption System	$10,000 /Intersection
Ethernet-Enabled Conflict Monitor Unit	$1,000/Intersection
Power Cycle Relay Switch	$800/Intersection
Adaptive Traffic Signal Deployment	$25,000/Intersection

5.6 Fiber Optic Communication Rings Topology

Fiber optic conduit and cable will be installed during the various implementation plan phases to complete a redundant and self-healing fiber optic communication rings topology around the City. Primary rings, the fiber optic backbone of the communication network, will connect the TMC at City Hall to major roadways throughout Chula Vista including Eastlake Parkway, Fourth Avenue, H Street, L Street, Lane Avenue, Main Street, Olympic Parkway, Orange Avenue, Otay Lakes Road, Proctor Valley Road, and Telegraph Canyon

Road. A secondary ring will provide redundant and robust communications to the future Smart Bayfront area. Linear branches will connect the remaining traffic signals throughout the City to the fiber optic communications network via primary and/or secondary rings. Future development projects that include new traffic signal and roadway improvements should implement new fiber optic communications infrastructure and connect to the rings topology. Future fiber associated with planned development projects, as previously discussed in Section 3 should also connect to the rings topology and be implemented by the Developer per City guidance. The following recommendations are provided for all future fiber optic cable deployments, including existing conduit and new conduit installations:

- Primary rings should be a minimum 144-strand of single-mode fiber optic cable.
- Secondary ring should be a minimum 72-strand single-mode fiber optic cable.
- Linear branches should be a minimum of 36-strand single-mode fiber optic cable.
- Local drop connections, for fiber MFED connections, should be a 12-strand single-mode fiber optic cable.

The fiber optic communications ring topology is depicted in **Figure 5-4**. Buildout of the future traffic systems communications network is summarized in **Appendix F**.

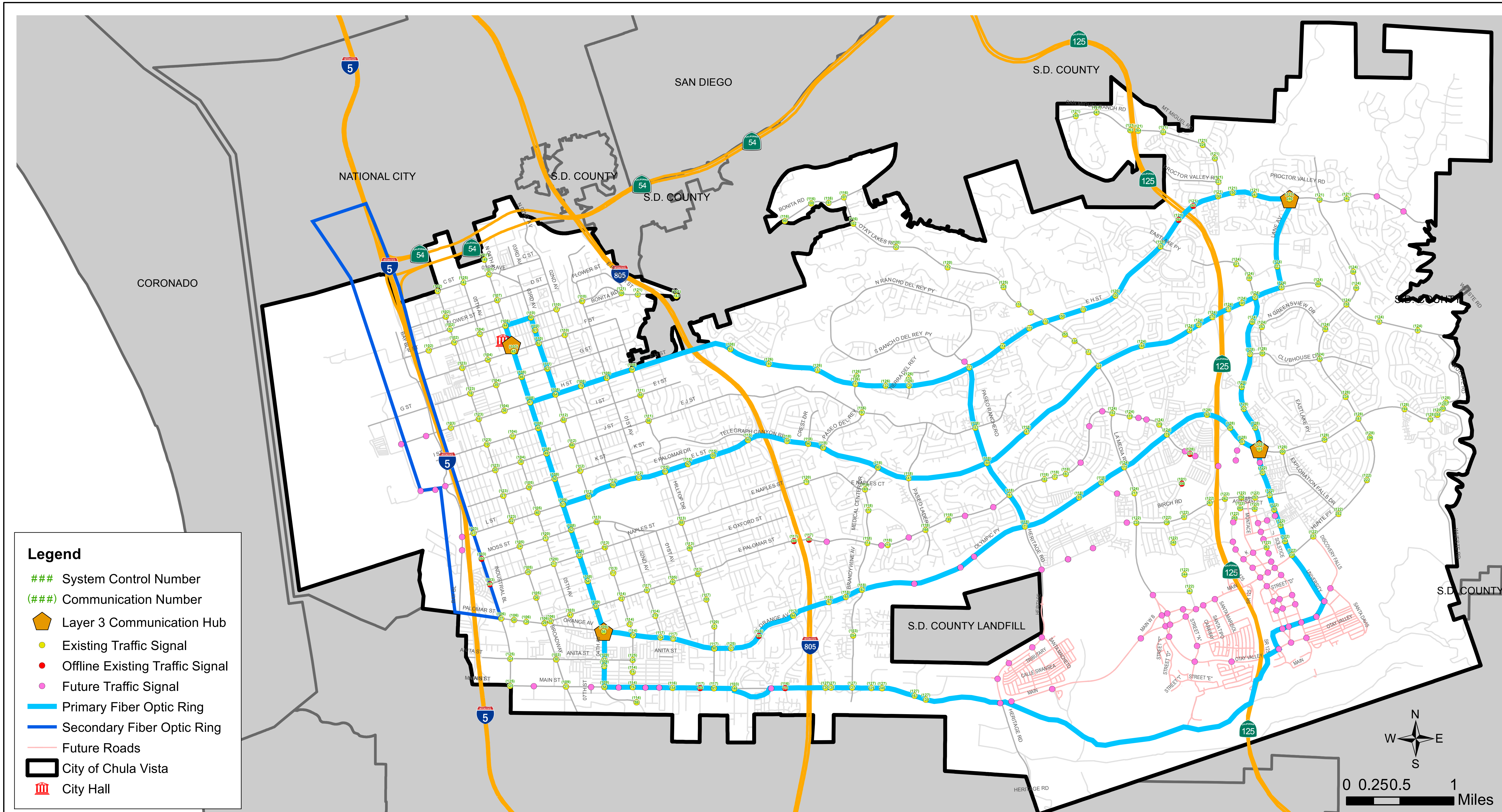

Figure 5-4 Fiber Optic Communication Rings Topology

CITY OF CHULA VISTA

TRAFFIC

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5.7 Order of Magnitude Cost Estimate

A summary of the costs for Master Plan deployment, organized by the implementation phase, is shown on the following tables.

Table 5-2 Phase 1 Deployment Cost Estimate

ITEM #	DESCRIPTION	TOTAL
1	Fiber Optic Communications System Conversion to Ethernet	$187,500
2	Leased Copper Conversion to City-Owned Broadband Wireless and Connected City-Owned Copper Conversion to Ethernet	$2,556,000
3	Leased Cellular Traffic Measurement Devices Conversion to City-Owned Broadband Wireless	$558,750
4	CCTV Camera Video Monitoring at Priority Locations	$336,000
5	Dynamic Message Signs	$285,000
6	Satellite Maintenance Facility Traffic Management Center	$111,300
7	Traffic Signal Controller Ethernet Conversion Upgrade	$160,200
8	Communications Hub Installation	$600,000
	Grand Total	**$4,794,750**

Table 5-3 Phase 2 Deployment Cost Estimate

ITEM #	DESCRIPTION	TOTAL
1	Existing Communications Conduit Upgrade	$1,374,375
2	Fiber Optic Communications Rings Topology	$4,610,700
3	Traffic Signal Equipment Upgrade on Priority Corridors	$1,107,000
	Grand Total	**$7,092,075**

Table 5-4 Phase 3 Deployment Cost Estimate

ITEM #	DESCRIPTION	TOTAL
1	Traffic Signal Equipment Upgrade at Remaining Intersections	$3,763,500
2	Video Detection Equipment Upgrade	$186,000
	Grand Total	**$3,949,500**

Table 5-5 Deployment Cost Estimate by Phase

PHASE	TOTAL
1	$4,794,750
2	$7,092,075
3	$3,949,500
Grand Total	**$15,836,325**

The order of magnitude cost estimate for the Master Plan implementation is $15,836,325. The quantities in the estimate were obtained using information from the GIS database and aerial photography. Quantities for conduit were increased by 10% and fiber optic cable by 25% to account for unknown factors. This cost includes a construction contingency of 25% and soft costs such as engineering, project management, and construction management. The breakdown for each phase and item number is included in **Appendix E**.

The goal of the Master Plan is to provide a citywide fiber optic communications network with state-of-the-art traffic signal communications devices and systems. Financial constraints typically necessitate partial phase implementation. If funding is limited, the focus should start at the TMC and move outward. Intersections along major corridors should be prioritized first before implementing upgrades to intersections on less critical streets.

5.8 Connection to City Facilities

Establishing a citywide fiber optic traffic signal communication system provides opportunities to connect other facilities throughout the City. These include City Hall, police stations, fire stations, libraries, and parks. The facilities can be connected to the fiber optic network individually as the system expands to adjacent corridors and intersections. The integration of the facilities by phase are shown in **Figure 5-6**. A cost estimate for the deployment of facility connections is shown in **Table 5-6** below.

Table 5-6 Deployment Cost Estimate of Connection to City Facilities

PHASE	TOTAL
1	$80,850
2	$254,400
3	$641,400
Grand Total	**$976,650**

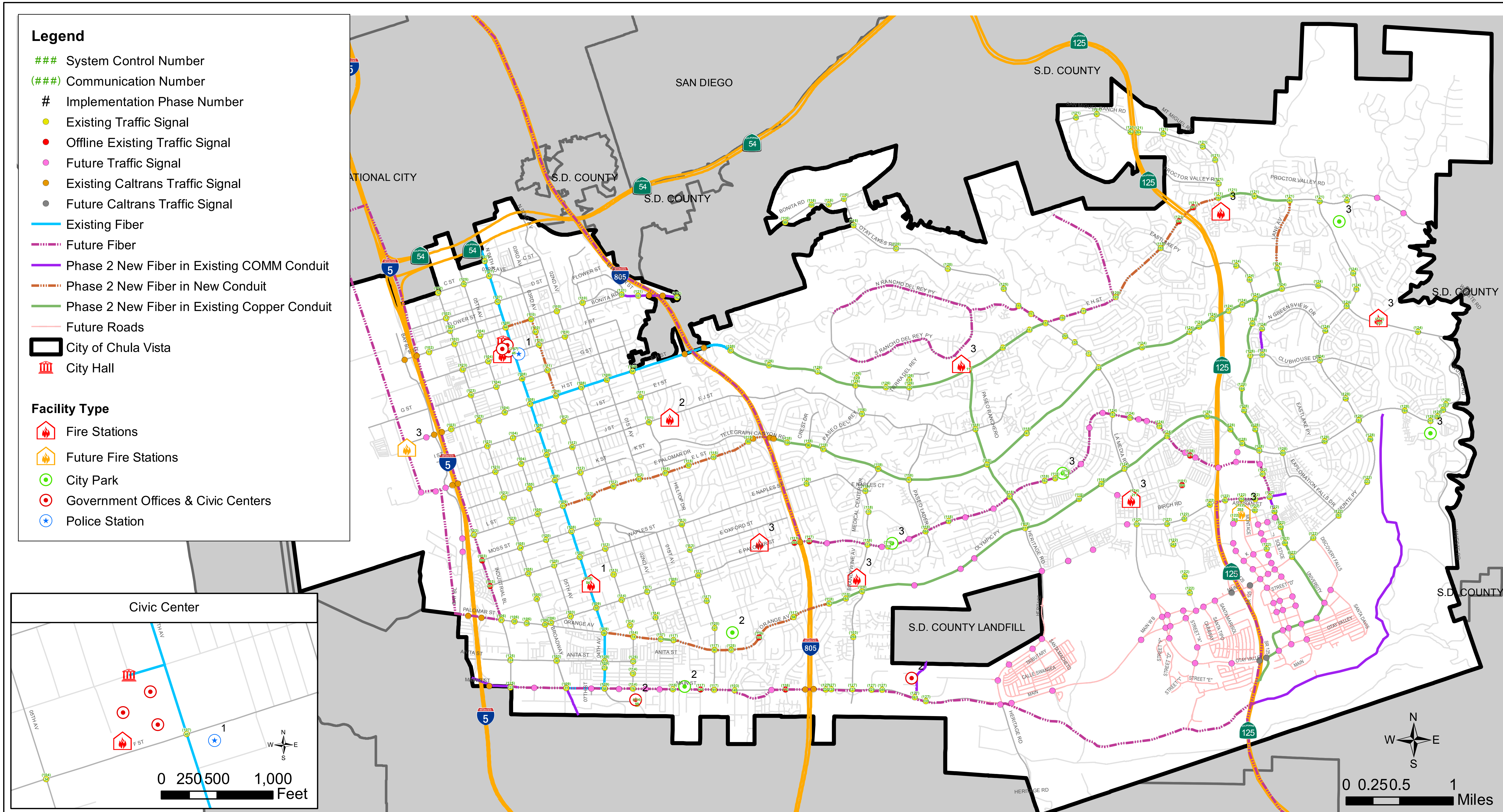

Figure 5-5 Communications System Extension per City Facilities

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5.9 Funding Sources

The City of Chula Vista's Capital Improvement Program (CIP) budget for traffic signal and street related projects is primarily supported by the Transportation Sales Tax (TransNet) and Gas Tax. The City's Transportation Development Impact fees and Transportation grants from the Active Transportation Program (ATP) and Federal Highway Safety Improvement Program (HSIP) also provide funding. Potential funding sources for the City's Traffic Signal Communications Master Plan are identified in the following.

5.9.1 Transportation Sales Tax (TransNet)

Established in 1988, the Transportation Sales Tax (TransNet) is a half-cent sales tax collected by the State of California that is dedicated to transportation improvements in the San Diego region. The program was extended in 2008 for 40 years for $14 billion. The regional metropolitan planning agency, San Diego Association of Governments (SANDAG), allocates funds to municipalities within San Diego County and supports highway, transit, and local street improvements. SANDAG administers funds, as determined by the SANDAG Board of Directors, based on the locally adopted Regional Transportation Plan (RTP), which is updated every three years[1]. Majority approval from the SANDAG Board of Directors and identification of need, as demonstrated in this document, is required to commit TransNet revenue for future deployment of Traffic Signal Communications Master Plan projects.

5.9.2 General Use Sales Tax

Measure P, a temporary half-cent general use sales tax, was approved by voters in Chula Vista. The tax went into effect April 1, 2017 and is expected to generate about $160 million over a 10-year period to repair, replace, and update failing/obsolete City infrastructure including streets, storm drains, public safety equipment, and parks. The tax revenue will be part of the City's General Fund and a citizen oversight committee will be responsible for annual spending plans, accounting, and advising[2].

5.9.3 Gas Tax

Voters approved Proposition 42, utilizing sales tax on fuel to provide funding for City street improvements. These funds have primarily served to augment the City's annual pavement rehabilitation efforts but has also included street reconstruction projects[3].

5.9.4 Development Impact Fees (DIF)

Development Impact Fees (DIF) are collected to mitigate the impact of new development to maintain existing levels of services throughout the community.

5.9.4.1 Transportation Development Impact Fee (TDIF)

The City of Chula Vista Transportation Development Impact Fee (TDIF) Program was established in 1988 and collects development impact fees to be used for constructing transportation facilities to accommodate increased traffic generated by new development within the City's eastern territories[4].

5.9.4.2 Traffic Signal Fee

The City's Traffic Signal Fee is a trip-based development impact fee associated with the issuance of building permits for new construction. This fee can be utilized for the installation and upgrade of traffic signals throughout the City, including traffic signal modifications and pedestrian improvements[5].

5.9.5 City General Funds/Capital Improvement Program

The City of Chula Vista's proposed budget for fiscal year (FY) 2017-2018 includes a CIP budget of $73,871,967 for capital improvement projects citywide. The forecasted five-year CIP program budget is estimated at $133,310,588. The FY 17/18 CIP budget is larger than typical due to Measure P funds. **Table 5-7** provides a summary of forecasted CIP budgets[6]. However, the CIP budgets are subject to change based on new grant opportunities and/or additional Measure P funds.

Table 5-7 FY 17/18-FY 21/22 Forecasted CIP Budget

FY 17/18	FY 18/19	FY 19/20	FY 20/21	FY 21/22	TOTAL
$73,871,967	$15,846,025	$16,265,806	$15,052,802	$12,273,988	$133,310,588

Roadway infrastructure is a major investment of the CIP funds with the bulk allocated to street repairs and other hardscape improvements. To achieve funding for the improvements identified by the Master Plan, a prioritization and recommendation for adoption in the next fiscal year CIP budget and/or as a reassignment of funds in the current fiscal year's budget is necessary.

5.9.6 Grant Opportunities

Grant opportunities for various types of transportation and roadway related infrastructure improvements are available. The most applicable grants for funding the Master Plan improvements are as follows:

5.9.6.1 Community Development Block Grant (CDBG) Funds

The City receives annual Community Development Block Grant (CDBG) funds for community development activities, including capital improvement projects. The bulk of the funds are allotted to the completion of the Castle Park Infrastructure Projects however, approximately $300,000-$500,000 are available for other capital improvement projects, including roadway related projects, annually for the next 14 years [7].

5.9.6.2 Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

The Fixing America's Surface Transportation Act (FAST Act) established the Advanced Transportation and Congestion Management Technologies Deployment Grant Program to develop model deployment sites for large scale installation and operation of advanced transportation technologies. The goal of the program is to improve safety, efficiency, system performance, and infrastructure return-on-investment. Funds are obtained through the Highway Research and Development, Technology and Innovation Deployment, and Intelligent Transportation System Research Programs and $60 million dollars is authorized for each fiscal year from 2016 to 2020. It is recommended that the City apply for future grant funding opportunities for innovative transportation technologies identified in the Master Plan that meet the required criteria[8].

5.9.6.3 Highway Safety Improvement Program (HSIP)

The Map-21 Highway Safety Improvement Program (HSIP) is a data-driven strategic approach to improving highway safety on all public roads. Performance-based, this program achieves a significant reduction in traffic fatalities and serious injuries on all public roadways. A highway safety improvement project is any strategy, activity, or project on a public road that is consistent with the data-driven State Strategic Highway Safety Plan (SHSP) and corrects or improves a hazardous road location or feature or addresses a highway safety problem[9]. It is recommended that the City apply for HSIP funding as improvements recommended in the Master Plan qualify for the grant. Also notable is the staff time required to apply for and administer the grant. Additionally, funding matches by the City may be required dependent on project improvements.

5.9.7 Assembly Bill 1447

Assembly Bill 1447 was passed on August 20, 2014 and clarifies that synchronization projects can qualify for money raised by the California Cap-and-Trade program, which seeks to cut greenhouse gas emissions. The carbon marketplace has generated approximately $5 billion in revenue since initiated in 2012[10]. The Cap-and-Trade program money is held by the Greenhouse Gas Reduction Fund. The Master Plan improvements qualify for funding through this legislation with the recommended technology being proven to reduce Green House Gasses (GHG's). As the process for administering these funds for traffic synchronization projects is determined, the City should present Master Plan improvements for funding.

5.9.8 Partnerships

Rising demand for high speed communication has increased the rate of telecommunication installation and upgrades in both the public and private sectors. Utilizing partnerships with interested parties could advance the Master Plan build. Each entity is unique and the best approach to partnering will depend on the factors involved.

5.9.8.1 Public-Private Partnership

As private companies and public agencies expand their telecommunication networks in Chula Vista, there may be opportunities for the City or private company to partner and cost share the installation and expansion of network infrastructure. The City should develop a policy to review planned installations of utilities within the City and cross reference the Master Plan for overlapping locations or additional routes for redundancy.

It is important that the City maintain control over its facility. Maintenance access, expansion, and future allocations require as high a degree as possible of physical separation. Order of precedence for infrastructure installation through public-private partnerships is as follows:

- Install City-owned conduit, vaults, and cable. This is most desirable and most expensive and unless associated with new construction can be cost prohibitive.
- Install separate cable in shared conduit and separate splice enclosures.
- Install shared cable and for proper segregation and maintenance of the system the minimum granularity of fiber designated for City allocation should be 12 (a complete buffer tube).
- If existing cable and limited fiber strands designate a minimum of 4 fibers for the City.
- The least desirable arrangement is sharing the same fiber with non-City entities.

Development projects should be conditioned to implement communication systems infrastructure as part of the overall facilities improvement requirements. This includes communications ducts, cable, splice vaults, and connectivity to City facilities.

5.9.8.1.1 Small Cell Networks

The telecommunications industry is utilizing small cell networks to expand wireless carrier network coverage and increase capacity for both voice and data across new generation mobile phone technology and Wi-Fi networks. In comparison to traditional cell towers, small cell networks utilize smaller nodes that require lower power and cover smaller areas. Increased node density enables larger coverage areas with more capacity than a traditional cell tower can provide. Nodes are installed on existing infrastructure such as telephone poles or street lights and connected to a central hub by fiber optic cable. This provides local agencies with opportunities to partner with private companies and receive infrastructure improvements in exchange for furthering current telecommunications company pursuits. For example, an agency could allow installation of nodes on City-owned street lights and fiber optic cable in City right-of-way in exchange for City-owned conduit and fiber optic cable installed by the private company. Different agreements of different magnitudes, such as full-funding or shared-cost partnerships, can be made. Small cell network partnerships can provide a good opportunity for an agency to obtain needed infrastructure at reduced costs outside of the CIP process.

5.9.8.2 Public-Public Partnerships

Like public-private partnerships there are opportunities to construct communications infrastructure through public-public partnerships. These would be interdepartmental projects within the City with Parks/ Recreation, Wastewater, IT, Police/Fire, and Public Works. These would also be regional or adjacent agency projects such as SANDAG, Caltrans, MTS, Port of San Diego, and the City of San Diego. Any construction that requires opening a trench in the public Right-of-Way is an opportunity for the City to have a conduit and vaults installed at no cost or a shared cost since the cost of construction is already incurred.

Additionally, existing and future street lighting system conduit should also be considered for establishing communications to traffic signals, other City Departments, and/or for Smart City initiatives.

5.10 Procurement and Delivery Methods

The City of Chula Vista's traffic signal communications system procurement choices impact deployment effectiveness and Return on Investment (ROI). Procurement and delivery methods include: best value procurement, design-bid-build, design-build, and system manager-integrator. The challenge associated with choosing the optimum procurement and delivery method lies in tailoring the specific work into bid packages and projects that achieve balance in technical complexity, system quality, cost savings, and deployment schedule. Many of the Master Plan systems are able to be deployed incrementally by system as well as all at once by a given area or group of areas. Contracting options are as follows:

5.10.1 Best Value Procurement

The Best Value Procurement process includes an analysis of technical alternatives to identify potential new systems that flow into a set of system requirements, becoming a technical specification. These technical specifications are incorporated into the "best-value" bid packages for equipment procurement. This typically results in reduced pricing as vendors compete with one other for equipment purchase agreements directly with the agency rather than through a contractor. The best value bid packages and equipment purchase agreements enable rapid system procurement of desired elements, ultimately benefiting the schedule significantly in comparison to typical bid advertisement processes. The systems can be installed and integrated by agency staff, the agency's on-call consultant firm, and/or a contract maintenance company[11].

5.10.2 Design-Bid-Build

Design–Bid–Build (D-B-B) is the traditional project delivery method where the agency contracts with separate entities for the design and construction of a project. The three main phases that occur sequentially during the D-B-B method include: design phase, bidding phase, and construction[12]. This delivery method can be used effectively to deploy physical Master Plan components such as communications infrastructure (conduit systems, fiber optic cable, pull boxes, etc.), foundations, and structure. However, it may not be suited for ITS projects involving software development, computer hardware, system integration, and system configuration. This method may be counterproductive for ITS applications as they cannot be effectively separated into design and construction services. The lowest bid may result in a contractor that is incapable of performing the required ITS-related services.

5.10.3 Design-Build

The Design–Build (D–B) project delivery method includes the contract of design and construction services by a single entity known as the design-build contractor. This contrasts from the Design-Bid-Build project delivery method in that the Design-Build utilizes a single point of contract responsibility, minimizing risks for the project owner and reducing the delivery schedule by overlapping the design and construction phases of the project. One single contract is awarded to a design-build team who is responsible for[13]:

- System engineering, design, and specifications.

- Procurement and provision of all products, systems, and services.
- Construction of all system elements.
- Testing, inspection, and integration of various subsystems.

Proceeding with the Design-Build project delivery method depends on agency policy and implementation timelines, and well-defined functional specifications. Project costs associated with D-B delivery method are typically higher due to the contractor taking on greater responsibility. This method may also result in engineering decisions being influenced by the builder in a contest of best design versus cost.

5.10.4 System Manager – Integrator

The System Manager-Integrator (SM-I) delivery method includes a consultant, under an engineering and design services contract, that performs or oversees the performance of all system/project engineering, design, interface, integration, and configuration functions while one or more contractors, under a construction contract, performs all related construction activities. This project delivery method combines design and implementation of work components under one contract including: testing, integration, configuration, and procurement support. These components of work are the most complex and require advanced expertise but are typically small in terms of total project costs. The System Manager-Integrator services are procured based on qualifications which enables the agency to have a high degree of control through a single point of management [14].

5.11 Master Plan Cost and Benefit Analysis

Implementation of the Master Plan is an investment in traffic systems technology that will improve traffic management, promote an environment for economic growth, and increase quality of life for Chula Vista residents. Implementation phasing costs, travel time, fuel, and emissions benefits were analyzed and a significant return on investment was identified.

5.11.1 Master Plan Costs

The annual Master Plan investment is summarized by phase in **Table 5-8** and on **Figure 5-6**. Phase 1 prioritizes City-owned communications infrastructure and ITS elements including CCTV cameras, fixed and portable CMS's, and a Sattelite TMC at the City's Traffic Signal Maintenance facility. Phase 2 upgrades twisted pair copper in existing conduit and wireless communications to fiber optic communications and upgrades priority corridors with the 2070 ATC controller platform and CCTV cameras. Phase 3 upgrades remaining signals to the 2070 ATC platform and converts analog video detection to Ethernet. ITS elements for Phase 3 also include CCTV cameras.

Table 5-8 Master Plan Spending by Phase

YEAR	PHASE 1		PHASE 2		PHASE 3		TOTAL
	COMM'S	ITS ELEMENTS	COMM'S	ITS ELEMENTS	COMM'S	ITS ELEMENTS	
1	$1,354,150	$244,100	-	-	-	-	$1,598,250
2	$1,354,150	$244,100	-	-	-	-	$1,598,250
3	$1,354,150	$244,100	-	-	-	-	$1,598,250
4	-	-	$1,635,019	$138,000	-	-	$1,773,019
5	-	-	$1,635,019	$138,000	-	-	$1,773,019
6	-	-	$1,635,019	$138,000	-	-	$1,773,019
7	-	-	$1,635,019	$138,000	-	-	$1,773,019
8	-	-	-	-	$544,500	$772,000	$1,316,500
9	-	-	-	-	$544,500	$772,000	$1,316,500
10	-	-	-	-	$544,500	$772,000	$1,316,500
Subtotal	**$4,062,450**	**$732,300**	**$6,540,075**	**$552,000**	**$1,633,500**	**$2,316,000**	**-**
Total	**$4,794,750**		**$7,092,075**		**$3,949,500**		**$15,836,325**

5.11.2 Master Plan Benefits

Annual benefits for travel time, fuel consumption, and Carbon Monoxide emissions were estimated based on Phase 1 implementation. **Table 5-9** below provides a summary of the annual Phase 1 monetary benefit saving in comparison with the annual Phase 1 implementation costs.

Table 5-9 Phase 1 Benefit Summary (Per Year)

# OF INT[1]	TT[2] (HR)	FUEL CON[3] (GAL)	CO EMISS[4] (MT CO_{2E})	TT SAVINGS[5]	FUEL SAVINGS[6]	CO EMISS SAVINGS[7]	PHASE 1 ANNUAL SAVINGS	PHASE 1 ANNUAL COST	BENEFIT : COST
267	-1.399M	-34.223M	-28,755	$764,107	$99.931M	$3,306,769	$104.002M	$1.598M	65

INT=Intersections, TT=Travel Time, CON=Consumption, EMISS=Emissions

1. Total number of intersections affected during Phase 1.
2. Hours spend in traffic in Chula Vista (46.2 hours per year per traveler) based on the INRIX 2016 Global Traffic Scorecard. 76% of the City's population drives to work based on data from Zip Atlas. 15% typical improvement in travel time for synchronization per ITE Typical Savings.
3. Fuel saved per intersection of 7,835 gallons/day with 260 work week days based on Fuel Savings from Retiming for 140 traffic signals with existing coordination timing. Typical 12% reduction in fuel usage based on signal synchronization per ITE Typical Savings.
4. Average CO2e of 41,078 lbs per 200 signals based on average savings documented from LADOT and OCTA's signal synchronization projects.
5. Travel Time savings of $16.79/hour of person travel based on 2015 Urban Mobility Report per Texas A&M Transportation Institute.
6. Fuel Consumption savings of $2.92 based on CA State average cost/gallon of gasoline and diesel per US Energy Information Administration.
7. CO emissions savings of $115/ton based on Highway Economic Requirements System Technical Report per US Department of Transportation.

Figure 5-6 Annual Master Plan Investment by Phase

S:\Projects\Chula Vista\0347_Chula Vista Traffic Signal Communications Master Plan\06 Excel-Calcs\Cost Benefits Analysis

5.11.3 Cost Effectiveness

Based on the cost-effectiveness methodology presented above, the resulting annual benefit-cost ratio for implementing Phase 1 is 65:1. This indicates that improvements would yield benefits of $65 dollars for every $1 dollar spent. With cost savings exceeding the State and National benefit-cost ratio range of 20 to 60:1 ROI for Phase 1 alone, the monetary investments identified in the Master Plan are poised to be recaptured many times over for both economic and social benefit.

5.11.4 Master Plan Maintenance

The Master Plan maps should be kept updated every 6 months to reflect changes in the system topology and architecture. This will require transfer of the GIS files developed for the Master Plan and coordination with the City's Information Technology Services GIS group. A full review and update of the Master Plan should take place every 5 years as an addendum to the original document.

6 References

Executive Summary

- 1: City of Chula Vista GIS Shapefiles, City of Chula Vista, March 2016
- 2: Chula Vista Bayfront Roadway Plan, City of Chula Vista, June 2016
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  Otay Ranch Villages Sectional Planning Area Plans, City of Chula Vista, 2016
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- 3: Largest Cities in San Diego County by Population, United States Census Bureau 2010 Census, 2010
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2. Existing Systems Assessment

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- 2: City Hall Building Plans, City of Chula Vista, April 2016

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- 4: SCATS Network Layout Report, City of Chula Vista, March 2016
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4. Future System Architecture and ITS Elements

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- 6: Personal Signal Assistant, Traffic Technology Services, 2017
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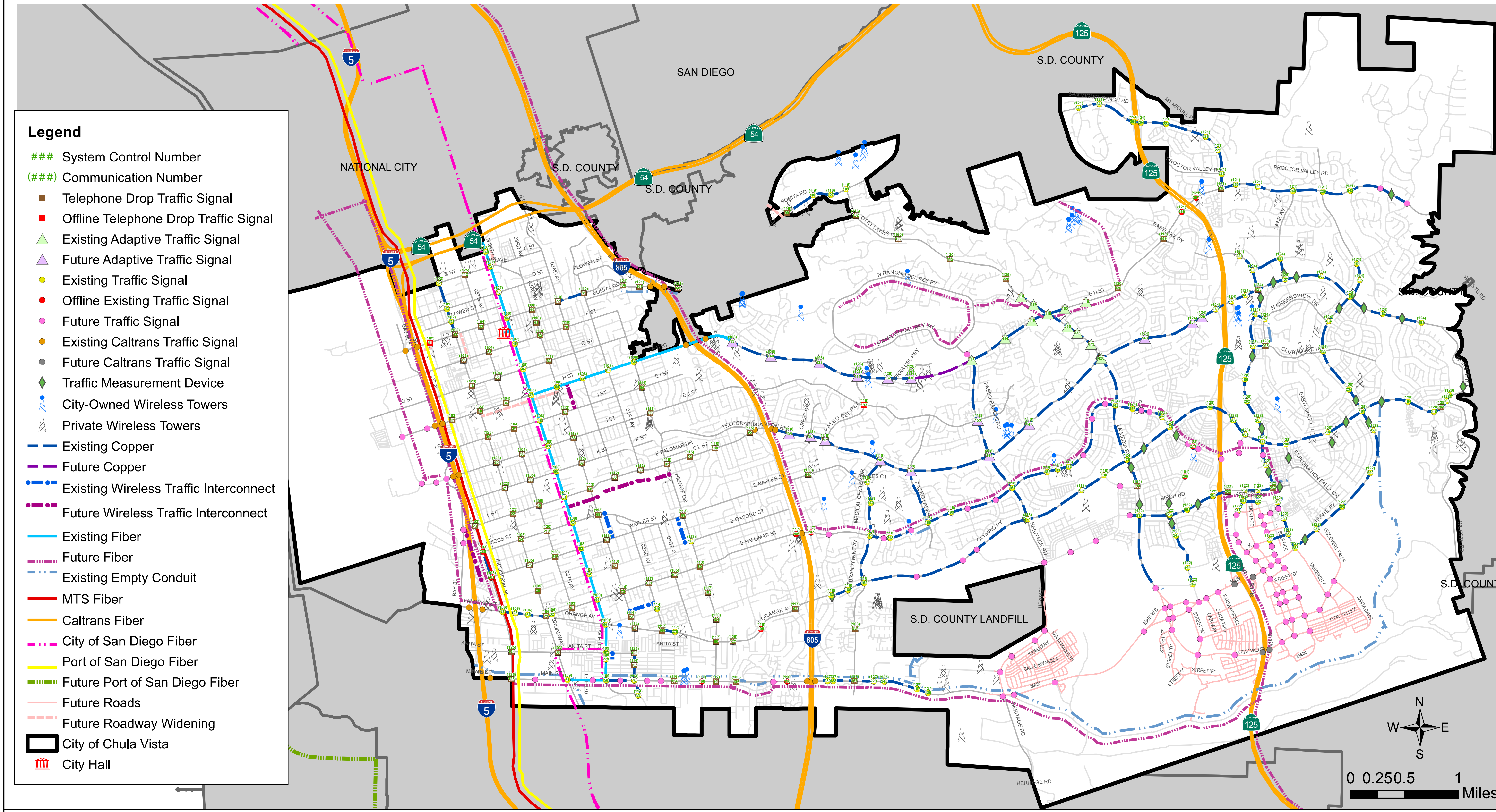
APPENDIX A

EXISTING TRAFFIC SYSTEMS TOPOLOGY AND FUTURE IMPROVEMENTS OPPORTUNITY AREAS



CITY OF CHULA VISTA

City of Chula Vista
Traffic Signal Communications Master Plan
Existing Traffic Systems Topology and Future Improvements Opportunity Areas

TRAFFIC

APPENDIX B

EXISTING TRAFFIC SIGNAL COMMUNICATIONS ARCHITECTURE

City of Chula Vista Traffic Signal Communications Master Plan

Existing Traffic System Communications Network Topology

0347 EX TS Communications Architecture.vsdx

APPENDIX C

FUTURE TRANSPORTATION PROJECTS & TRAFFIC SIGNALS

Future Road Widening

PROJECT NAME	PROJECT DESCRIPTION	SOURCE
E STREET WIDENING	WIDEN E STREET BETWEEN WOODLAWN AND I-5 TO ADD A WESTBOUND RIGHT-TURN LANE AT THE I-5 NB RAMP, IMPROVE OPERATIONS AT THE I-5 NB RAMP, AND REDUCE QUEUES IN THE WESTBOUND DIRECTION.	URBAN CORE SPECIFIC PLAN
H STREET WIDENING	WIDEN H STREET BETWEEN THIRD AVENUE AND BROADWAY BY 8 FEET FOR A NEW SEGMENT CONFIGURATION AND BUILDOUT TRAFFIC.	URBAN CORE SPECIFIC PLAN
BROADWAY WIDENING	WIDEN BROADWAY BETWEEN E STREET AND F STREET BY 14 FEET FOR A CONSISTENT ROADWAY SEGMENT CONFIGURATION.	URBAN CORE SPECIFIC PLAN
WILLOW STREET BRIDGE WIDENING	REPLACE AND WIDEN BRIDGE INCLUDING SHOULDERS.	SANDAG 2050 RTP, TABLE A.8 - PHASED ARTERIAL PROJECTS - REVENUE CONSTRAINED PLAN
NORTH FOURTH AVENUE AND BRISBANE STREET WIDENING	ADD ADDITIONAL TRAVEL LANE ON THE EAST SIDE OF FOURTH AVE.	SANDAG 2050 RTP, TABLE A.8 - PHASED ARTERIAL PROJECTS - REVENUE CONSTRAINED PLAN

Future Traffic Communications Interconnect

INTERCONNECT	PROJECT DESCRIPTION	SOURCE
COPPER	INSTALL NEW COPPER BASED WIRE INTERCONNECT TO CLOSE THE COMMUNICATIONS GAP BETWEEN EAST H STREET/ TIERRA DEL REY AND EAST H STREET/ PASEO RANCHERO.	ATCS EXPANSION PROJECT
FIBER	IN COOPERATION WITH MTS, NEW CITY-OWNED CONDUIT AND SINGLEMODE FIBER OPTIC CABLE WILL BE INSTALLED ALONG PORTIONS OF THE I-805, EAST PALOMAR STREET, EASTLAKE PARKWAY, BIRCH ROAD, AND THE SR-125.	SOUTH BAY RAPID PROJECT
FIBER	IN COOPERATION WITH MTS, NEW CONDUIT AND FIBER WILL BE INSTALLED ALONG MAIN STREET FROM INDUSTRIAL BOULEVARD TO SR-125. A CITY-OWNED INNERDUCT AND DEDICATED FIBER WILL BE INCLUDED.	MAIN STREET FIBER OPTIC PROJECT
FIBER	IN COOPERATION WITH A PRIVATE DEVELOPMENT PROJECT IN THE RANCHO DEL REY AREA, NEW CONDUIT XXX SINGLEMODE FIBER OPTIC CABLE WILL BE INSTALLED ALONG PORTIONS OF NORTH RANCHO DEL REY PARKWAY, SOUTH RANCHO DEL REY PARKWAY, RIDGEBACK ROAD, OTAY LAKES ROAD, EAST H STREET, AND CORRAL CANYON ROAD.	CITY OF CHULA VISTA STAFF
WIRELESS	INSTALL WIRELESS RADIO COMMUNICATIONS FROM INDUSTRIAL BOULEVARD AND L STREET (EXISTING TELEPHONE DROP SIGNAL) TO INDUSTRIAL BOULEVARD AND NAPLES STREET	CITY OF CHULA VISTA STAFF
WIRELESS	INSTALL WIRELESS RADIO COMMUNICATIONS FROM FOURTH AVENUE AND L STREET (EXISTING FIBER SIGNAL) TO HILLTOP DRIVE AND L STREET	CITY OF CHULA VISTA STAFF
WIRELESS	INSTALL WIRELESS RADIO COMMUNICATIONS FROM THIRD AVENUE AND H STREET (EXISTING FIBER SIGNAL) TO THIRD AVENUE AND I STREET	CITY OF CHULA VISTA STAFF

Future Traffic Signals

TRAFFIC SIGNAL LOCATION	SOURCE
MAIN ST/HERITAGE RD	VILLAGE 3 SPA
HERITAGE RD/SANTA MACHETO	VILLAGE 3 SPA
HERITAGE RD/SANTA PICACHO	VILLAGE 3 SPA
HERITAGE RD/SANTA MAYA	VILLAGE 3 SPA
HERITAGE RD/ENERGY WAY	VILLAGE 3 SPA
MAIN ST/QUARRY ACCESS RD	VILLAGE 3 SPA
MAIN ST/PRIVATE RD	VILLAGE 3 SPA
MAIN ST/SANTA MARISOL	VILLAGE 8E SPA
OTAY VALLEY RD/SANTA MARISOL	VILLAGE 8E SPA
DISCOVERY FALLS DR/SANTA DAVIS	VILLAGE 10 SPA
DISCOVERY FALLS/UNIVERSITY DR	VILLAGE 10 SPA
DISCOVERY FALLS DR/SANTA JULIARD	VILLAGE 10 SPA
DISCOVERY FALLS DR/STREET 'B'	VILLAGE 10 SPA
OTAY VALLEY RD/MAIN ST	CITY OF CHULA VISTA STAFF
LA MEDIA RD SB/MAIN ST WB	VILLAGE 8W SPA
LA MEDIA RD SB/MAIN ST EB	VILLAGE 8W SPA
LA MEDIA RD NB/MAIN ST EB	VILLAGE 8W SPA
STREET 'A'/MAIN ST WB	VILLAGE 8W SPA
OTAY VALLEY RD/STREET 'C'	VILLAGE 8W SPA
STREET 'A'/MAIN ST EB	VILLAGE 8W SPA
OTAY VALLEY RD/STREET 'A'	VILLAGE 9 SPA, VILLAGE 8W SPA
STREET 'A'/STREET 'B'	VILLAGE 8W SPA
LA MEDIA RD NB/MAIN ST WB	VILLAGE 8W SPA
MILLENIA AVE/HUNTE PKWY	VILLAGE 9 SPA
HUNTE PKWY/ORION AVE	VILLAGE 9 SPA
STREET "C"& STREET "F"/STREET "A"	VILLAGE 9 SPA
STREET "C"/STREET "B"	VILLAGE 9 SPA
STREET "E"/STREET "B"	CITY OF CHULA VISTA STAFF
STREET "E"/STREET "A" NB	VILLAGE 9 SPA
STREET "E"/STREET "A" SB	VILLAGE 9 SPA
CAMPUS BLVD/STREET "B"	VILLAGE 9 SPA
CAMPUS BLVD/STREET "A" NB	VILLAGE 9 SPA
CAMPUS BLVD/STREET "A" SB	VILLAGE 9 SPA
STREET "I"/STREET "A" NB	VILLAGE 9 SPA
STREET "I"/STREET "A" SB	VILLAGE 9 SPA
OTAY VALLEY RD/STREET "A"	VILLAGE 9 SPA
OTAY VALLEY RD/STREET "I"	VILLAGE 9 SPA
E PALOMAR/MEDICAL CENTER CT	CITY OF CHULA VISTA STAFF
E PALOMAR/SANTA OLIVA/SANTA CARINA	CITY OF CHULA VISTA STAFF
E PALOMAR/SANTA MARIA/SANTA SIERRA	CITY OF CHULA VISTA STAFF
E PALOMAR/SANTA ALICIA	CITY OF CHULA VISTA STAFF
E PALOMAR/SANTA FLORA	CITY OF CHULA VISTA STAFF
E PALOMAR/SANTA DELPHINA	CITY OF CHULA VISTA STAFF
E PALOMAR/VISTA SONRISA	CITY OF CHULA VISTA STAFF

TRAFFIC SIGNAL LOCATION	SOURCE
E PALOMAR ST/OLEANDER AV	CITY OF CHULA VISTA STAFF
E PALOMAR ST/SHOPPING CTR	CITY OF CHULA VISTA STAFF
OLYMPIC PW/FUTURE RD	CITY OF CHULA VISTA STAFF
OLYMPIC PW/FUTURE RD	CITY OF CHULA VISTA STAFF
OLYMPIC PW/FUTURE RD	CITY OF CHULA VISTA STAFF
MAIN ST	CITY OF CHULA VISTA STAFF
MAIN ST/MAGDALENA AV	CITY OF CHULA VISTA STAFF
MAIN ST/SANTA TIPO	CITY OF CHULA VISTA STAFF
SANTA VENETIA ST/SANTA VICTORIA RD	CITY OF CHULA VISTA STAFF
TOWN CENTER DR/FUTURE RD	CITY OF CHULA VISTA STAFF
TOWN CENTER DR/FUTURE RD	CITY OF CHULA VISTA STAFF
SR-125 NB/FUTURE RD	CITY OF CHULA VISTA STAFF
EASTLAKE PW/ENTRANCE	CITY OF CHULA VISTA STAFF
MILLENIA AVE/FIRE STATION SIGNAL	CITY OF CHULA VISTA STAFF
BOB PLETCHER WY/MILLENIA AVE	CITY OF CHULA VISTA STAFF
MILLENIA AVE/FUTURE INTERSECTION	CITY OF CHULA VISTA STAFF
K STREET/MILLENIA AVE	CITY OF CHULA VISTA STAFF
AVANT ST/MILLENIA AVE	CITY OF CHULA VISTA STAFF
K STREET/MONTACE	CITY OF CHULA VISTA STAFF
HUNTE PW/MONTACE	CITY OF CHULA VISTA STAFF
AVANT ST/BRT	CITY OF CHULA VISTA STAFF
J ST/BRT	CITY OF CHULA VISTA STAFF
H ST/BRT	CITY OF CHULA VISTA STAFF
G ST/C ST	CITY OF CHULA VISTA STAFF
AGUA VISTA DR & PROCTOR VALLEY RD	CITY OF CHULA VISTA STAFF
PROCTOR VALLEY RD & COASTAL HILLS	CITY OF CHULA VISTA STAFF
E PALOMAR ST&VIEW PARK WY	CITY OF CHULA VISTA STAFF
E PALOMAR ST&MAGDALENA AV	CITY OF CHULA VISTA STAFF
E PALOMAR ST&VISTA SONRISA CROSSWALK	CITY OF CHULA VISTA STAFF
LA MEDIA RD&SANTA LUNA ST	CITY OF CHULA VISTA STAFF
PASEO MAGDA&PASEO RANCHERO	CITY OF CHULA VISTA STAFF
SANTA CHRISTINA AV&SANTA VICTORIA RD	CITY OF CHULA VISTA STAFF
STATE ST&RETAIL DR	CITY OF CHULA VISTA STAFF
SANTA ALEXIA AV&SANTA VICTORIA RD	CITY OF CHULA VISTA STAFF
HERITAGE RD &SANTA VICTORIA RD	CITY OF CHULA VISTA STAFF
ORION AV&NORTHERLY DRIVEWAY	CITY OF CHULA VISTA STAFF
BRT GUIDEWAY & SOLSTICE AV	CITY OF CHULA VISTA STAFF
SANTA CHRISTINA AV&SANTA VICTORIA RD	CITY OF CHULA VISTA STAFF
BRT GUIDEWAY & CROSSWALK AT EASTLAKE PW	CITY OF CHULA VISTA STAFF
J ST & BAY BLVD	BAYFRONT MASTER PLAN
L ST & BAY BLVD	BAYFRONT MASTER PLAN
BAY BLVD & I-5 SB	BAYFRONT MASTER PLAN
H ST & STREET "A"	BAYFRONT MASTER PLAN
J ST & MARINA PKWY	BAYFRONT MASTER PLAN
J ST & STREET "A"	BAYFRONT MASTER PLAN
H ST & MARINA PW	BAYFRONT MASTER PLAN

TRAFFIC SIGNAL LOCATION	SOURCE
DEL MONTE AVE & MAIN ST	MAIN STREET STREETSCAPE MASTER PLAN
BANNER AVE & MAIN ST	MAIN STREET STREETSCAPE MASTER PLAN
OTAY VALLEY RD/MAPLE DR & MAIN ST	MAIN STREET STREETSCAPE MASTER PLAN
JACQUA ST & MAIN ST	MAIN STREET STREETSCAPE MASTER PLAN
7TH ST & MAIN ST	MAIN STREET STREETSCAPE MASTER PLAN
FRESNO AVE & MAIN ST	MAIN STREET STREETSCAPE MASTER PLAN

APPENDIX D

FUTURE TRAFFIC SIGNAL COMMUNICATIONS ARCHITECTURE

Future Traffic System Communications
Network Architecture

APPENDIX E

ORDER OF MAGNITUDE COST ESTIMATES

TRAFFIC SIGNAL COMMUNICATION MASTER PLAN
PHASE 1 ORDER OF MAGNITUDE COST ESTIMATE

Phase: 1 - Item 1
Scenario: Fiber Communications System Conversion to Ethernet
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install Layer 2 Ethernet Switch with 2-Dual Fiber Ports	25	EA	$5,000.00	**$125,000.00**
				Sub Total:	**$125,000.00**
				Soft Costs (25%):	**$31,250.00**
				Construction Contingency (25%):	**$31,250.00**
				Total:	**$187,500.00**

Phase: 1 - Item 2
Scenario: Leased Copper Conversion to City-Owned Broadband Wireless and Connected City-Owned Copper Conversion to Ethernet
Prepared By: STC Traffic, Inc
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install Single Radio	39	EA	$5,000.00	**$195,000.00**
2	Furnish and Install Dual Radio	82	EA	$7,500.00	**$615,000.00**
3	Furnish and Install Sectoral Antenna for Dual Radios	82	EA	$2,000.00	**$164,000.00**
4	Furnish and Install Layer 2 Ethernet Switch with 2-Dual Fiber Ports	146	EA	$5,000.00	**$730,000.00**
				Sub Total:	**$1,704,000.00**
				Soft Costs (25%):	**$426,000.00**
				Construction Contingency (25%):	**$426,000.00**
				Total:	**$2,556,000.00**

Phase: 1 - Item 3
Scenario: Leased Cellular Traffic Measurement Devices Conversion to City-Owned Broadband Wireless
Prepared By: STC Traffic, Inc
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install Single Radio	55	EA	$5,000.00	**$275,000.00**
2	Furnish and Install Dual Radio	13	EA	$7,500.00	**$97,500.00**
				Sub Total:	**$372,500.00**
				Soft Costs (25%):	**$93,125.00**
				Construction Contingency (25%):	**$93,125.00**
				Total:	**$558,750.00**

Phase: 1 - Item 4
Scenario: Video Monitoring at Priority Locations
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install CCTV Camera	28	EA	$8,000.00	**$224,000.00**
				Sub Total:	**$224,000.00**
				Soft Costs (25%):	**$56,000.00**
				Construction Contingency (25%):	**$56,000.00**
				Total:	**$336,000.00**

Phase: 1 - Item 5
Scenario: Dynamic Message Signs
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Dynamic Message Sign - Fixed	1	EA	$150,000.00	**$150,000.00**
2	Dynamic Message Sign - Portable	2	EA	$20,000.00	**$40,000.00**
				Sub Total:	**$190,000.00**
				Soft Costs (25%):	**$47,500.00**
				Construction Contingency (25%):	**$47,500.00**
				Total:	**$285,000.00**

Phase: 1 - Item 6
Scenario: Satellite Maintenance Facility Traffic Management Center
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	IBase Video Wall Server	1	EA	$2,200.00	**$2,200.00**
2	46" Television Monitors with Mounts	4	EA	$18,000.00	**$72,000.00**
				Sub Total:	**$74,200.00**
				Soft Costs (25%):	**$18,550.00**
				Construction Contingency (25%):	**$18,550.00**
				Total:	**$111,300.00**

Phase: 1 - Item 7
Scenario: Traffic Signal Controller Ethernet Conversion Upgrade
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 170E Serial to Ethernet Converter	267	EA	$400.00	**$106,800.00**
				Sub Total:	**$106,800.00**
				Soft Costs (25%):	**$26,700.00**
				Construction Contingency (25%):	**$26,700.00**
				Total:	**$160,200.00**

Phase: 1 - Item 8
Scenario: Communications Hub Installation
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install Layer 3 Communication Hub	4	EA	$100,000.00	**$400,000.00**
				Sub Total:	**$400,000.00**
				Soft Costs (25%):	**$100,000.00**
				Construction Contingency (25%):	**$100,000.00**
				Total:	**$600,000.00**

TRAFFIC SIGNAL COMMUNICATION MASTER PLAN
PHASE 2 ORDER OF MAGNITUDE COST ESTIMATE

Phase: 2 - Item 1
Scenario: Existing Communications Conduit Upgrade
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 3" PVC Conduit	250	LF	$100.00	**$25,000.00**
2	Furnish and Install Fiber Optic Vault	5	EA	$2,500.00	**$12,500.00**
3	Furnish and Install Fiber Optic Pull Box	5	EA	$1,500.00	**$7,500.00**
4	Furnish and Install Trunk SMFO Cable	170,000	LF	$5.00	**$850,000.00**
5	Furnish and Install Breakout SMFO Cable	500	LF	$2.50	**$1,250.00**
6	Furnish and Install Fiber Distribution Unit	5	EA	$2,000.00	**$10,000.00**
7	Furnish and Install Strand Splice Closure	5	EA	$2,000.00	**$10,000.00**
				Sub Total:	**$916,250.00**
				Soft Costs (25%):	**$229,062.50**
				Construction Contingency (25%):	**$229,062.50**
				Total:	**$1,374,375.00**

Phase: 2 - Item 2
Scenario: Wireless Radio Communications to Fiber Optic Communications Upgrade
Prepared By: STC Traffic, Inc
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 3" PVC Conduit	45,000	LF	$50.00	**$2,250,000.00**
2	Furnish and Install Trunk SMFO Cable	50,000	LF	$5.00	**$250,000.00**
3	Furnish and Install Breakout SMFO Cable	3,400	LF	$2.00	**$6,800.00**
4	Furnish and Install Fiber Optic Vault	68	EA	$2,500.00	**$170,000.00**
5	Furnish and Install Splice Closure	68	LF	$2,000.00	**$136,000.00**
6	Furnish and Install Fiber Distribution Unit	68	EA	$2,000.00	**$136,000.00**
7	Furnish and Install Layer 2 Ethernet Switch with 2-Dual Fiber Ports	25	EA	$5,000.00	**$125,000.00**
				Sub Total:	**$3,073,800.00**
				Soft Costs (25%):	**$768,450.00**
				Construction Contingency (25%):	**$768,450.00**
				Total:	**$4,610,700.00**

Phase: 2 - Item 3
Scenario: Traffic Signal Equipment Upgrade on Priority Corridors
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 2070 Controller Assembly	74	EA	$5,000.00	**$370,000.00**
4	Furnish and Install CCTV Camera	46	EA	$8,000.00	**$368,000.00**
				Sub Total:	**$738,000.00**
				Soft Costs (25%):	**$184,500.00**
				Construction Contingency (25%):	**$184,500.00**
				Total:	**$1,107,000.00**

TRAFFIC SIGNAL COMMUNICATION MASTER PLAN
PHASE 3 ORDER OF MAGNITUDE COST ESTIMATE

Phase: 3 - Item 1
Scenario: Traffic Signal Equipment Upgrade at Remaining Intersections
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 2070 Controller Assembly	193	EA	$5,000.00	**$965,000.00**
2	Furnish and Install CCTV Camera	193	EA	$8,000.00	**$1,544,000.00**
				Sub Total:	**$2,509,000.00**
				Soft Costs (25%):	**$627,250.00**
				Construction Contingency (25%):	**$627,250.00**
				Total:	**$3,763,500.00**

Phase: 3 - Item 2
Scenario: Video Detection Equipment Upgrade
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install Analog to Ethernet Video Encoder	155	EA	$800.00	**$124,000.00**
				Sub Total:	**$124,000.00**
				Soft Costs (25%):	**$31,000.00**
				Construction Contingency (25%):	**$31,000.00**
				Total:	**$186,000.00**

TRAFFIC SIGNAL COMMUNICATION MASTER PLAN
CITY FACILITIES ORDER OF MAGNITUDE COST ESTIMATE

Phase: 1
Scenario: Fiber Connection to City Facilities (Police Station, Fire Station)
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 3" PVC Conduit	300	LF	$100.00	**$30,000.00**
2	Furnish and Install Fiber Optic Pull Box	3	EA	$1,500.00	**$4,500.00**
3	Furnish and Install Layer 2 Ethernet Switch with 2-Dual Fiber Ports	2	EA	$5,000.00	**$10,000.00**
4	Furnish and Install Breakout SMFO Cable	700	LF	$2.00	**$1,400.00**
5	Furnish and Install Fiber Distribution Unit	2	EA	$2,000.00	**$4,000.00**
6	Furnish and Install Splice Closure	2	EA	$2,000.00	**$4,000.00**
				Sub Total:	**$53,900.00**
				Soft Costs (25%):	**$13,475.00**
				Construction Contingency (25%):	**$13,475.00**
				Total:	**$80,850.00**

Phase: 2
Scenario: Fiber Connections to City Facilities (Fire Station 3, Otay Rec Center, Chula Vista Transit)
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

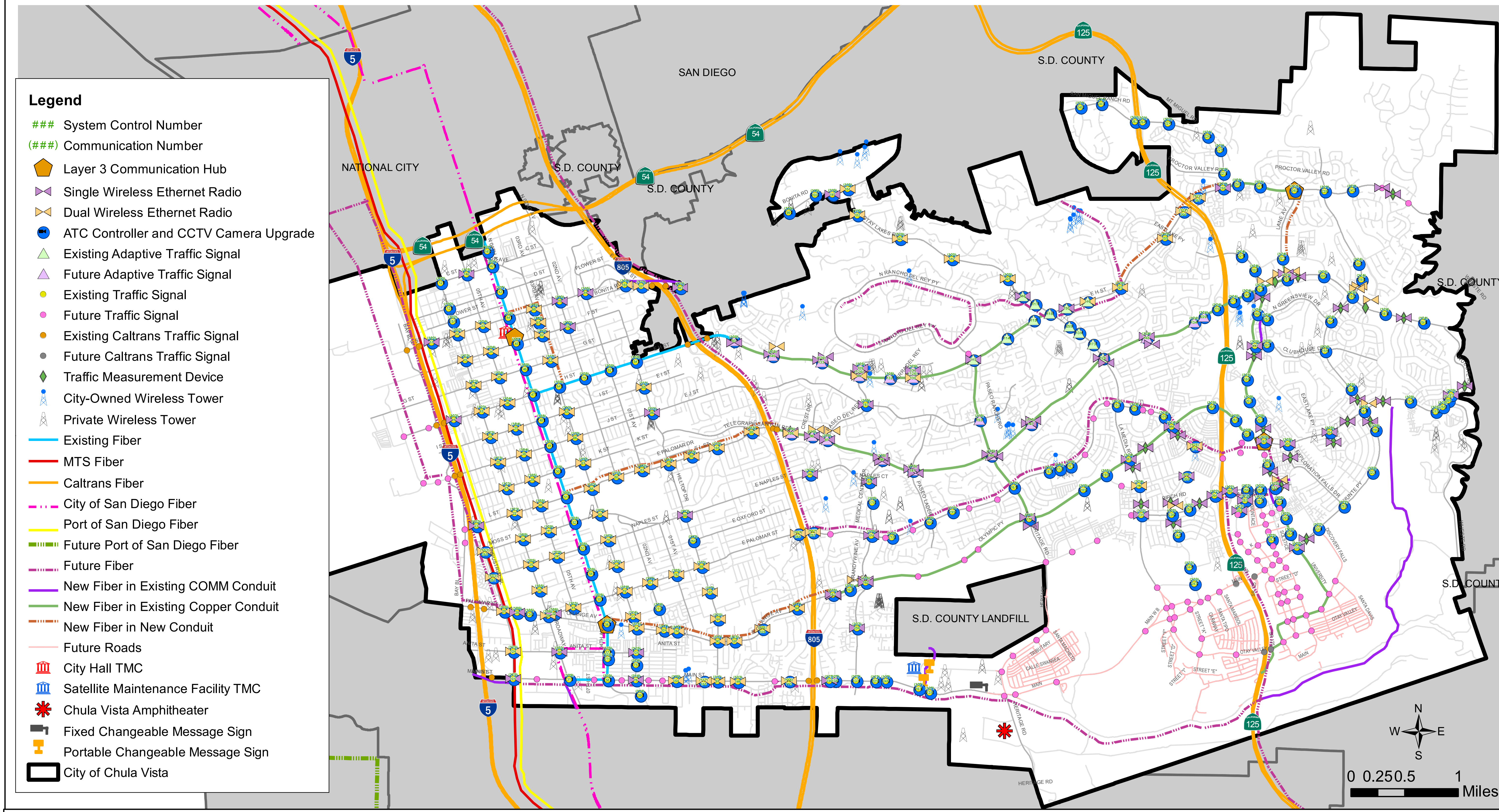
Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 3" PVC Conduit	2,300	LF	$50.00	**$115,000.00**
2	Furnish and Install Fiber Optic Pull Box	14	EA	$1,500.00	**$21,000.00**
3	Furnish and Install Layer 2 Ethernet Switch with 2-Dual Fiber Ports	3	EA	$5,000.00	**$15,000.00**
4	Furnish and Install Breakout SMFO Cable	3,300	LF	$2.00	**$6,600.00**
5	Furnish and Install Fiber Distribution Unit	3	EA	$2,000.00	**$6,000.00**
6	Furnish and Install Splice Closure	3	EA	$2,000.00	**$6,000.00**
				Sub Total:	**$169,600.00**
				Soft Costs (25%):	**$42,400.00**
				Construction Contingency (25%):	**$42,400.00**
				Total:	**$254,400.00**

Phase: 3
Scenario: Fiber Connections to City Facilities (Fire Stations 3,4,6,7,8,9, Veterans Community Park, Montevalle Community Center)
Prepared By: STC Traffic, Inc.
Date: 7/13/2017

Item #	Item Description	Quantity	Unit	Unit Price	Amount
1	Furnish and Install 3" PVC Conduit	5,400	LF	$50.00	**$270,000.00**
2	Furnish and Install Fiber Optic Pull Box	40	EA	$1,500.00	**$60,000.00**
3	Furnish and Install Layer 2 Ethernet Switch with 2-Dual Fiber Ports	9	EA	$5,000.00	**$45,000.00**
4	Furnish and Install 12 SMFO Cable	8,300	LF	$2.00	**$16,600.00**
5	Furnish and Install Fiber Distribution Unit	9	EA	$2,000.00	**$18,000.00**
6	Furnish and Install 96 Strand Splice Closure	9	EA	$2,000.00	**$18,000.00**
				Sub Total:	**$427,600.00**
				Soft Costs (25%):	**$106,900.00**
				Construction Contingency (25%):	**$106,900.00**
				Total:	**$641,400.00**

APPENDIX F

FUTURE TRAFFIC SIGNAL COMMUNICATIONS NETWORK MAP



City of Chula Vista
Traffic Signal Communications Master Plan
Future Traffic Signal Communications Network Map

Document Path: S:\Projects\Chula Vista\0347_Chula Vista Traffic Signal Communications Master Plan\04 Design\GIS\MXD Files\Chula Vista Comm Phase Implementation Figures.mxd