CITY OF SAN RAMON

INTELLIGENT TRANSPORTATION SYSTEM MASTER PLAN

FINAL REPORT

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Executive Summary

This ITS Master Plan will serve as the City's tool to define essential ITS deployment recommendations needed to take full advantage of the City's communication and traffic signal system and to achieve the City's Smart City goals. The Master Plan process began with an inventory and assessment of the City's existing infrastructure. Then, a Needs Assessment workshop was held with key City Staff Stakeholders from various departments to establish a vision for the plan, as well as goals. The Stakeholders identified key needs which would help to shape the recommendations of the plan. With needs established, gaps were identified to complete the ITS network to achieve the City's identified needs and goals. Once gaps were identified, strategies were developed to eliminate the gaps and account for planned communications infrastructure. Finally, the overall set of planned communications infrastructure was divided into segments and prioritized so that the ITS network could be implemented in phases.

Vision & Goals

The Vision statement provides the framework for the Master Plan and defines the long-range outlook for the intelligent transportation system in the City.

- Establish a plan to implement a comprehensive intelligent transportation system network
- Provide reliable and robust connectivity and cost-effective communications solutions for City facilities and designated areas
- Provide intelligent, scalable, and flexible infrastructure
- Provide a roadmap for implementation
- Establish San Ramon as a Smart City
- Welcoming business environment with next-generation technology and connectivity
- Support deployment of future technologies

The primary goal for the overall master plan is to establish a framework from which the City can plan, design, and implement a comprehensive fiber optic network. This network is for the use by all city agencies and departments, and will carry the city into the next generation of communications technologies and tools and beyond.

Based on discussions with the stakeholders, the primary objectives of the plan are to:

- Connect existing and future City facilities and provide them with high-speed communications;
- Help set priorities for projects to install the communications infrastructure based on available funding;
- Connect designated areas within the City to the high-speed communications network in order to help with attracting businesses and development; and

- Reduce overall operating costs, particularly through eliminating the need for leased line connections.

Proposed ITS Infrastructure

To achieve the goals and address needs summarized as part of this master plan, this section covers the proposed infrastructure required to achieve this end. Proposed fiber optic infrastructure (conduit and cable routing, etc.) and CCTV cameras are proposed for installation around the City.

The majority of the City's existing signal interconnect infrastructure is likely suitable for use in deployment of fiber optic infrastructure. The City of San Ramon's fiber optic network will consist of two types of fiber cables, trunk cables (288-strand single mode fiber optic cable) and distribution cables (48-strand signal mode fiber optic cable). The cable sizes recommended within this Study are anticipated to be sufficient for the anticipated communication needs of the City, but can be increased or decreased depending on cost, procurement, and timeline for any given corridor or segment of new fiber optic cable to be installed.

The proposed layout of the fiber communication system is intended to form a series of "rings," also referred to as a ring topology, with main corridors handling most of the trunk cable rings to provide redundancy in the network. A complete ring will offer an alternate route for the communication of intersections or equipment if there is equipment failure.

There are also new fiber connections proposed to connect existing City facilities and other key areas within the City. Figure E-1 shows the locations of City facilities that are proposed to have connectivity to the fiber optic network.

In addition to communications infrastructure to support the existing traffic signal system and its components, this plan will also recommend the installation of closed circuit television (CCTV) Citywide. To address the City's and Public Safety Community's needs and vision, it is recommended in the nearer term to deploy cameras at key intersections. This plan suggests placement at major arterials, key public areas, or maintenance-sensitive areas Citywide. Strategic CCTV placement will help the City to enhance mobility, responsiveness to issues in the network, and will help to standardize traffic operations through the ability to monitor and diagnose remotely with consistent coverage.

Prioritization of Corridor Segments

The recommended priority for the corridor segments are shown in Table E-1 and in Figure E-1.

Table E-1: Recommended Project Corridor Segment Priorities

Proposed Priority	Corridor	Corridor Name	Cost
1	A	Crow Canyon Road	$3.62M
1a	A1	Crow Canyon Road connection to City Offices (Traffic Server)	$0.32M

Table E-1: Recommended Project Corridor Segment Priorities			
Proposed Priority	Corridor	Corridor Name	Cost
2	C	Downtown	$2.92M
3	E	Bollinger Canyon Road	$2.30M
4	H	Dougherty Road and Bollinger Canyon Road	$3.21M
5	J	Windemere Parkway and East Branch Parkway	$2.05M
6	B	San Ramon Valley Boulevard North	$0.87M
7	K	Alcosta Boulevard and Old Ranch Road	$3.12M
8	F	San Ramon Valley Boulevard South	$3.12M
9	G	Alcosta Boulevard	$1.11M
10	I	Albion Road	$1.02M
11	D	Dougherty Road North	$1.14M
12	L	Bollinger Canyon Road West	$1.83M
		Total	**$26.63M**

The costs were developed based on the proposed infrastructure for each segment and are planning level estimates. The prioritization of the segments was based on several factors including the importance of each corridor with respect to the entire traffic network, number of traffic signals connected, number of City facilities connected and costs.

The Crow Canyon Road corridor is a key access point to the business districts in San Ramon and has the highest number of signals for integration. This corridor is also adjacent the City's Public Works office, which will likely be where network equipment will be located, thus making it the number one priority for deployment of the main system equipment. The Downtown and Bollinger Segments are prioritized next for similar reasons, and because both segments act as connectors to the rest of the City's future network. The projects are further prioritized from there into the areas with the maximum impact for business and City facilities, while prioritizing remote residential areas on a lower basis.

Plan Updates

This Master Plan is a living document that provides a blueprint and roadmap for ITS deployments in the City of San Ramon. As such, it should be updated periodically for changes to the needs and resulting ITS strategies over time as transportation technology evolves. Moreover, the update should include any major changes that would significantly change the course of the plan, and should occur typically within a three- to five-year timeframe.

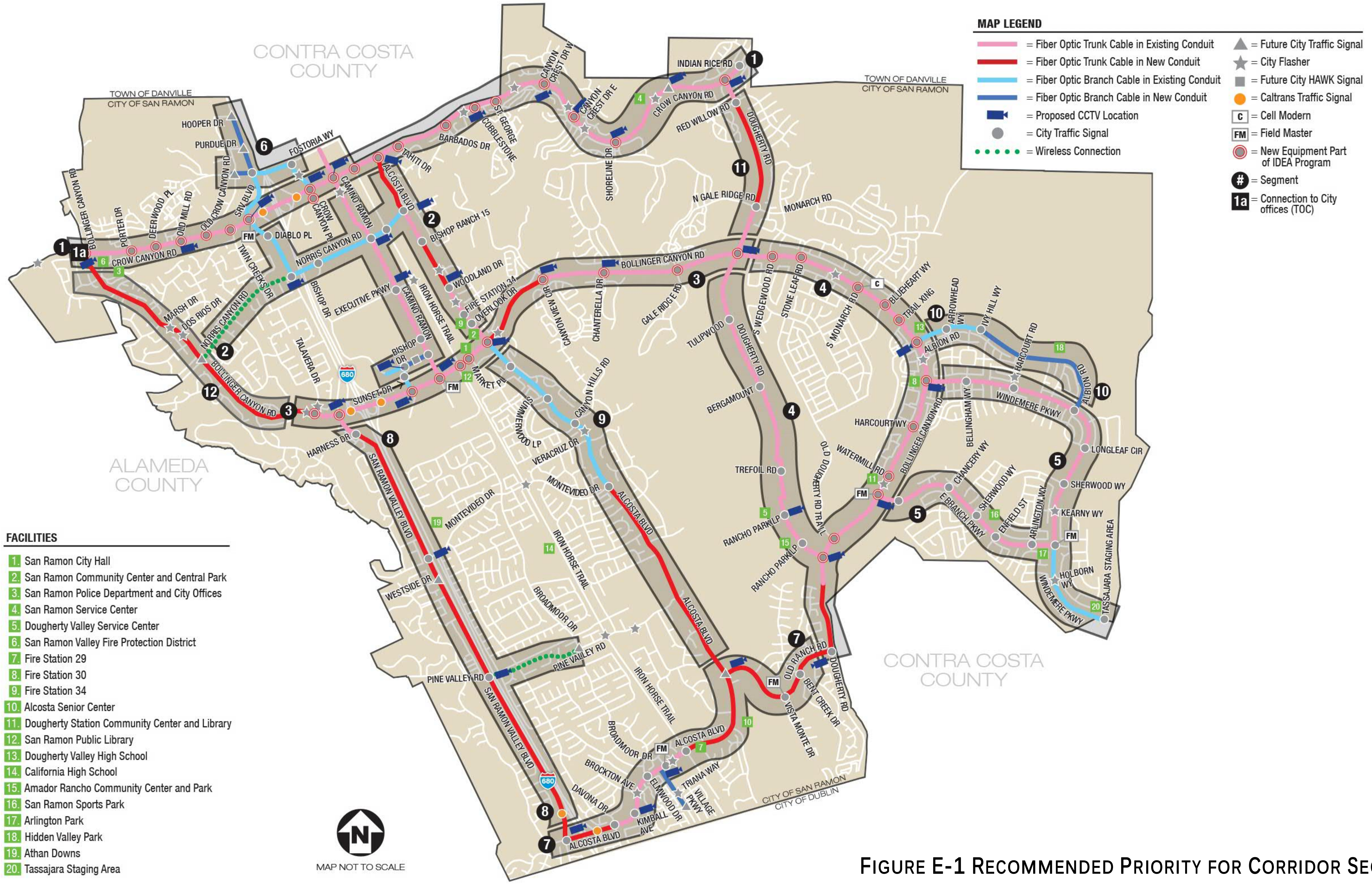

FIGURE E-1 RECOMMENDED PRIORITY FOR CORRIDOR SEGMENTS

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1. Introduction

The City of San Ramon is embarking on an effort to begin the implementation of advanced systems to continue to support traffic and transportation operations and management within the City. This effort is part of a greater goal to procure and deploy a complete, economical, efficient, and reliable Intelligent Transportation System (ITS). The City has an immediate need to evaluate and upgrade the communication infrastructure, which will require the most level of effort in the preparation of the City's ITS Master Plan.

The Intelligent Transportation System Master Plan will serve as the City's tool to identify needed resources, and a general strategy for procuring and deploying them.

The Master Plan process began by preparing a technical memorandum and map to summarize the City's existing communications network and ITS infrastructure. Following initial data gathering, input from stakeholders was assembled at stakeholder needs assessment workshops, which shaped the vision, goals, and needs of the intelligent transportation network in the City from multiple perspectives.

Lastly, existing infrastructure opportunities and gaps were identified through a gap analysis and strategies were developed to eliminate communication gaps and account for planned communications and ITS infrastructure, as well as other key infrastructure identified as part of the needs assessment.

1.1. Purpose of Document

The purpose of this document is to present the Vision statement for the ITS Master Plan, a summary of the findings from a needs assessment of various City departments, a gap analysis of the current communications and ITS network, and recommendations on how to procure and deploy a desired fiber optic infrastructure connecting to City ITS devices and City facilities. The organization of the report is as follows:

- Vision, Goals, and Objectives
- Needs Assessment
- Existing ITS Infrastructure
- Proposed ITS Infrastructure
- Gap Analysis
- Recommendations and Strategies

1.2. Plan Development Process

The Plan was developed primarily based on an assessment of the City's existing traffic signal communications infrastructure and stakeholder outreach. Through stakeholder meetings, the development of the plan started with the overall vision followed by the needs and gaps, resulting in the development of proposed infrastructure improvements to satisfy the needs and close the gaps. Figure 1 illustrates this process.

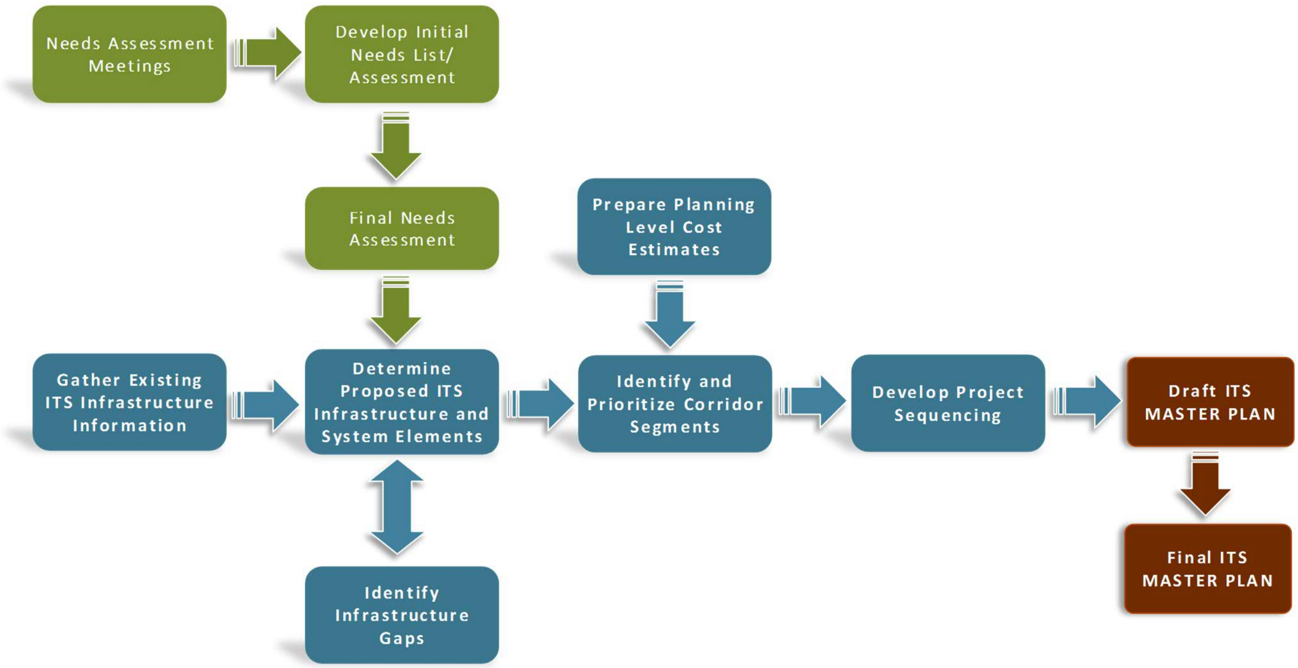


Figure 1 – Plan Development Process

2. Vision, Goals, and Objectives

2.1 Vision

The Vision statement provides the framework for the Master Plan and defines the long-range outlook for the intelligent transportation system in the City.

- Establish a plan to implement a comprehensive Intelligent Transportation System network
- Provide reliable and robust connectivity and cost-effective communications solutions for City facilities and designated areas
- Provide intelligent, scalable, and flexible infrastructure
- Provide a roadmap for implementation
- Establish San Ramon as a Smart City[1]
- Welcoming business environment with next-generation technology and connectivity
- Support deployment of future technologies

In becoming a Smart City, the City stands to realize certain benefits including the implementation of an integrated set of systems and processes in public administration that streamline and optimize the allocation of resources using technological tools. The utilization of technological tools will help monitor public services, inform citizens and interact with the municipality when addressing concrete urban issues and produce performance indicators that help measure, benchmark, and improve public policy.

2.2 Needs, Goals and Objectives

A needs assessment was conducted with the City's Traffic Engineering group and key City department stakeholders to identify both current and possible future needs for ITS infrastructure and operations, communications connections to City and outside facilities, communications with external agency and private entities, and cost considerations. The needs assessment workshop was attended by representatives from the following City of San Ramon Stakeholders:

- Traffic Engineering Division
- Police Department
- IT Department
- Fire Department

[1] Smart Cities are Cities that have "developed some technological infrastructure that enables it to collect, aggregate, and analyze real-time data, and has made a concerted effort to use that data to improve the lives of residents." Source: National League of Cities publication *Trends in Smart City Development*, 2016.

- Parks & Recreation Department
- Public Services Division

The primary goal for the overall Master Plan is to establish a framework from which the City can plan, design, and implement a comprehensive fiber optic network. This network is for the use by all city agencies and departments, and will carry the City into the next generation of communications technologies and tools and beyond.

Based on discussions with the stakeholders, the primary objectives of the plan are to:

- Connect existing and future City facilities and provide them with high-speed communications;
- Help set priorities for projects to install the communications infrastructure based on available funding;
- Connect designated areas within the City to the high-speed communications network to help with attracting businesses and development; and
- Reduce overall operating costs, particularly through eliminating the need for leased line connections.

3. Needs Assessment

This section presents a summary of the needs for a future fiber optic network and ITS field devices for the City of San Ramon. The needs were developed based on input from the City stakeholders and are summarized into three categories, including:

- Infrastructure
- Operations
- External Public Agency Communications

The needs associated under each of these categories are summarized below.

3.1 Infrastructure

1. There is a need to achieve a high security and tamper-proof network with an established communications infrastructure that can support the increasing bandwidth needs of the City departments including Traffic, Police, and Fire.
2. There is a need to create a robust CCTV camera system with real-time video feeds and storage capabilities for shared use amongst the City departments. This includes the installation of cameras on all traffic signals.
3. There is a need to develop a more reliable communications network and infrastructure connecting City facilities throughout the City in order to improve the existing general operations and security at these locations.
4. There is a need to connect existing cameras which are mounted on city infrastructure and connected by cellular connections to a fiber infrastructure that will allow live video feeds and central storage in order to reduce recurring costs for the communications.
5. There is a need to transfer credit card processing systems from mobile devices' network to a high security and tamper-proof fiber network.
6. There is a need to move the Police and Fire Department's dual-card mobile services to a more reliable and higher bandwidth citywide fiber network.
7. There is a need to directly connect the Police Department Dispatch Center to a City-owned fiber infrastructure.
8. There is a need for a fiber optic infrastructure to support the implementation of connected vehicles and autonomous vehicles, which are expected to be prevalent in the City in the near future.
9. There is a need to connect newly planned GPS/Strobe-based emergency vehicle preemption (Opticom) being installed around the City.

10. There is a need to connect to remote facilities and dead spots, such as locations in the Dougherty Valley.

3.2 Operations and Management

1. There is a need for a redundant, stable, reliable, fast, and interconnected fiber network between the City facilities that could service and accommodate the City's increasing bandwidth needs.
2. There is a need to increase the data transfer speed and capacity in the field to allow the inspection crew workers to download/upload information from/to the City in a timely manner.
3. There is a possible need to connect the City-owned Smart Street Lights (Echelon/Hubble) to fiber for better monitoring and control remotely.
4. There is a need to connect to fiber to facilitate network maintenance, operation, and management services provided by the IT department.
5. There is a need to install a new fiber infrastructure to reduce maintenance expenses related to Public Works maintenance services in the City.
6. There is a need for performance monitoring and data collection Citywide.
7. There is a possible need to communicate to water pumps in the field through Wi-Fi systems to receive data remotely.

3.3 External Public Agency Communications

1. There is a potential need for the City Traffic Engineering Division to exchange real-time information with Caltrans, Contra Costa Transportation Authority (CCTA), Traffic Communications Centers in Contra Costa and Alameda Counties, and neighboring cities of Dublin and Danville.
2. There is a need for the Police Department to connect to neighboring cities and develop strong backup arrangements in case of emergencies.

4. Existing ITS Infrastructure

Kimley-Horn has reviewed and inventoried the City's existing communications infrastructure and existing City facilities. This section provides a summary of the City's infrastructure and the existing facilities. Figure 2 provides an overall illustration of the existing traffic communications infrastructure, which includes central traffic signal systems, a copper communications network, signals, adaptive control, detection, flashers, and emergency vehicle preemption.

4.1 Central Traffic Signal Systems

The City currently operates three central systems for traffic signals: InSync, TrafficView, and MaxView. The InSync system communicates with the traffic controllers with the adaptive upgrades; the TrafficView system communicates with traffic controllers running Wapiti software; and the MaxView system communicates with traffic controllers running MaxTime software. The MaxView and TrafficView central systems do not communicate with Caltrans' signals running C8 or Safetran software. The InSync adaptive system manipulates the four Caltrans signal controllers in the adaptive Crow Canyon and Bollinger Canyon corridors.

4.2 Traffic Signal Communications Network

The City's existing traffic signal communications network consists of a combination of wireless radio and copper signal interconnect. Currently, 96 of the City's 99 existing City traffic signals are interconnected. There are also six Caltrans intersections which are not interconnected to the City's signal system.

Most of the existing traffic signals that are connected to the Central Traffic Signal Systems are connected via copper signal interconnect cables in underground conduit. There is an existing wireless radio link that connects three traffic signals along Old Ranch Road between Dougherty Road and Vista Monte Road, and a second that connects San Ramon Valley Boulevard/Alcosta Boulevard with the Alcosta network.

There are five existing field masters that are connected to the central systems, three of them connected via leased lines, while one is connected via traffic signal interconnect cable (copper). In addition, the traffic signals operating under the MaxView system are connected to that central system via a cell modem. The locations of the field masters and cell modems are shown in the overall map.

The existing underground conduits vary in sizes (two to four inches) with pull boxes installed approximately every 200 to 300 feet. The conduits carry from one to three interconnect cables.

Refer to Figure 2 for more information on the traffic signal communications network and infrastructure.

4.3 Traffic Signals

The City's traffic signal system consists of a total of 105 traffic signals within the City limits. Six signals are owned, operated, and maintained by Caltrans. The remaining 99 signals are owned, operated, and maintained by the City of San Ramon.

Approximately 80% of the City's traffic signals are controlled using Model 170E controllers using Wapiti software. The remaining signals have Model 2070 and 2070 ATC controllers using MaxTime or Apogee software. The six Caltrans signals use C8 software. All the intersections have Type 332 cabinets. Refer to Appendix A for more detailed controller and software information.

4.4 Traffic Signal Coordination

The City's signal system also includes the implementation of the InSync Adaptive Traffic Signal System, which was installed in 2010. The City currently has 18 signals operating under adaptive control, including four Caltrans' traffic signals along Crow Canyon Road and Bollinger Canyon Road. Outside of the adaptive system, most of the other traffic signals in the Crow Canyon Road and Bollinger Canyon Road corridors operate under time-of-day coordination.

4.5 Detection

The City currently utilizes in-pavement loop detectors at a majority of intersections. Video detection has been implemented on select legs at some intersections due to pavement constraints. Bicycle loop detection has also been implemented at a majority of the intersections. Refer to Appendix A for intersections operating with video detection.

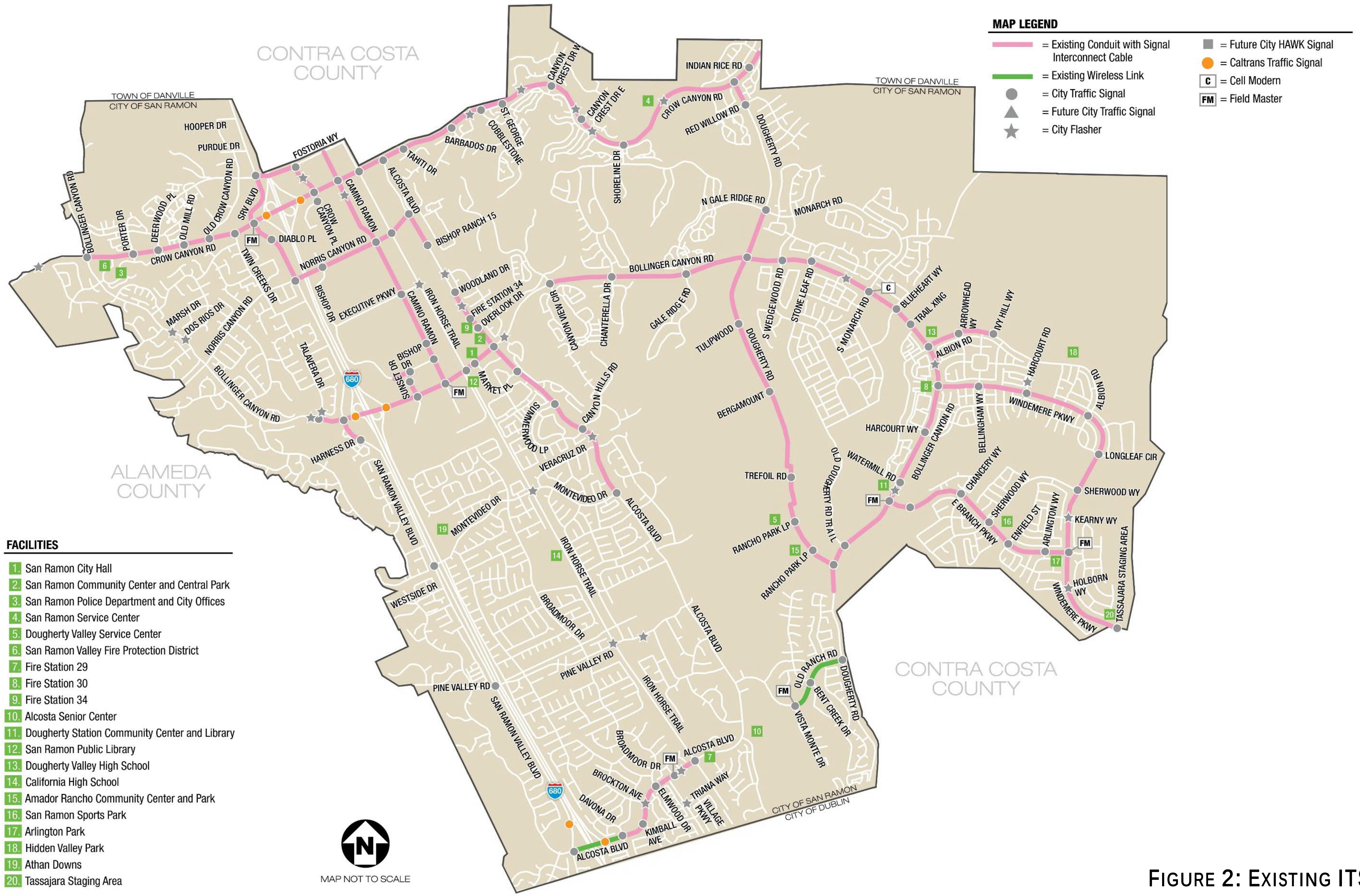
4.6 Flashers

The City has approximately 26 locations with flashers. Flashers are installed in advance of pedestrian crossings, at school zone speed limit signs, at advisory speed signs, and for signal ahead notifications. The flashers are coupled with lighted crosswalks, which utilize in-pavement flashers and lighted signs. Some locations have RRFBs in advance of the crosswalk as well. Refer to Appendix B for an inventory listing of the flashers.

4.7 Emergency Vehicle Preemption

The City currently has Emergency Vehicle Preemption (EVP) operating at all signalized intersections. The EVP system is the Opticom system. The City is currently upgrading to a GPS-based Opticom system.

EVP Detector



FACILITIES

1. San Ramon City Hall
2. San Ramon Community Center and Central Park
3. San Ramon Police Department and City Offices
4. San Ramon Service Center
5. Dougherty Valley Service Center
6. San Ramon Valley Fire Protection District
7. Fire Station 29
8. Fire Station 30
9. Fire Station 34
10. Alcosta Senior Center
11. Dougherty Station Community Center and Library
12. San Ramon Public Library
13. Dougherty Valley High School
14. California High School
15. Amador Rancho Community Center and Park
16. San Ramon Sports Park
17. Arlington Park
18. Hidden Valley Park
19. Athan Downs
20. Tassajara Staging Area

Figure 2: Existing ITS Infrastructure

5. Proposed ITS Infrastructure

To achieve the goals and address needs summarized as part of this Master Plan, this section covers the proposed infrastructure required to achieve this end. Proposed fiber optic infrastructure (conduit and cable routing, etc.) and CCTV cameras are proposed for installation around the City. The graphic layout of the proposed infrastructure is presented in Figure 3.

There are several key reasons for implementing a fiber optic network, which includes, but is not limited to:

- New technologies/applications require the bandwidth and reliability of fiber
- City's existing communications infrastructure is outdated and not expandable
- Replacing existing leased connections – cost savings
- Fiber offers better management and control of essential communications assets
- Highly applicable to emerging industries - higher speeds than currently available from ISPs (Comcast, etc.)
- Investment in Community - enterprise-ready network connections to attract businesses
- Potential to lease out dark fiber – revenue generator

5.1 Fiber Optic Network

The majority of the City's existing signal interconnect infrastructure is likely suitable for use in deployment of fiber optic infrastructure. This will include the replacement of the existing copper signal interconnect with fiber optic cable, and adjustment of other structures, such as the conduit sweeps into the pull boxes and pull boxes themselves, as well as installation of new conduit.

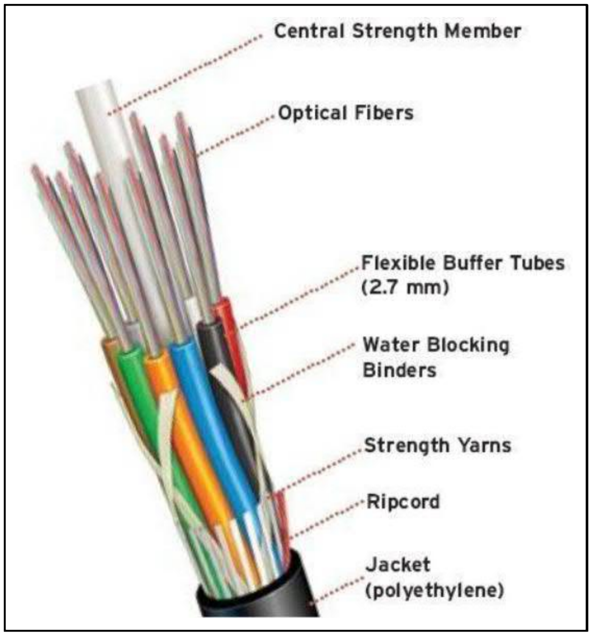
Fiber Optic Cable

The City of San Ramon's proposed fiber optic network will consist of two types of fiber cables, trunk cables (minimum 288-strand single mode fiber optic cable) and distribution cables (minimum 48-strand signal mode fiber optic cable). The cable sizes recommended within this Study are anticipated to be sufficient for the anticipated communication needs of the City, but may be increased or decreased depending on cost, procurement, and timeline for any given corridor or segment of new fiber optic cable to be installed.

Trunk cables are recommended to be 288-strand cables to allow for expansion of the system, as well as the possibility of private use (i.e. leasing dark, unused fiber) in the future. Many cities and counties choose to allocate fiber to share with partner agencies as well, and extra capacity will allow for these possibilities in the future. The distribution cables, also referred to as branch cables, are recommended to be 48-strand cables. Like the larger trunk cables, sufficiently large branch cables will enable additional connections in the future, such as connection of City facilities in all parts of the City, including more remote areas.

Fiber Optic Cable Routing

The proposed layout of the fiber communication system is intended to form a series of "rings," also referred to as a ring topology, with main corridors handling most of the trunk cable rings to provide redundancy in the network. This is especially important in the event of a severed trunk cable or equipment failure. A complete ring will offer an alternate route for the communication of intersections or equipment on either side of the break.



Fiber Optic Cable Components

The proposed layout also includes some rings formed with the branch cable connections, further securing the infrastructure on those more minor rings against failure. Those rings may not be recommended as trunk cables due to their remoteness or lack of City need for connection (i.e. strictly residential neighborhoods), and are thus recommended to be equipped with distribution sized cables. The remaining distribution cables will not provide redundant rings connections, and behave more as their "branch" name suggests: as a connection to more remote areas away from the central trunk rings.

5.2 CCTV Cameras

In addition to communications infrastructure to support the existing traffic signal system and its components, this plan also recommends the installation of closed circuit television (CCTV) Citywide. To address the City's and Public Safety Community's needs and vision, it is recommended in the nearer term to deploy cameras at key intersections.


CCTV Camera

The use of CCTV cameras provides several key benefits to the City including the ability to positively identify and verify incidents along roadways and at intersections, confirming problems at traffic signals remotely (e.g., if a traffic signal head bulb is out, or if a signal phase is not being serviced) without the need to travel to the location, which requires valuable staff time and resources and to monitor traffic flow along key arterials to track and fine tune traffic signal coordination.

Strategic CCTV placement will help the City to enhance mobility, improve responsiveness to issues in the network, and help to standardize traffic operations through the ability to monitor and diagnose remotely with consistent coverage.

This Plan suggests placement at major arterials, key public areas, or maintenance-sensitive areas citywide.

It should also be noted that CCTV cameras will likely utilize most of the bandwidth on the communications network (approximately six Mbps per camera), and thus should be planned for such that sufficient fiber strands exist for the intended number and placement of the CCTVs around the City and along the communications network.

With the deployment of field CCTV cameras, there will be a need for a central Video Management System to manage, distribute, and route the video streams from the CCTV cameras. The Video Management System will be modular and be expanded as the ITS network expands, i.e., the first set of CCTV cameras will require a certain number of video management system servers and licenses that will be expanded as more CCTV cameras are installed.

5.3 Connected and Autonomous Vehicles

The City is at the forefront of connected automated vehicle technologies with the autonomous shuttle that is currently operating in the Bishop Ranch area. The shuttle has been undergoing testing on a route that includes private and public roads, but presently does not travel through any traffic signals. The next step in the routing of this shuttle is to travel along public roads with traffic signals. Operating this shuttle requires several distinct technologies that must all work together, especially when traveling through traffic signals.

The use of connected vehicles and technology will provide several benefits to the City. This includes benefits in the areas of Safety, Mobility, and the Environment. More specifically, connected vehicles provide the following benefits:[2]

Safety

Reductions in crashes with combinations of safety and road weather applications including:

- Red Light Violation Warning and Pedestrian in Signalized Crosswalk Warnings
- Curve Speed Warnings
- Weather Warnings

Mobility

Applications that are effective in prioritizing signal timing and reducing travel time and overall delay with the following:

- Combinations of signal control applications such as Intelligent Traffic Signal Systems, Transit Signal Priority, and Freight Signal Priority
- The Incident Scene Pre-Arrival Staging Guidance for Emergency Responders

[2] Source: USDOT report, *Estimated Benefits of Connected Vehicle Applications: Dynamic Mobility Applications, AERIS, V2I Safety, and Road Weather Management, August 2015*

- Cooperative adaptive cruise control and speed harmonization

Environmental

Applications have potential congestion and lane management capabilities and can reduce fuel consumption and emissions through:

- Optimized signal operations and freeway lane management applications
- Low Emissions Zone applications

What is a Connected Vehicle?

Connected Vehicle (CV) technology will enable cars, trucks, buses, and other vehicles to "talk" to each other, to infrastructure (traffic signals), and with other road users (pedestrians with compatible smartphones) using built-in, or add-on devices that continuously share important safety and mobility information. CV technology enables communications among vehicles, infrastructure, and personal communications devices operated by passengers, pedestrians, bicyclists, or other road users.

While many existing wireless technologies can support a range of CV operations, including cellular networks and Wi-Fi, safety-related systems for CV technology will likely be based on Dedicated Short-Range Communications (DSRC), a technology similar to Wi-Fi but optimized to be fast, secure, reliable, and not vulnerable to interference. Wireless 5G is another technology that is currently being tested for CV operations.

Connected vehicles are vehicles that use any number of different communication technologies to provide communications between the vehicle, the driver, and other elements. Listed below are the types of communications under Connected Vehicles:

- V2I – Vehicle-to-Infrastructure (roadside infrastructure such as traffic signals)
- V2V – Vehicle-to-Vehicle
- V2C – Vehicle-to-Cloud
- V2P – Vehicle-to-Pedestrian
- V2X – Vehicle-to-Everything

Vehicle-to-Infrastructure (V2I) is the next generation of Intelligent Transportation Systems where V2I technologies capture vehicle-generated traffic data, wirelessly providing information such as advisories to the vehicle to inform the driver of safety, mobility, or environment-related conditions. The current thinking is that agencies will install V2I infrastructure alongside or integrated with existing ITS equipment. Because of this, the majority of V2I deployments may qualify for similar federal-aid programs as ITS deployments, if the deploying agency meets certain eligibility requirements.

What is an Autonomous Vehicle?

Autonomous Vehicles (AV) operate with little to no human input. At least some aspect of a safety- critical control function (e.g., steering, throttle, or braking) occurs without direct driver input. Using a variety of technologies, they detect their surroundings and interpret the sensory information to identify appropriate navigation paths, potential obstacles and signage. AVs may use only conventional on-board vehicle sensors or may also be connected (i.e., use communications systems such as CV technology, in which cars, roadside infrastructure, and other roadway users communicate wirelessly). Vehicle connectivity is important to realizing the full potential benefits of AVs. Autonomous and Driverless Vehicles perform their functions based on the following:

- Array of sensors to detect other vehicles and obstacles
- Requires a detailed map
- Uses machine learning to make its software smarter
- Doesn't rely on communications with other vehicles

A key element with autonomous vehicles traveling on public roads is the recognition of traffic signals and their indications. There is technology that enables traffic signals to provide real-time data on current signal timing such as which movements are green and red. This will be essential to operating autonomous vehicles on the City's streets.

Levels of Automation

Fully automated, autonomous, or "self-driving" vehicles are defined by the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) as "those in which operation of the vehicle occurs without direct driver input to control the steering, acceleration, and braking and are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode." There have been multiple definitions for various levels of automation, for the sake of standardization, and to aid clarity and consistency, NHTSA has adopted the SAE International definitions for levels of automation. These definitions divide vehicles into levels based on "who does what, when." Table 1 provides descriptions of the various levels of automation for autonomous vehicles.

Table 1: Levels of Automation for Autonomous Vehicles

Level	Description
Level 0	The human driver does all the driving.
Level 1	An Advanced Driver Assistance System (ADAS) on the vehicle can assist the human driver with either steering or braking/accelerating.

Table 1: Levels of Automation for Autonomous Vehicles	
Level	**Description**
Level 2	An ADAS on the vehicle can control both steering and braking/accelerating under some circumstances. The human driver must continue to pay full attention ("monitor the driving environment") at all times and perform the rest of the driving task.
Level 3	An Automated Driving System (ADS) on the vehicle can perform all aspects of the driving task under some circumstances. The human driver must be ready to take back control at any time the ADS requests the human driver to do so. In all other circumstances, the human driver performs the driving task.
Level 4	An ADS on the vehicle can itself perform all driving tasks and monitor the driving environment – essentially, do all the driving – in certain circumstances. The human need not pay attention in those circumstances.
Level 5	An ADS on the vehicle can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving.

Source: National Highway Traffic Safety Administration (NHTSA)

Existing Autonomous Shuttle

There is an autonomous shuttle vehicle that is currently being tested for service in the Bishop Ranch area. This shuttle is fully-autonomous traveling on public and private roads that do not have any traffic signals. The next phase of this shuttle's route will be to travel on public roads with traffic signals. In this scenario, there will be a need to equip the traffic signals with new devices that will be able to communicate with the shuttle to exchange real-time signal timing status. At a minimum, the type of data that is needed includes the Signal Phasing and Timing (SPaT) data, which is currently available with most of the traffic signal controller vendors.

CV/AV and the ITS Master Plan

While there are still many unknowns and unproven technologies for connected and autonomous vehicles, this Master Plan incorporates this future technology in the Vehicle-to-Infrastructure (V2I) category where additional field equipment will be installed at the traffic signals (existing and future) as well as some level of integration with the central systems. This could include additional standalone processors and/or embedded processors within the traffic signal controller, and additional software and integration with the City's Traffic Signal Systems. This additional equipment is primarily reflected in the cost estimates for the project corridor segments and is assumed to be ultimately installed at all City traffic signals.

5.4 Bandwidth Demand for Devices

There are different types of devices that will be able to utilize an ITS fiber optic network. These devices include, but are not limited to:

- Traffic controllers
- Sensors to measure traffic volumes
- Connected Vehicle Roadside Units
- CCTV cameras
- Transit Signal Priority (TSP) Units
- Local weather control sensors
- Changeable Message Signs (CMS)
- Extinguishable Message Signs (EMS)
- Parking management units
- Wireless routers (aggregation points)
- Video detection cameras
- Bluetooth Readers
- Connected Vehicle Roadside Equipment (DSRC or 5G)

These devices will consume a certain amount of bandwidth for transferring data, with the video from CCTV cameras requiring the most bandwidth. Table 2 presents a summary of the bandwidth demand of various field devices, which are typically installed at signalized intersections.

Table 2: Bandwidth Demand for Various Field Devices

System Component	Device	Per Unit Bandwidth Steady Demand (Mbps)
Traffic Management	Traffic Signal Controller	0.20
	Uninterruptible Power Supply (UPS)	0.05
	Conflict Monitor Unit (CMU)/ Malfunction Management Unit (MMU)	0.05
	Transit Signal Priority (TSP) Unit	0.10
Monitoring and Surveillance	Video Detection Camera	8.00 [1]
	Microwave Detectors	0.10
	CCTV Camera (high definition)	6.00 [2]
	License Plate Reader Camera	6.00 [2]
	Bluetooth Detectors	0.10
	Connected Vehicle Road Side Unit (DSRC)	6.00 [3]

Table 2: Bandwidth Demand for Various Field Devices		
System Component	Device	Per Unit Bandwidth Steady Demand (Mbps)
Control	Local Weather Control Sensors	0.10
Parking Management	Parking Monitoring Devices	1.00
En-Route Traveler Information Device	Changeable Message Sign (CMS)	0.05

1. Assumes up to four cameras with video compression.
2. Assumes some compression of the video streams. With more compression, bandwidth can be reduced significantly, but the resolution and video frame rate functions will be affected.
3. Assumes real-time transfer of data that is collected from the roadside units.

These device bandwidths are provided for information on the what demands can be expected on an ITS communications network. It should be noted that with a fiber optic network, the limitations on bandwidth is strictly a function of the communications end equipment and not the fiber optic cables. This Master Plan identifies the recommended fiber optic infrastructure. Depending on the specific devices and services that are connected to and utilize the fiber optic network, the communications network equipment will need to be sized accordingly based on the connected devices and services.

5.5 Innovative Deployments to Enhance Arterials (IDEA) Grant

The City of San Ramon, in partnership with Contra Costa County Transit Authority and the San Ramon Police Department, was recently awarded an IDEA Grant from the Metropolitan Transportation Commission (MTC). As part of the category 1 projects, the City proposes to implement Automated Traffic Signal Performance Measures (ATSPM) along two critical regional arterials within San Ramon: Bollinger Canyon Road and Crow Canyon Road. The proposed project also upgrades existing traffic signal controllers to newer, modern controllers. The project also involves the installation of advanced detection systems to include bicycle lane detection and improved video monitoring capabilities. The City is deploying a new ATSPM system for reporting and data analysis, with plans to use this new system for enhanced performance monitoring, traffic conditions monitoring, performing before and after studies, and sharing data among partner agencies. Figure 6 depicts the intersections that will undergo improvements as part of this program.

5.6 Wireless Communications

Due to the high costs and funding challenges involved with the preferred fiber optic cable network, many municipalities have successfully deployed lower-cost wireless communications technologies to fill communications needs. Wireless systems offer the advantage of fairly high-capacity bandwidth at distances of up to 20 miles. However, they require unobstructed lines of sight between antennas in order to achieve best results. They are also susceptible to interference from a variety of sources and require considerably more maintenance than underground cable systems. Although they cannot match in speed and capacity of fiber optic interconnect, this alternative can provide satisfactory communications to meet short-term needs at a very low cost. Inexpensive wireless options available to the City include:

- Leased wireless (cellular) technology such as that commonly used in smartphones.
- Private wireless technology that uses radio signals between points with mounted radios and antennas that transmit and receive data between strategic points.

The leased wireless option requires the procurement of services from a cellular provider with service level agreements on the performance of the wireless connection (e.g., bandwidth). For the private wireless option, there are licensed and unlicensed radio spectrum that can be used. It is fairly common for traffic signal and ITS networks to utilize the unlicensed spectrum, particularly the frequencies in the ISM (Industrial, Scientific, and Medical) bands.

The City of San Ramon already possesses the following assets that offer unique opportunities to exploit wireless solutions. Some examples are listed below:

- The natural topography of the San Ramon Valley and Dougherty Valley has a number of elevated positions on adjacent hills that offer potentially advantageous positions for wireless radio transmission.
- Many excellent broadcasting positions are already occupied by towers constructed and operated by the East Bay Regional Communications System Authority (EBRCSA). Opportunities may exist to utilize some existing towers outside of the City limits or within the City at existing Fire Station towers.
- Fifteen of the City's signals on Bollinger Canyon Road in Dougherty Valley currently communicate through a cellular modem. Monthly charges apply, but these costs may prove cost-effective for some segments of the system.
- The City's Public Works Maintenance Department controls the City's entire irrigation system through multiple wireless networks. The system was upgraded many years ago from analog telephone modem control. Opportunities may exist to either convert some of the former telephone service locations to allow internet access to the traffic signal network or to utilize other abandoned irrigation infrastructure to close gaps in the traffic signal network.

An interim wireless communication plan may be feasible to provide for the City's traffic engineering communications needs until the entire fiber optic communications network can be completed. City staff will collaborate with EBRCSA to determine the most cost-effective approach to an interim wireless infrastructure plan.

5.7 Detection

The City currently uses pavement loops for a majority of the traffic signals. However, video detection has also been implemented on select intersection legs at a few intersections. Given the progress that video detection has made over the years including accuracy and reliability that are nearly comparable with pavement loops, the City should consider implementing video detection more citywide. The use of pavement loops has been assumed for the Plan, but as video detection continues to improve in accuracy and reliability, it should be considered and would have the benefit of cost savings and improved flexibility during construction (i.e., no need to re-cut loops when moving lanes).

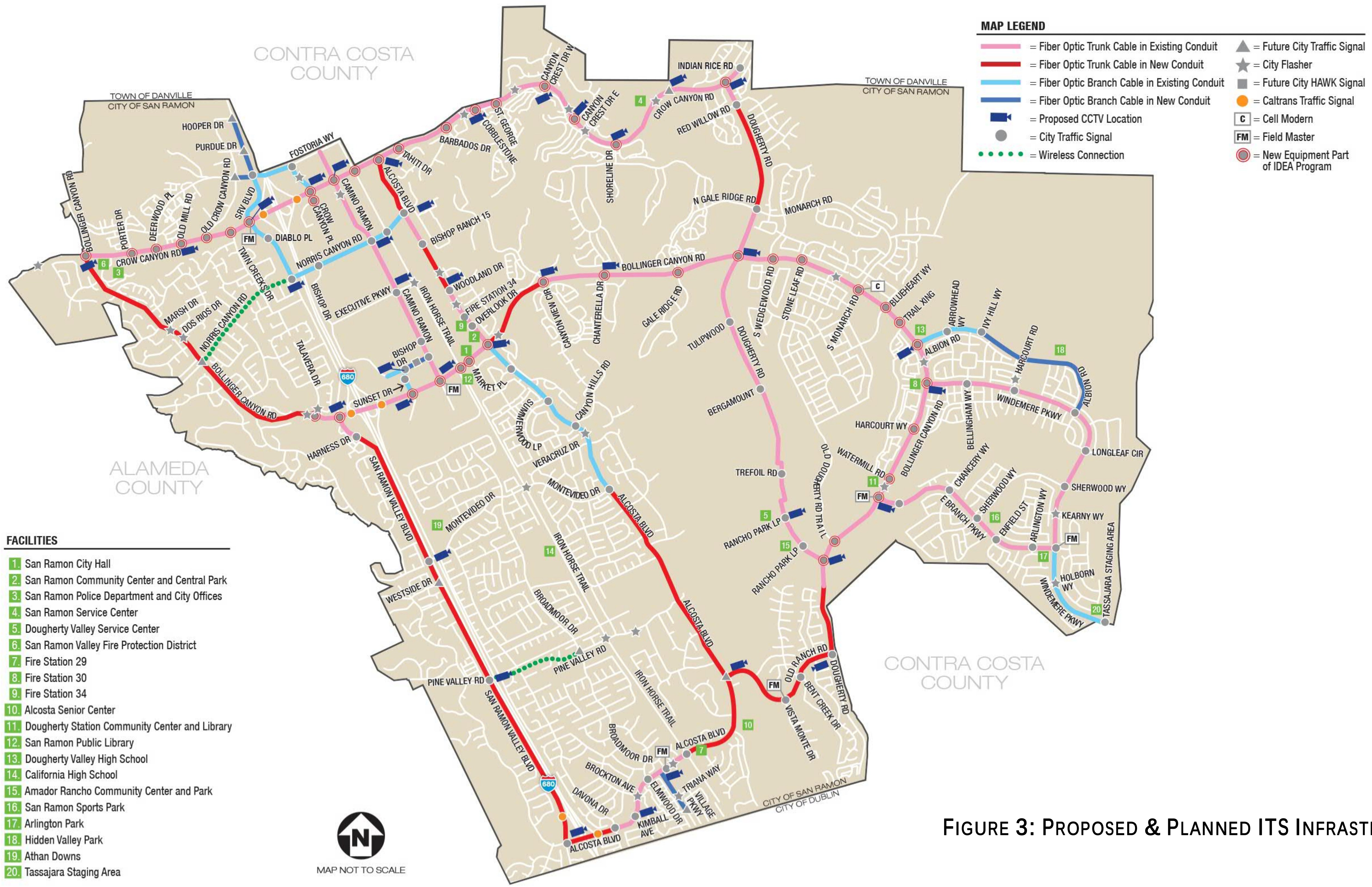


Figure 3: Proposed & Planned ITS Infrastructure

6. Infrastructure Gaps

Based on the existing and proposed communications system, there is new infrastructure that is necessary to accommodate the proposed fiber optic communications system. This primarily consists of the installation of new conduits and pull boxes as well as the fiber optic cables and associated fiber optic elements (e.g., splice cases).

Figure 4 provides an overview of the conduit infrastructure improvements that are necessary in order to accommodate the proposed fiber optic communications system. It should be noted that in the segment along Alcosta Boulevard between Montevideo and Old Ranch, this connection would be primarily for redundancy of the fiber network.

The existing conduit system travels along major corridors and main areas in the City and should satisfy the bandwidth need to operate the traffic signals and other associated ITS field devices. However, if fiber installation were to be limited by existing infrastructure, fiber will not be accessible by City facilities with high bandwidth demand needs based on the needs assessment.

The existing communication gaps are identified and fiber optic routing opportunities are proposed to eliminate these gaps.

6.1 Conduit System

The existing traffic communications conduit system consists of conduits 2 inches, 3 inches, and 4 inches in diameter. In order to provide capacity for future demand, new conduit required for the communications system should be minimum 3” in diameter. This allows for additional cables to be installed in the system as needed in the future.

In addition to conduit installation and replacement, the system will require new pull boxes and splice vaults to be fiber-ready. Fiber optic cable has minimum bending radii that must not be exceeded in order to avoid damage to the fiber. The minimum bending radii increases with the diameter of the cable meaning larger cables require larger pull boxes and vaults to protect the cable and provide space for coiling of the cables. Most of the existing pull boxes in the interconnect system will need to be replaced with larger boxes. Also, splice vaults and closures will need to be installed at all points that require splicing to the fiber trunk line.

6.2 City Facility Connections

The City has a variety of facilities spread around the City that may benefit from fiber optic interconnection. Most of the facilities are in close proximity to the plan fiber trunk line. These facilities require a modest amount of conduit, pull box, and fiber optic cable infrastructure to make the connections to the fiber optic system.

The following facilities are proposed for fiber connections:

- San Ramon City Hall
- San Ramon Community Center and Central Park
- San Ramon Police Department and City Offices
- San Ramon Service Center
- Dougherty Valley Service Center
- San Ramon Valley Fire Protection District
  - Fire Station 29
  - Fire Station 30
  - Fire Station 34
- Alcosta Senior Center
- Dougherty Station Community Center and Library
- San Ramon Public Library
- Dougherty Valley Performing Arts Center and Aquatic Center
- Amador Rancho Community Center and Park
- San Ramon Sports Park
- Arlington Park
- Hidden Valley Park
- Athan Downs
- Tassajara Stage Area
- San Ramon Valley Unified School District (includes all schools)
- Forest Home Farms

Each of the maps in this report show the locations of City facilities that are proposed to have connectivity to the fiber optic network. One of the benefits and potential outcomes is to identify components that serve these agencies for cost-sharing.

6.3 Operations and Management

To ensure proper performance of the fiber network, some form of maintenance will need to occur to repair any problems with the fiber network. One benefit of a fiber network is the relatively low amount of maintenance needed to keep the system up and running. The system should work properly unless there is specific damage that occurs somewhere in the network. The main maintenance will stem from breaks that occur in the fiber due to damage to infrastructure like conduit or poles, or any damage to the end equipment, such as a splice cabinet knockdown or a patch panel disconnection.

There are a few options for maintenance on the equipment located in the field, such as the fiber optic cables, splice cabinets, and CCTV cameras. The City could hire a full-time field technician to make any repairs necessary. Using the City's workforce will require new skills and a training program for staff. Additionally, new fiber optic equipment and precision tools will be necessary including test kits, splicing equipment, and other tools for troubleshooting and making repairs.

As there will likely not be enough work to keep a City field technician busy full time, another option would be to hire an external contractor on an on-call basis. This could either be a field technician from another agency or a third-party licensed contractor. By this method, the City would have an outside source ready to troubleshoot any problems that occur and pay them on a case-by-case basis, as opposed to employing a full-time employee.

If the City decides to lease fiber strands out to commercial clients for internet access, the City will need staff resources in place to manage the billings for commercial client use of the fiber. Depending on how extensive the services become and how many commercial clients wish to use the fiber network, this task could require hiring new full-time staff, but it would likely become a responsibility for a current staff member.

With the addition of CCTV cameras to the City's ITS network, there will be a need for a Video Management System that will serve to operate and manage the video feeds of the CCTV cameras. This includes managing the addresses and names of the cameras, routing video streams to the appropriate computers, displays, or even other systems, and enabling video "preset views" so the City can effectively monitor traffic conditions. An example is the Video Management System would be able to pull up and organize all of the cameras along Crow Canyon Road so the City can monitor the corridor with the click of a preset view.

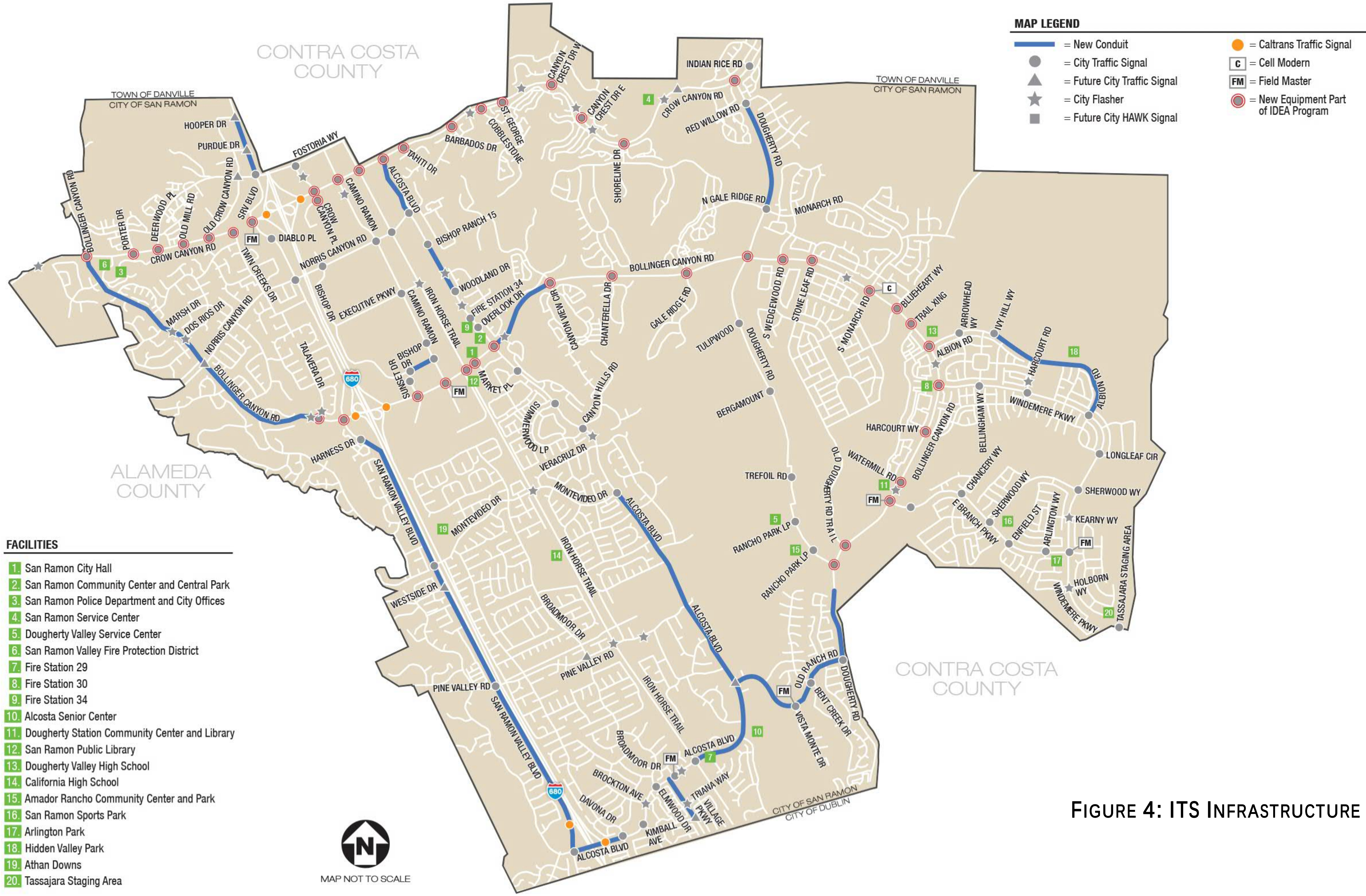


Figure 4: ITS Infrastructure Gaps

7. Prioritization of Projects

7.1 Project Corridor Segments

The project corridors were divided into shorter segments based on several different factors including the number of traffic signals, number of planned CCTVs, number of flashers, number of City facilities and general limits for providing connectivity of the City's major arterials and facilities. Based on these factors, the City's corridors were divided into 12 segments:

- Segment A: Crow Canyon Road – between Bollinger Canyon Road and Indian Rice Road
- Segment A1: Crow Canyon Road connection to City Offices (Traffic Server)
- Segment B: San Ramon Valley Boulevard North – between Crow Canyon Road and Hooper Drive; Fostoria Way between Old Crow Canyon Road and Crow Canyon Place; and Crow Canyon Place – between Fostoria Way and Crow Canyon Road
- Segment C: Downtown – Alcosta Boulevard – between Crow Canyon Road and Bollinger Canyon Road; Camino Ramon – between Crow Canyon Road and Bollinger Canyon Road; Twin Creeks Drive – between Crow Canyon Road and Norris Canyon Road; Norris Canyon Road – between Twin Creeks Drive and Alcosta Boulevard; Bishop Drive; and Sunset Drive
- Segment D: Dougherty Road – between Crow Canyon Road and Bollinger Canyon Road
- Segment E: Bollinger Canyon Road – between Talavera Drive and Dougherty Road
- Segment F: San Ramon Valley Boulevard South – between Bollinger Canyon Road and Alcosta Boulevard
- Segment G: Alcosta Boulevard – between Bollinger Canyon Road and Old Ranch
- Segment H: Dougherty Road and Bollinger Canyon Road – Dougherty Road – between Bollinger Canyon Road North and Bollinger Canyon Road South; Bollinger Canyon Road – between Dougherty Road North and Dougherty Road South
- Segment I: Albion Road – between Bollinger Canyon Road and Windemere Parkway
- Segment J: Windemere Parkway and East Branch Parkway – Windemere Parkway – between Bollinger Canyon Road and Tassajara Staging Area (City Limit); East Branch Parkway – between Bollinger Canyon Road and Windemere Parkway

- Segment K: Alcosta Boulevard and Old Ranch Road – Alcosta Boulevard – between San Ramon Valley Boulevard and Old Ranch Road; Old Ranch Road – between Alcosta Boulevard and Dougherty Road; Dougherty Road – between Old Ranch Road and 0.3 miles north of Old Ranch Road
- Segment L: Bollinger Canyon Road West – between Crow Canyon Road and Talavera Drive.

These segments would constitute segments that would formulate projects for the phased implementation of the fiber optic network. Figure 5 shows the segment limits and Table 3 provides a summary of the proposed project corridor segments.

Table 3: Project Corridor Segments

Corridor	Name	Traffic Signals	CCTVs	Flashers	City Facilities
A	Crow Canyon Road	22	8	7	3
A1	Crow Canyon Road connection to City Offices (Traffic Server)	-	-	-	1
B	San Ramon Valley Boulevard North	5	-	-	-
C	Downtown	16	5	2	1
D	Dougherty Road North	2	-	-	-
E	Bollinger Canyon Road	13	5	3	3
F	San Ramon Valley Boulevard South	5	2	-	1
G	Alcosta Boulevard	4	2	1	-
H	Dougherty Road and Bollinger Canyon Road	18	6	3	5
I	Albion Road	2	-	-	1
J	Windemere Parkway and Branch Parkway	12	1	2	3
K	Alcosta Boulevard and Old Ranch Road	11	5	3	2
L	Bollinger Canyon Road West	-	-	-	-

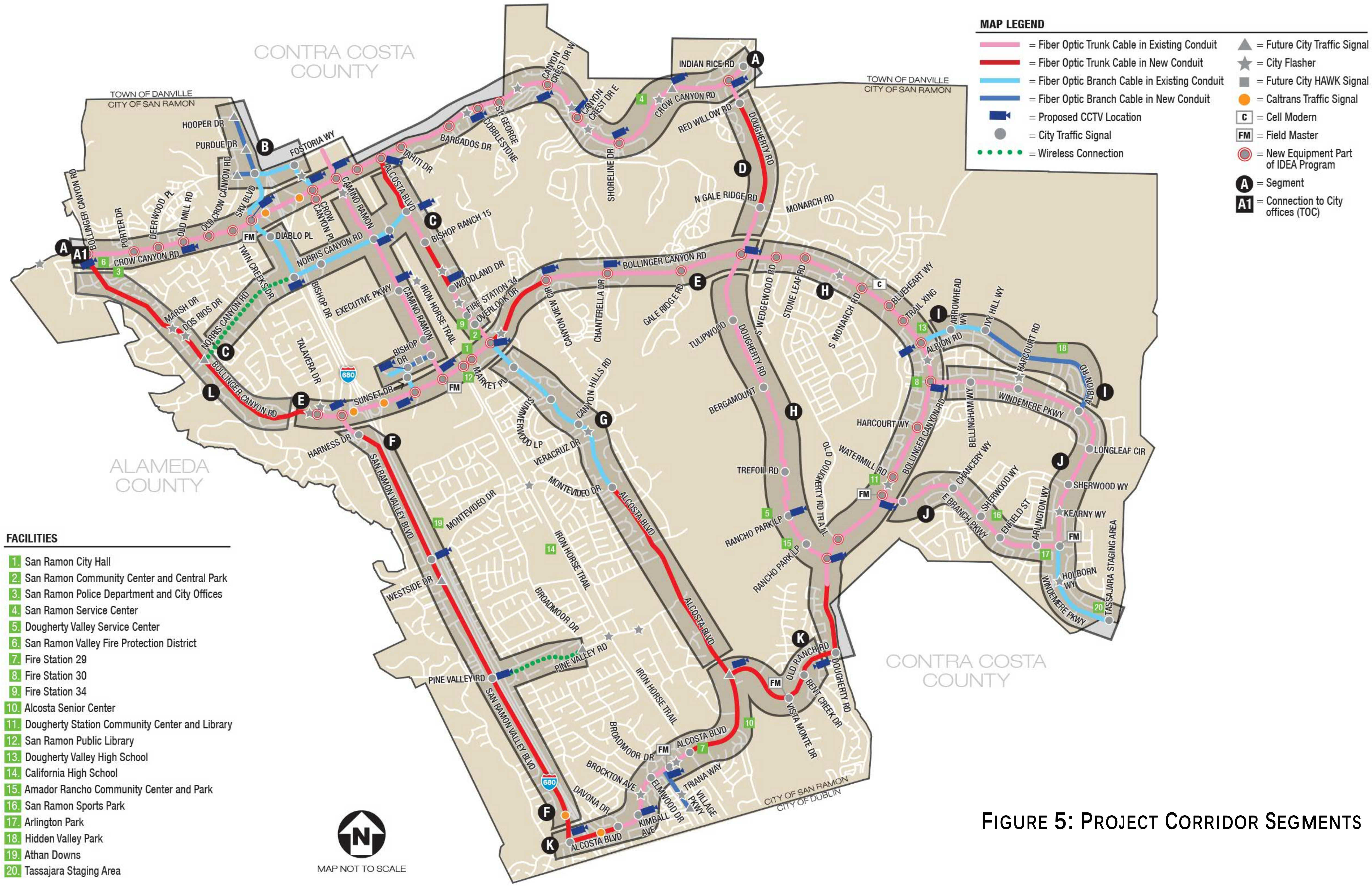


Figure 5: Project Corridor Segments

7.2 Order of Magnitude Estimates of Cost

Planning level (order of magnitude) cost estimates were developed for the proposed ITS infrastructure, field elements and central system components. The estimates include all infrastructure necessary to replace the existing signal interconnect with fiber optic cable, to connect the remote City facilities, install field equipment, and central system elements.

This ITS infrastructure includes new fiber optic cable and new 3 inch conduit, pull boxes, splice vaults, fiber splicing, fiber optic testing, and Ethernet switches. Additionally, the costs include fiber connections to the City facilities along each segment. Where there are existing conduits, the assumption is that new fiber cable can be installed in those conduits with required modifications to existing sweeps and new pull boxes. Other items that are part of the estimates include CCTV cameras and allowances for future technologies such as connected vehicles/automated vehicles.

The estimates do not include specific field devices such as new traffic controllers, or other devices other than the communications equipment needed for the fiber communications network. The estimates also include engineering design, construction management and environmental clearance.

Table 4 below summarizes the preliminary estimated costs to build-out the fiber optic communications network. The details of the cost estimates including assumptions are included in Appendix C.

Table 4: Order of Magnitude Estimate of Costs for ITS Improvements

Corridor	Project Corridor / Project Area	Estimated Cost*
A	Crow Canyon Road	$3,620,000
A1	Crow Canyon Road connection to City Offices (Traffic Server)	$320,000
B	San Ramon Valley Boulevard North	$870,000
C	Downtown	$2,920,000
D	Dougherty Road North	$1,140,000
E	Bollinger Canyon Road	$2,300,000
F	San Ramon Valley Boulevard South	$3,120,000
G	Alcosta Boulevard	$1,110,000
H	Dougherty Road and Bollinger Canyon Road	$3,210,000
I	Albion Road	$1,020,000
J	Windemere Parkway and East Branch Parkway	$2,050,000
K	Alcosta Boulevard and Old Ranch Road	$3,120,000
L	Bollinger Canyon Road West	$1,830,000
	Total Cost	**$26,630,000**

*Order of magnitude costs to be used for planning purposes only.

7.3 Prioritization of Corridor Segments

The prioritization of the project segments was conducted using some basic criteria including the following:

- Relative importance of the corridor
- Amount of existing infrastructure available (for use with fiber)
- Connectivity to City facilities and designated areas
- Number of signals to be interconnected
- Cost

Table 4 lists the segments along with the associated quantity and measurement for each of the criteria along with the proposed priority for each segment.

Table 5: Recommendations for Prioritizing Corridor Segments

Corridor	Name	No. of Traffic Signals	No. of CCTVs	No. of Flashers	No. of City Facilities	Available Infrastructure (% of corridor length)	Cost (millions)	Cost per mile (millions)	Proposed Priority
A	Crow Canyon Rd	22	9	7	3	89%	$3.62	$0.77	1
A1	Crow Canyon traffic server connection	-	-	-	-	0%	$0.32	$1.07	1a
B	San Ramon Valley Blvd North	5	-	-	-	73%	$0.87	$0.58	6
C	Downtown	16	5	2	1	83%	$2.92	$0.68	2
D	Dougherty Rd North	2	-	-	-	30%	$1.14	$0.95	11
E	Bollinger Canyon Rd	13	6	3	3	70%	$2.30	$0.79	3
F	San Ramon Valley Blvd South	5	2	-	1	17%	$3.12	$1.04	8
G	Alcosta Blvd	4	2	1	-	100%	$1.10	$0.44	9
H	Dougherty Rd and Bollinger Canyon Rd	17	6	3	5	88%	$3.20	$0.67	4
I	Albion Rd	2	-	-	1	39%	$1.02	$0.73	10
J	Windemere Pkwy and Branch Pkwy	12	1	2	3	90%	$2.05	$0.55	5
K	Alcosta Blvd and Old Ranch Rd	12	5	3	2	28%	$3.12	$1.11	7
L	Bollinger Cnyn West	-	-	-	-	0%	$1.83	$1.00	12

The Crow Canyon Road corridor is a key access point to the business districts in San Ramon and has the highest number of signals for integration. This corridor is also adjacent the City's Public Works office, which will likely be where network equipment will be located, thus making it the number one priority for deployment of the main system equipment.

The Downtown and Bollinger Segments are prioritized next for similar reasons, and because both segments act as connectors to the rest of the City's future network.

The projects are further prioritized from there into the areas with the maximum impact for business and City facilities, while prioritizing remote residential areas on a lower basis.

Based on the criteria for determining the corridor segment priorities, the following are the recommended sequences for the corridor segments in order of priority.

- 1a) Segment A1: Crow Canyon Road Connection to City Offices (Traffic Server)
- 1) Segment A: Crow Canyon Road
- 2) Segment C: Downtown
- 3) Segment E: Bollinger Canyon
- 4) Segment H: Dougherty Road and Bollinger Canyon Road
- 5) Segment J: Windemere Parkway and East Branch Parkway
- 6) Segment B: San Ramon Valley Boulevard North
- 7) Segment K: Alcosta Boulevard and Old Ranch Road
- 8) Segment F: San Ramon Valley Boulevard South
- 9) Segment G: Alcosta Boulevard
- 10) Segment I: Albion Road
- 11) Segment D: Dougherty Road North
- 12) Segment L: Bollinger Canyon Road West

Figure 6 shows the proposed segments' priorities.

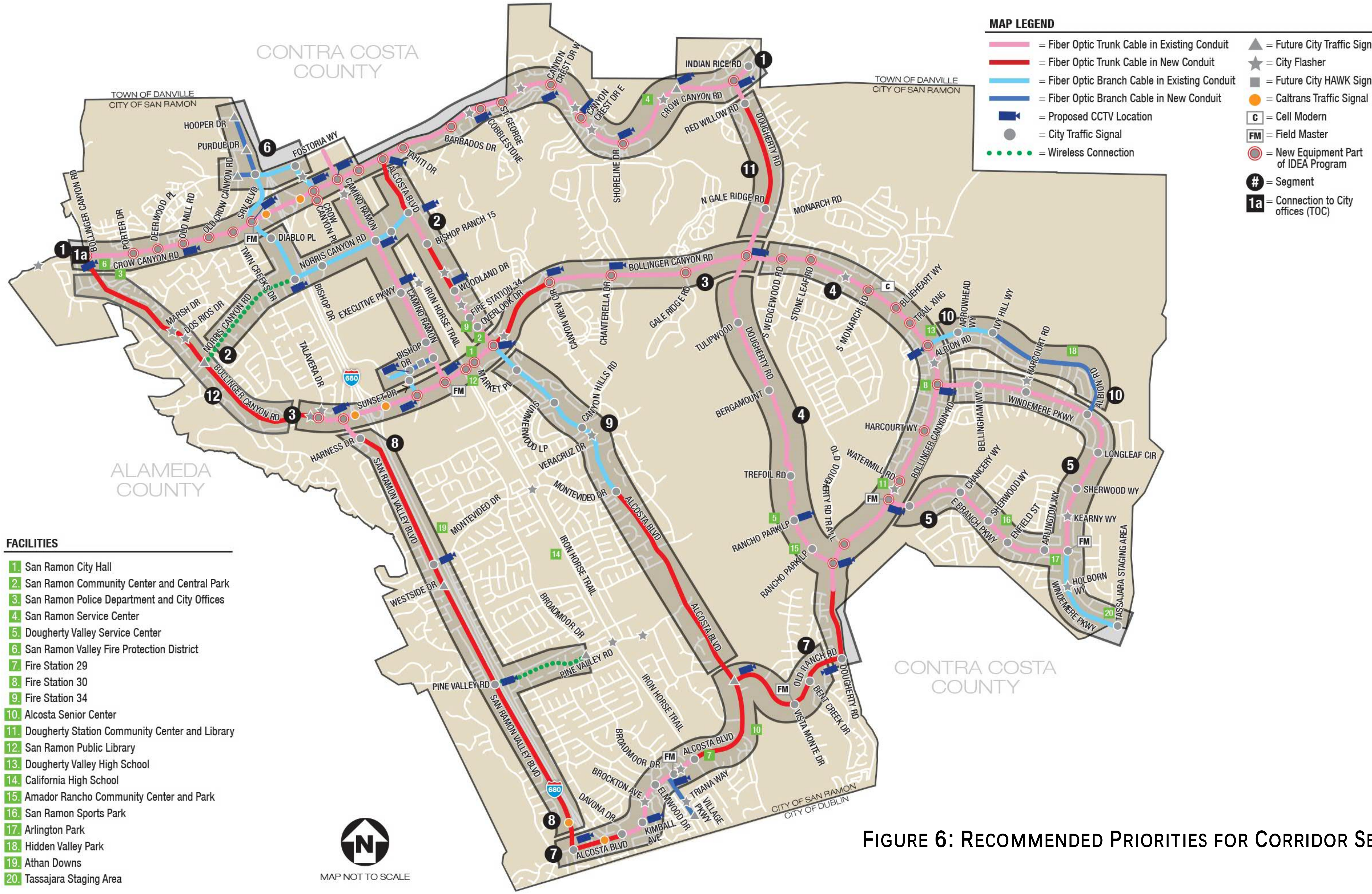


Figure 6: Recommended Priorities for Corridor Segments

APPENDICES

APPENDIX A – TRAFFIC SIGNAL LOCATIONS

No.	Intersections	Area	Master	Central Software	System	Controller	Type of Interconnect	Video Detection	Audible Ped
1	Crow @ Bollinger	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper	Econolite - Terra	
3	Crow @ Deerwood - Park	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper	Econolite - Terra	
5	Crow @ Old Mill	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper	Econolite - Terra	
8	SRVB @ Fostoria	CITY	Crow 1		Wapiti	170	Copper		Old
9	Crow @ Twin Creeks *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	Old
10	Crow @ SRVB (Field Master) *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	Old
11	Camino Ramon @ BR 3 - 2700 Camino Ramon **	CITY	Crow 2	MaxView	MaxTime	2070 ATC	Copper	No	Polara 12/16
12	Bollinger @ Canyon Lakes **	CITY	Dougherty	MaxView	MaxTime	2070 ATC	Copper	Peek	
13	Crow Cyn Pl @ Fostoria	CITY	Crow 1		Wapiti	170	Copper		Old
14	Crow Cyn Pl @ Commons Shopping Center *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	Old
15	Crow @ Crow Pl *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	
16	Crow @ Camino Ramon *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	Polara 3/15
17	Norris @ Bishop – Annabel	CITY	Crow 2		Wapiti	170	Copper		Old
18	Camino Ramon @ Norris	CITY	Crow 2		Wapiti	170	Copper		Old
19	Crow @ Alcosta *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	
20	Crow @ Tahiti - El Capitan *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	
21	Crow @ Dougherty	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
22	Bollinger @ Camino Ramon (Field Master)	CITY	Bollinger 2		Wapiti	170	Copper	Rhythm	Old
23	Bollinger @ Sunset *	CITY	Bollinger 2		Wapiti	170	Copper	Rhythm	Old
24	Bollinger @ SRVB *	CITY	Bollinger 2		Wapiti	170	Copper	Rhythm	
25	Bollinger @ Alcosta *	CITY	Bollinger 2		Wapiti	170	Copper	Rhythm	
26	SRVB @ Harness	CITY	Bollinger 2		Wapiti	170	Copper		
27	SRVB @ Montevideo	CITY	None	None	Wapiti	170	None		
30	Alcosta @ Montevideo	CITY	Bollinger 2		Wapiti	170	Copper		
31	SRVB @ Pine Valley	CITY	None	None	Apogee	2070 - Naztec	None		
32	Old Ranch @ Dougherty	CITY	Old Ranch	Translink	Wapiti	170	Copper/Radio	Econolite Solo Mini Hub 2	
33	Old Ranch @ Old Ranch Estates - Bent Creek	CITY	Old Ranch	Translink	Wapiti	170	Copper/Radio	Econolite Solo Mini Hub 2	
34	Old Ranch @ Vista Monte (Field Master)	CITY	Old Ranch	Translink	Wapiti	170	Radio		
35	Alcosta @ SRVB	CITY	None	None	Wapiti	170	Radio		Polara 7/16
36	Alcosta @ Davona	CITY	Alcosta	Translink	Wapiti	170	Copper/Radio		

No.	Intersections	Area	Master	Central Software	System	Controller	Type of Interconnect	Video Detection	Audible Ped
37	Alcosta @ Belle Meade	CITY	Alcosta	Translink	Wapiti	170	Copper		
39	Alcosta @ Kimball	CITY	Alcosta	Translink	Wapiti	170	Copper		
40	Alcosta @ BR 15 - Medical Center	CITY	Crow 2		Wapiti	170	None		
41	SRVB @ Norris	CITY	Crow 2		Wapiti	170	Copper	Econolite - Terra	
42	Alcosta @ Norris	CITY	Crow 2		Wapiti	170	Copper		
43	Alcosta @ NB I-680	CT		Caltrans	C8	170	None		
44	Crow @ Barbados	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
45	Crow @ Canyon Crest West	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		Old North only
46	Crow @ Canyon Crest East	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
47	Crow @ Shoreline	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
48	Crow @ St. George	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
49	Crow @ Indian Rice	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
50	Crow @ Porter – Creekside	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper	Econolite - Terra	
51	Crow @ Old Crow	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper	Econolite - Terra	
52	Crow @ SB I-680 *	CT		Caltrans	C8	170	Copper		
53	Crow @ NB I-680 *	CT		Caltrans	C8	170	Copper		
55	Bollinger @ Talavera	CITY	Bollinger 2		Wapiti	170	Copper		
56	Bollinger @ SB I-680 *	CT		Caltrans	C8	170	Copper		
57	Bollinger @ NB I-680 *	CT		Caltrans	C8	170	Copper		
58	Bollinger @ Market *	CITY	Bollinger 2		Wapiti	170	Copper	Rhythm	Old
59	Camino Ramon @ Executive	CITY	Bollinger 2		Wapiti	170	Copper		Old
60	Camino Ramon @ Bishop	CITY	Bollinger 2		Wapiti	170	Copper		Old
61	Bishop @ Sunset	CITY	Bollinger 2		Wapiti	170	Copper		Old
62	BR 2 @ Sunset	CITY	Bollinger 2		Wapiti	170	Copper		
63	Alcosta @ Fire Station	CITY	Bollinger 2		Wapiti	170	Copper		
64	Alcosta @ Market Pl	CITY	Bollinger 2		Wapiti	170	Copper		
65	Alcosta @ Overlook	CITY	Bollinger 2		Wapiti	170	Copper	Econolite Solo Mini Hub 2	
66	Alcosta @ Woodland	CITY	Bollinger 2		Wapiti	170	Copper		
67	Alcosta @ Summerwood South	CITY	Bollinger 2		Wapiti	170	Copper		
69	SRVB @ SB I-680	CT		Caltrans	C8	170	None		
70	Crow @ IHT *	CITY	Crow 1		Wapiti	170	Copper	Rhythm	Old
71	Norris @ IHT	CITY	Crow 2		Wapiti	170	Copper		Old

No.	Intersections	Area	Master	Central Software	System	Controller	Type of Interconnect	Video Detection	Audible Ped
72	Bollinger @ IHT - BR 1 East *	CITY	Bollinger 2		Wapiti	170	Copper	Rhythm	Polara 5/14
75	Alcosta @ Iron Horse Trail	CITY	Alcosta	Translink	Wapiti	170	Copper		
76	SRVB @ Courtyard - Diablo Shopping Center	CITY	Crow 1		Wapiti	170	Copper	Econolite - Terra	Old
77	Alcosta @ Summerwood North	CITY	Bollinger 2		Wapiti	170	Copper		
80	Crow @ Cobblestone	CITY	Crow 1	MaxView	MaxTime	2070 ATC	Copper		
81	Alcosta @ Village Pkwy (Field Master)	CITY	Alcosta	Translink	Wapiti	170	Copper		
83	Dougherty @ Red Willow	DV	Crow 1	None	Apogee	2070 - Naztec	Copper		
86	Dougherty @ Gale Ridge - Monarch	DV	None	None	Wapiti	170	None		
87	Bollinger @ Chanterella **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
88	Bollinger @ Gale Ridge **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
89	Bollinger @ Dougherty (N) **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
90	Bollinger @ Wedgewood **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		Polara 10/15
91	Bollinger @ Briar Oaks – Stoneleaf **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		Polara 10/15
92	Bollinger @ Blueheart - Main Branch **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper	Peek	Polara 10/15
93	Bollinger @ Monarch **	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		Polara 10/15
94	Bollinger @ Albion	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
95	Bollinger @ Windemere	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
96	Bollinger @ Harcourt	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
97	Bollinger @ Watermill	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
98	Bollinger @ East Branch Pkwy (Field Master)	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		Old
99	Albion @ Arrowfield - DVHS	DV	Dougherty	Translink	Wapiti	170	Copper		
100	Bollinger @ Trail Crossing	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
102	Albion @ Ivy Hill	DV	Dougherty	Translink	Wapiti	170	Copper		
110	Windemere Pkwy @ Bellingham Wy	DV	Dougherty	Translink	Apogee	2070 - Naztec	Copper	Econolite - Terra	
112	Windemere Pkwy @ Harcourt	DV	Dougherty	Translink	Wapiti	170	Copper		Old
114	Windemere Pkwy @ Silva	DV	Dougherty	Translink	Wapiti	170	Copper	Econolite - Terra	
116	Windemere Pkwy @ Bethany - Albion	DV	Dougherty	Translink	Wapiti	170	Copper		
118	Windemere Pkwy @ Longleaf - Bethany	DV	Dougherty	Translink	Wapiti	170	Copper		
119	Windemere Pkwy @ Sherwood	DV	Dougherty	Translink	Wapiti	170	Copper		
120	East Branch Pkwy @ WRMS Dwy	DV	Dougherty	Translink	Wapiti	170	Copper		
122	East Branch Pkwy @ Sherwood	DV	Dougherty	Translink	Wapiti	170	Copper		
124	East Branch Pkwy @ Chancery	DV	Dougherty	Translink	Wapiti	170	Copper		
125	East Branch Pkwy @ Enfield	DV	Dougherty	Translink	Wapiti	170	Copper		

No.	Intersections	Area	Master	Central Software	System	Controller	Type of Interconnect	Video Detection	Audible Ped
126	East Branch Pkwy @ Arlington	DV	Dougherty	Translink	Wapiti	170	Copper		
130	Windemere Pkwy @ E. Branch	DV	Dougherty	Translink	Wapiti	170	Copper		
132	Windemere Pkwy @ Tassajara Staging Area	DV	Dougherty	Translink	Wapiti	170	Copper		
140	Bollinger @ Old Dougherty (Stoneleaf)	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
141	Bollinger @ Dougherty (S)	DV	Dougherty	MaxView	MaxTime	2070 ATC	Copper		
144	Dougherty @ Rancho Park Lp (S)	DV	Dougherty	Translink	Wapiti	170	Copper		
143	Dougherty @ Rancho Park Lp (N) - Hibiscus	DV	Dougherty	Translink	Wapiti	170	Copper		
146	Dougherty @ Trefoil **	DV		MaxView	MaxTime	2070 ATC	Copper		
147	Dougherty @ Tulipwood **	DV		MaxView	MaxTime	2070 ATC	Copper		
148	Dougherty @ New Unnamed **	DV		MaxView	MaxTime	2070 ATC	Copper		

APPENDIX B – FLASHER LOCATIONS

No.	Main Street	Cross Street	Type	Installed
F1	Crow	West of Bollinger	Flashing Message Sign / Beacon	1994
F2	SB Bollinger	Marsh	School Flashing Beacon	1999
F3	NB Bollinger	Dos Rios	School Flashing Beacon	1999
F4	Crow	Service Center	Flashing Beacon	1990
F5	Iron Horse Trail	Executive	Trail Crossing Beacon	1998
F6	SB Alcosta	Veracruz	Flashing Beacon	1997
F7	Montevideo	Iron Horse Trail	Lighted Crosswalk System	2008
F8	Pine Valley	Iron Horse Trail	Lighted Crosswalk System	2008
F9	NB/SB Bollinger	E Branch Pkwy	Flashing Beacon	2008
F10	Bollinger	Talavera	Flashing Beacon	2008
F11	Village Pkwy	Triana	Crosswalk Flashing Beacon	2008
F12	NB/SB Alcosta	Iron Horse MS - Woodland & Fire Station	School Flashing Beacon	2006
F13	WB/EB Crow	Golden View ES at Canyon Crest East	School Flashing Beacon	2006
F14	Pine Valley	Walt Disney ES	Lighted Crosswalk System	2008
F15	WB Crow	St. George	Flashing Beacon	1991
F16	EB Crow	Cobblestone	Flashing Beacon	1997
F17	Alcosta	Brockton	Lighted Crosswalk System	2015
F18	Camino Ramon	South of Crow at Commons Shopping Center	Lighted Crosswalk System	2014
F19	Crow Cyn Pl	South of Fostoria at Magnolia Shopping Center	Lighted Crosswalk System	2014
F20	Windemere	Holborn	Lighted Crosswalk System	2015
F21	Windemere	Kearny	Lighted Crosswalk System	2015
F22	Harcourt	Craiglee	Lighted Crosswalk System	2015
F23	Talavera	Cardona	Lighted Crosswalk System	2015
F24	Alcosta	Broadmoor	Lighted Crosswalk System	2015
F25	Bollinger	West of Monarch	School Flashing Beacon	2015
F26	Bollinger	South of Albion	School Flashing Beacon	2015
F27	Bollinger	East of Alcosta	Flashing Beacon	2011
F29	Alcosta	Belle Meade	Lighted Crosswalk System	1995
F30	Dougherty Road	South of Hibiscus	School Flashing Beacon	2018
F31	Dougherty Road	North of Trefoil	School Flashing Beacon	2018

APPENDIX C – ORDER OF MAGNITUDE COST ESTIMATES

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SEGMENT A - Crow Canyon Road				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	24770	LF	$20	$495,400
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	2750	LF	$65	$178,750
Fiber optic pull box (N48) [2]	25	EA	$5,500	$137,500
Pull box (No. 6E) [2]	60	EA	$3,500	$210,000
Splice closure	25	EA	$3,000	$75,000
Splicing (at signals)	640	EA	$100	$64,000
Splicing (at Key City Facilities)	40	EA	$100	$4,000
Splicing (at other City Facilities)	20	EA	$100	$2,000
Fiber Optic Testing	1	LS	$28,000	$28,000
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	25	EA	$5,000	$125,000
CV/AV equipment	22	EA	$7,500	$165,000
Central Equipment	1	LS	$150,000	$150,000
Video Management System (Deploy VMS)	1	LS	$200,000	$200,000
CCTV Camera Assembly	12	EA	$15,000	$180,000
Miscellaneous Items	1	LS	$110,000	$110,000
1. Assumes trenching of new conduits			*Subtotal (Construction):*	*$2,124,650*
2. Assumes minor restoration work around each pull box			Design (15%)	$318,698
			Construction Management (15%)	$318,698
			Environmental Clearance (5%)	$106,233
			Subtotal (Design, CM, Environmental):	*$743,628*
			Contingency (35%):	*$743,628*
			TOTAL:	***$3,620,000***

SEGMENT A1 - Crow Canyon Road Connection to TOC				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	1650	LF	$20	$33,000
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	1320	LF	$65	$85,800
Fiber optic pull box (N48) [2]	0	EA	$5,500	$0
Pull box (No. 6E) [2]	4	EA	$3,500	$14,000
Splice closure	0	EA	$3,000	$0
Splicing (at signals)	0	EA	$100	$0
Splicing (at Key City Facilities)	288	EA	$100	$28,800
Splicing (at other City Facilities)	0	EA	$100	$0
Fiber Optic Testing	1	LS	$11,520	$11,520
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	0	EA	$5,000	$0
CV/AV equipment	0	EA	$7,500	$0
Central Equipment	0	LS	$150,000	$0
Video Management System (Deploy VMS)	0	LS	$200,000	$0
CCTV Camera Assembly	0	EA	$15,000	$0
Miscellaneous Items	1	LS	$10,000	$10,000
1. Assumes trenching of new conduits			*Subtotal (Construction):*	*$183,120*
2. Assumes minor restoration work around each pull box			Design (15%)	$27,468
			Construction Management (15%)	$27,468
			Environmental Clearance (5%)	$9,156
			Subtotal (Design, CM, Environmental):	*$64,092*
			Contingency (35%):	*$64,092*
			TOTAL:	***$320,000***

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SEGMENT B - San Ramon Valley Boulevard North				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	0	LF	$20	$0
Fiber optic cable (48 strands)	9320	LF	$12	$111,840
3 inch conduit [1]	2500	LF	$65	$162,500
Fiber optic pull box (N48) [2]	5	EA	$5,500	$27,500
Pull box (No. 6E) [2]	15	EA	$3,500	$52,500
Splice closure	5	EA	$3,000	$15,000
Splicing (at signals)	180	EA	$100	$18,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	0	EA	$100	$0
Fiber Optic Testing	1	LS	$7,200	$7,200
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	5	EA	$5,000	$25,000
CV/AV equipment	5	EA	$7,500	$37,500
Central Equipment	1	LS	$30,000	$30,000
CCTV Camera Assembly	0	LS	$15,000	$0
VMS (Licensing and Integration)	0	EA	$3,000	$0
Miscellaneous Items	1	LS	$23,125	$23,125
1. Assumes trenching of new conduits			*Subtotal (Construction)*	*$510,165*
2. Assumes minor restoration work around each pull box			Design (15%)	$76,525
			Construction Management (15%)	$76,525
			Environmental Clearance (5%)	$25,508
			Subtotal (Design, CM, Environmental):	*$178,558*
			Contingency (35%):	$178,558
			TOTAL:	***$870,000***

SEGMENT C - Downtown San Ramon				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	17630	LF	$20	$352,600
Fiber optic cable (48 strands)	10700	LF	$12	$128,400
3 inch conduit [1]	4910	LF	$65	$319,150
Fiber optic pull box (N48) [2]	17	EA	$5,500	$93,500
Pull box (No. 6E) [2]	48	EA	$3,500	$168,000
Splice closure	17	EA	$3,000	$51,000
Splicing (at signals)	930	EA	$100	$93,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	20	EA	$100	$2,000
Fiber Optic Testing	1	LS	$38,000	$38,000
Wireless Communication Assembly	1	EA	$30,000	$30,000
Communications Switch	17	EA	$5,000	$85,000
CV/AV equipment	16	EA	$7,500	$120,000
Central Equipment	1	LS	$60,000	$60,000
CCTV Camera Assembly	6	EA	$15,000	$90,000
VMS (Licensing and Integration)	6	EA	$3,000	$18,000
Miscellaneous Items	1	LS	$66,250	$66,250
1. Assumes trenching of new conduits			*Subtotal (Construction):*	*$1,714,900*
2. Assumes minor restoration work around each pull box			Design (15%)	$257,235
			Construction Management (15%)	$257,235
			Environmental Clearance (5%)	$85,745
			Subtotal (Design, CM, Environmental):	*$600,215*
			Contingency (35%):	*$600,215*
			TOTAL:	***$2,920,000***

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SEGMENT D - Dougherty Road North				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	7390	LF	$20	$147,800
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	2500	LF	$65	$162,500
Fiber optic pull box (N48) [2]	2	EA	$5,500	$11,000
Pull box (No. 6E) [2]	15	EA	$3,500	$52,500
Splice closure	2	EA	$3,000	$6,000
Splicing (at signals)	320	EA	$100	$32,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	0	EA	$100	$0
Fiber Optic Testing	1	LS	$12,800	$12,800
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	2	EA	$5,000	$10,000
CV/AV equipment	2	EA	$7,500	$15,000
Central Equipment	1	LS	$15,000	$15,000
CCTV Camera Assembly	0	EA	$15,000	$0
VMS (Licensing and Integration)	0	EA	$3,000	$0
Miscellaneous Items	1	LS	$10,000	$10,000

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$474,600*
Design (15%)	$71,190
Construction Management (15%)	$71,190
Environmental Clearance (5%)	$23,730
Subtotal (Design, CM, Environmental):	*$166,110*
Contingency (35%):	*$166,110*
TOTAL:	***$1,140,000***

SEGMENT E - Bollinger Canyon Road				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	18900	LF	$20	$378,000
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	5720	LF	$65	$371,800
Fiber optic pull box (N48) [2]	16	EA	$5,500	$88,000
Pull box (No. 6E) [2]	31	EA	$3,500	$108,500
Splice closure	16	EA	$3,000	$48,000
Splicing (at signals)	550	EA	$100	$55,000
Splicing (at Key City Facilities)	40	EA	$100	$4,000
Splicing (at other City Facilities)	20	EA	$100	$2,000
Fiber Optic Testing	1	LS	$24,400	$24,400
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	16	EA	$5,000	$80,000
CV/AV equipment	13	EA	$7,500	$97,500
Central Equipment	1	LS	$60,000	$60,000
CCTV Camera Assembly	7	EA	$15,000	$105,000
VMS (Licensing and Integration)	7	EA	$3,000	$21,000
Miscellaneous Items	1	LS	$59,375	$59,375

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$1,502,575*
Design (10%)	$150,258
Construction Management (10%)	$150,258
Environmental Clearance (3%)	$45,077
Subtotal (Design, CM, Environmental):	*$345,592*
Contingency (30%)	*$450,773*
TOTAL:	***$2,300,000***

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SEGMENT F - San Ramon Valley Boulevard South				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	19380	LF	$20	$387,600
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	16020	LF	$65	$1,041,300
Fiber optic pull box (N48) [2]	6	EA	$5,500	$33,000
Pull box (No. 6E) [2]	31	EA	$3,500	$108,500
Splice closure	6	EA	$3,000	$18,000
Splicing (at signals)	370	EA	$100	$37,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	20	EA	$100	$2,000
Fiber Optic Testing	1	LS	$15,600	$15,600
Wireless Communication Assembly	1	EA	$30,000	$30,000
Communications Switch	6	EA	$5,000	$30,000
CV/AV equipment	5	EA	$7,500	$37,500
Central Equipment	1	LS	$30,000	$30,000
CCTV Camera Assembly	2	EA	$15,000	$30,000
VMS (Licensing and Integration)	2	EA	$3,000	$6,000
Miscellaneous Items	1	LS	$24,375	$24,375
1. Assumes trenching of new conduits			*Subtotal (Construction):*	*$1,830,875*
2. Assumes minor restoration work around each pull box			Design (15%)	$274,631
			Construction Management (15%)	$274,631
			Environmental Clearance (5%)	$91,544
			Subtotal (Design, CM, Environmental):	*$640,806*
			Contingency (35%):	*$640,806*
			TOTAL:	***$3,120,000***

SEGMENT G - Alcosta Boulevard				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	0	LF	$20	$0
Fiber optic cable (48 strands)	7750	LF	$12	$93,000
3 inch conduit [1]	6900	LF	$65	$448,500
Fiber optic pull box (N48) [2]	4	EA	$5,500	$22,000
Pull box (No. 6E) [2]	13	EA	$3,500	$45,500
Splice closure	4	EA	$3,000	$12,000
Splicing (at signals)	120	EA	$100	$12,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	0	EA	$100	$0
Fiber Optic Testing	1	LS	$4,800	$4,800
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	4	EA	$5,000	$20,000
CV/AV equipment	4	EA	$7,500	$30,000
Central Equipment	1	LS	$15,000	$15,000
CCTV Camera Assembly	0	EA	$15,000	$0
VMS (Licensing and Integration)	0	EA	$3,000	$0
Miscellaneous Items	1	LS	$16,250	$16,250
1. Assumes trenching of new conduits			*Subtotal (Construction):*	*$719,050*
2. Assumes minor restoration work around each pull box			Design (15%)	$71,905
			Construction Management (15%)	$71,905
			Environmental Clearance (5%)	$21,572
			Subtotal (Design, CM, Environmental):	*$165,382*
			Contingency (35%):	*$215,715*
			TOTAL:	***$1,110,000***

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SEGMENT H - Dougherty Road and Bollinger Canyon Road				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	33850	LF	$20	$677,000
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	4000	LF	$65	$260,000
Fiber optic pull box (N48) [2]	21	EA	$5,500	$115,500
Pull box (No. 6E) [2]	51	EA	$3,500	$178,500
Splice closure	21	EA	$3,000	$63,000
Splicing (at signals)	580	EA	$100	$58,000
Splicing (at Key City Facilities)	40	EA	$100	$4,000
Splicing (at other City Facilities)	40	EA	$100	$4,000
Fiber Optic Testing	1	LS	$26,400	$26,400
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	21	EA	$5,000	$105,000
CV/AV equipment	18	EA	$7,500	$135,000
Central Equipment	1	LS	$75,000	$75,000
CCTV Camera Assembly	6	EA	$15,000	$90,000
VMS (Licensing and Integration)	6	EA	$3,000	$18,000
Miscellaneous Items	1	LS	$78,750	$78,750

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$1,888,150*
Design (15%)	$283,223
Construction Management (15%)	$283,223
Environmental Clearance (5%)	$94,408
Subtotal (Design, CM, Environmental):	*$660,853*
Contingency (35%):	*$660,853*
TOTAL:	***$3,210,000***

SEGMENT I - Albion Road				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	0	LF	$20	$0
Fiber optic cable (48 strands)	8730	LF	$12	$104,760
3 inch conduit [1]	5320	LF	$65	$345,800
Fiber optic pull box (N48) [2]	3	EA	$5,500	$16,500
Pull box (No. 6E) [2]	14	EA	$3,500	$49,000
Splice closure	3	EA	$3,000	$9,000
Splicing (at signals)	80	EA	$100	$8,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	20	EA	$100	$2,000
Fiber Optic Testing	1	LS	$4,000	$4,000
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	3	EA	$5,000	$15,000
CV/AV equipment	2	EA	$7,500	$15,000
Central Equipment	1	LS	$15,000	$15,000
CCTV Camera Assembly	0	EA	$15,000	$0
VMS (Licensing and Integration)	0	EA	$3,000	$0
Miscellaneous Items	1	LS	$11,250	$11,250

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$595,310*
Design (15%)	$89,297
Construction Management (15%)	$89,297
Environmental Clearance (5%)	$29,766
Subtotal (Design, CM, Environmental):	*$208,359*
Contingency (35%):	*$208,359*
TOTAL:	***$1,020,000***

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SEGMENT J - Windemere Parkway and Branch Parkway				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	19880	LF	$20	$397,600
Fiber optic cable (48 strands)	4250	LF	$12	$51,000
3 inch conduit [1]	2500	LF	$65	$162,500
Fiber optic pull box (N48) [2]	15	EA	$5,500	$82,500
Pull box (No. 6E) [2]	39	EA	$3,500	$136,500
Splice closure	15	EA	$3,000	$45,000
Splicing (at signals)	470	EA	$100	$47,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	50	EA	$100	$5,000
Fiber Optic Testing	1	LS	$20,800	$20,800
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	15	EA	$5,000	$75,000
CV/AV equipment	11	EA	$7,500	$82,500
Central Equipment	1	LS	$45,000	$45,000
CCTV Camera Assembly	0	EA	$15,000	$0
VMS (Licensing and Integration)	0	EA	$3,000	$0
Miscellaneous Items	1	LS	$50,625	$50,625

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$1,201,025*
Design (15%)	$180,154
Construction Management (15%)	$180,154
Environmental Clearance (5%)	$60,051
Subtotal (Design, CM, Environmental):	*$420,359*
Contingency (35%):	*$420,359*
TOTAL:	***$2,050,000***

SEGMENT K - Alcosta Boulevard and Old Ranch Road				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	16270	LF	$20	$325,400
Fiber optic cable (48 strands)	1850	LF	$12	$22,200
3 inch conduit [1]	13060	LF	$65	$848,900
Fiber optic pull box (N48) [2]	14	EA	$5,500	$77,000
Pull box (No. 6E) [2]	33	EA	$3,500	$115,500
Splice closure	14	EA	$3,000	$42,000
Splicing (at signals)	530	EA	$100	$53,000
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	40	EA	$100	$4,000
Fiber Optic Testing	1	LS	$22,800	$22,800
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	14	EA	$5,000	$70,000
CV/AV equipment	11	EA	$7,500	$82,500
Central Equipment	1	LS	$45,000	$45,000
CCTV Camera Assembly	4	EA	$15,000	$60,000
VMS (Licensing and Integration)	4	EA	$3,000	$12,000
Miscellaneous Items	1	LS	$49,375	$49,375

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$1,829,675*
Design (15%)	$274,451
Construction Management (15%)	$274,451
Environmental Clearance (5%)	$91,484
Subtotal (Design, CM, Environmental):	*$640,386*
Contingency (35%):	*$640,386*
TOTAL:	***$3,120,000***

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SEGMENT L - Bollinger Canyon Road West				
Item	Quantity	Unit	Unit Price	Total
Fiber optic cable (288 strands)	12080	LF	$20	$241,600
Fiber optic cable (48 strands)	0	LF	$12	$0
3 inch conduit [1]	10630	LF	$65	$690,950
Fiber optic pull box (N48) [2]	0	EA	$5,500	$0
Pull box (No. 6E) [2]	25	EA	$3,500	$87,500
Splice closure	0	EA	$3,000	$0
Splicing (at signals)	288	EA	$100	$28,800
Splicing (at Key City Facilities)	0	EA	$100	$0
Splicing (at other City Facilities)	40	EA	$100	$4,000
Fiber Optic Testing	1	LS	$13,120	$13,120
Wireless Communication Assembly	0	EA	$30,000	$0
Communications Switch	2	EA	$5,000	$10,000
CV/AV equipment	0	EA	$7,500	$0
Central Equipment	0	LS	$45,000	$0
CCTV Camera Assembly	0	EA	$15,000	$0
VMS (Licensing and Integration)	0	EA	$3,000	$0
Miscellaneous Items	0	LS	$2,500	$0

1. Assumes trenching of new conduits
2. Assumes minor restoration work around each pull box

Subtotal (Construction):	*$1,075,970*
Design (15%)	$161,396
Construction Management (15%)	$161,396
Environmental Clearance (5%)	$53,799
Subtotal (Design, CM, Environmental):	*$376,590*
Contingency (35%):	*$376,590*
TOTAL:	***$1,830,000***

TOTAL COST	$26,630,000