SAN GABRIEL VALLEY TRAFFIC FORUM

COMMUNICATIONS SYSTEMS ALTERNATIVES ANALYSIS REPORT

Deliverable 2.5.2.1

DRAFT

Prepared for:

Los Angeles County Department of Public Works

Prepared by:

TRANSCORE

626 Wilshire Boulevard
Suite 818
Los Angeles, California 90017

May 16th, 2005

TABLE OF CONTENTS **PAGE#**

TABLE OF EXHIBITS **PAGE #**

1. INTRODUCTION

1.1 PROJECT OVERVIEW

The San Gabriel Valley Traffic Forum (SGVTF) is one of the planned Intelligent Transportation Systems (ITS) improvement projects that the Los Angeles County Department of Public Works (County) is developing as part of the Traffic System Management (TSM) program in order to improve traffic flow and enhance arterial capacity in a cost-effective way where roadway widening is not possible. The purpose of the SGVTF project is to design, develop, and deploy an Advanced Transportation Management System (ATMS) that can be tailored to each Agency's operational needs so that traffic signals can be synchronized and ITS systems integrated across jurisdictional boundaries. The SGVTF project focuses on the specific needs of each Agency to manage their ATMS and recommends improvements to field infrastructure (e.g., controllers, detection systems, communications, etc.) and centralized Traffic Control Systems (TCSs) and/or Traffic Management Centers (TMCs) to meet those requirements. When the SGVTF is successfully completed, each of the Agencies responsible for traffic signal operations will have full access to an ATMS that monitors and controls the traffic signals within their jurisdiction. In addition, Agencies will be able to synchronize their signals and exchange traffic information in real-time with neighboring Agencies. This will allow the Agencies to respond to recurrent and non-recurrent congestion in a coordinated fashion across jurisdictional boundaries.

The SGVTF project area ranges from Cities bordering the California State Route (CA SR) 110 and I-710 freeways to the west, I-210 freeway to the north, CA SR 57 freeway to the east, and the CA SR 60 freeway to the south. It encompasses 24 municipalities as well as unincorporated portions of Los Angeles County. The traffic signals in this region are operated by many of the individual Agencies, County, and Caltrans District 7.

Developed by the County, the Countywide Information Exchange Network (IEN) is the integrated system framework that connects participating Agency ATMSs into a regional network to support the operational goals identified above. The Countywide IEN supports traffic signal operations at the Local level, Corridor level, and Regional level. The SGVTF assumes the availability of the Countywide IEN at the Corridor and Regional levels. Therefore, the SGVTF project is focused on the selection of TCSs and the integration of those systems to the Countywide IEN at the Local level. The eventual ATMS design for the SGVTF will take into account the interface to the Countywide IEN and its requirements at the Local level and encompass the following six (6) core components:

- ATMS and/or TCS (Individual Agency)
- Detection and Surveillance
- TMC and/or Workstation Layouts (ATMS and/or IEN)
- Communications Network
- SGVTF Participation/Coordination (City-specific and/or SGVTF-Regional integration)
- Operations and Maintenance (O&M)

The Countywide IEN comprises a series of computer servers, communication networks, and software applications that integrates these components for the collection and transfer of data to support Corridor and Regional functions throughout Los Angeles County. Exhibit 1.1 provides a high-level graphical representation of the Countywide IEN framework.

Exhibit 1.1 – Countywide IEN

1.2 PURPOSE OF DOCUMENT

This document provides the Communications System Alternatives Analysis Report (Deliverable 2.5.2.1), which is a deliverable related to the Alternatives Analysis Task of the SGVTF Project. This document will address the fundamentals of the communications technologies that are related to this project. In addition, it will utilize the needs and objectives of the Stakeholders, and incorporate the technology capabilities in order to provide an economically robust communication system for the SGVTF. This document will also provide an overview and quantity of the existing and planned ITS field devices in order to provide an accurate calculation of the bandwidth required to communicate with the field equipment as well as to support center-to-center (C2C) communication.

1.3 REPORT ORGANIZATION

This document is organized into the following sections:

- **Section 1: Introduction**

  This section presents the project overview, background, and introduces the document. It also presents a brief history of the project highlighting on past communications-related work. In addition, it provides different levels of the Countywide IEN and how it supports Agency traffic signal operations.

- **Section 2: Field Devices and Communication Systems**

  This section identifies the existing and planned ITS field devices and also the Local communication network that reside in each SGVTF Agency. In addition, it presents brief overviews of the communication network architecture for both field-to-center (F2C) and also center-to-center (C2C) communication.

- **Section 3: Review of Communication Technologies**

  This section presents different communication technologies that are relevant and may be an option to be implemented for the SGVTF Project. It will provide a brief description of each technology including its limitations and best use of the technology.

- **Section 4: Technology Recommendations**

  This section will integrate the recommended technologies for the SGVTF Project with the needs and requirements of the SGVTF Agency Stakeholders.

- **Section 5: Project Recommendations**

  This section will present the technologies that are best suited for each Agency Level within the SGVTF Project. It will also include a cost analysis of the overall deployment of each recommended technology within the SGVTF.

1.4 METHODOLOGY

The methodology of assessing the different types of technologies of communication for the SGVTF Project includes the following categories:

- Assessment of existing and planned ITS field devices
- Assessment of existing communication networks
- Needs and objectives of the SGVTF Stakeholders
- Conformance with the communications needs and objectives of the Stakeholders, and any related documentations mentioned in Section 1.5.
- Based on proven ITS communication technologies related to the SGVTF Project
- Assessment and engineering of the most economical communications alternative network

1.5 REFERENCED DOCUMENTS

The following documents have been used as reference material in the preparation of this report:

- San Gabriel Valley Traffic Forum Project
  - Deliverable 2.1.1: Operational Objectives
  - Deliverable 2.2.1: System Needs
  - Deliverable 2.3.1.1: Concept-of-Operations
  - Deliverable 2.3.2.1: ATMS User Requirements
  - Deliverable 2.3.3.1: ATMS Functional Requirements
  - Deliverable 2.3.4.1: LCCS System Requirements
  - Deliverable 2.3.5.1: Sub-Regional TMC Requirements
  - Deliverable 2.3.8.1: Communications System Requirements
- I-105 Corridor Project
  - TSMACS User Requirements Report (Final)
  - Functional Requirements Report (Draft)
- San Gabriel Valley Pilot Project
  - System Design Report, Final Version 1.0
  - Communications Report, 2003 Update (Final)
- Pomona Valley ITS Project
  - Sub-Regional TMC Report

1.6 ACRONYMS AND ABBREVIATIONS

ATMS	Advanced Transportation Management System
bps	bytes per second
C2C	Center-to-Center
CCTV	Closed Circuit Television
CDI	Command/Data Interface
CO	Central Office
CSU/DSU	Channel Service Unit/Data Service Unit
DDS	Digital Data Service
DLCI	Data Link Connection Identifier
DPW	Department of Public Works
F2C	Field-to-Center
fps	Frames Per Second
GHz	Giga Hertz
HAR	Highway Advisory Radio
HAT	Highway Advisory Telephone
IEN	Information Exchange Network
ISP	Internet Service Providers
ITS	Intelligent Transportation System(s)
LA	Los Angeles
LACDPW	Los Angeles County Department of Public Works
LAN	Local Area Network
LCCS	Local City Control Site
MHz	Mega Hertz
O&M	Operations and Maintenance
POP	Internet Point of Presence
PVC	Permanent Virtual Circuits
SGVTF	San Gabriel Valley Traffic Forum
TCS	Traffic Control System
TDM	Time Division Multiplexed
TMC	Transportation Management Center
TSM	Traffic System Management
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network

2. FIELD DEVICES AND COMMUNICATION SYSTEMS

The communications systems deployed as part of future traffic projects will need to support a variety of field components. These components are the integral part of the communication system, in order to share traffic data, video images, traffic signal information, etc. within an Agency, with other Agencies, and also with the SGVTF IEN Corridor Server.

2.1 ITS FIELD DEVICE SUMMARY

The individual Agencies that are involved with the SGVTF Project currently have an extensive ITS infrastructure that will need to be supported by the communications network. In addition to the existing field equipment many Agencies also have plans to install additional devices. Exhibit 2.1 presents a summary of all ITS field devices (existing and planned) for the SGVTF Project.

Exhibit 2.1 – Existing and Planned ITS Field Devices

Agency	Traffic Controller			CCTV Camera			CMS		
	Existing	Planned	Total	Existing	Planned	Total	Existing	Planned	Total
Alhambra	99	0	99	0	0	0	0	0	0
Arcadia	71	0	71	0	10	10	0	2	2
Azusa	52	0	52	0	4	4	0	0	0
Baldwin Park	56	8	64	0	5	5	0	0	0
Covina	49	0	49	0	5	5	0	0	0
Duarte	11	3	14	0	3	3	0	0	0
El Monte	67	3	70	0	0	0	0	0	0
Glendora	40	4	44	2	0	2	0	0	0
Irwindale	15	19	34	0	9	9	0	2	2
La Puente	11	0	11	0	0	0	0	0	0
LADPW	200	0	200	2	0	2	0	0	0
Monrovia	34	1	35	0	3	3	0	3	3
Montebello	78	0	78	0	0	0	0	2	2
Monterey Park	65	0	65	0	0	0	0	0	0
Pasadena	308	0	308	10	8	18	9	2	11
Rosemead	51	1	52	0	0	0	0	0	0
San Dimas	33	0	33	2	5	7	0	0	0
San Gabriel	34	0	34	0	5	5	0	2	2
San Marino	18	0	18	0	2	2	0	0	0
South El Monte	22	0	22	0	2	2	0	0	0
S. Pasadena	36	0	36	0	1	1	0	0	0
Temple City	28	0	28	0	5	5	0	0	0
West Covina	112	0	112	0	0	0	0	0	0
Total	Traffic Controller		**1,529**	CCTV Camera		**83**	CMS		**22**

2.2 INFORMATION EXCHANGE NETWORK (IEN)

The Countywide Information Exchange Network (IEN) provides the communications between the Agencies involved in the SGVTF. The IEN coordinates all of the traffic and incident data coming in from various Traffic Forums. In order to communicate with the various Local Agencies, the following servers and workstations are needed:

- **IEN Corridor Server** -The IEN Corridor Server is a computer that is installed and is operational at the Sub-Regional TMC. For this project, the SGV IEN Corridor Server will be located at the Los Angles County Department of Public Works (LACDPW) Traffic Management Center (TMC). It collects traffic data from individual Agency Traffic Control Systems (TCS) within the SGVTF Region, and then provides a regional view of the traffic condition via the IEN Workstation.

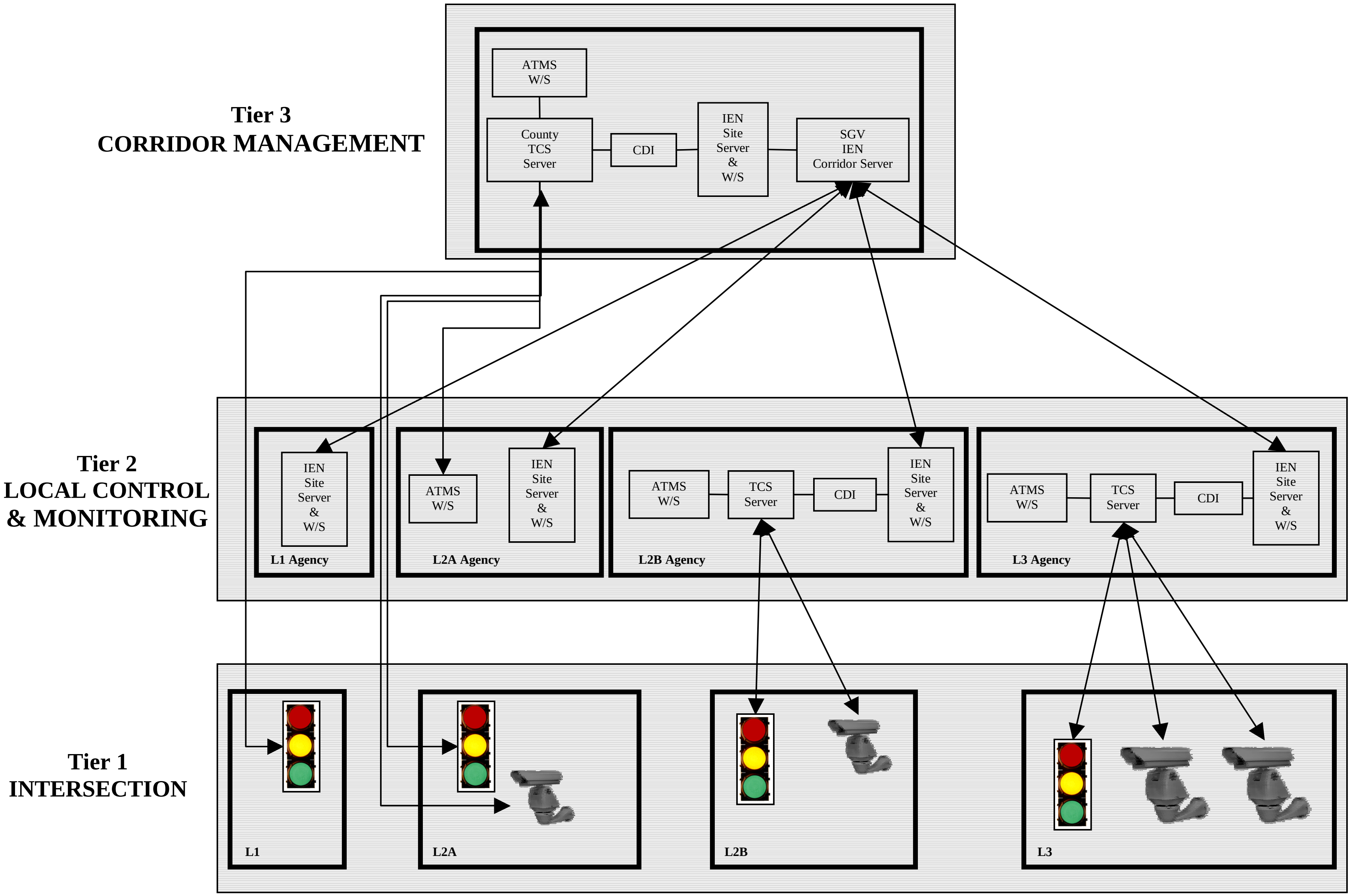
- **IEN Site Server** - The IEN Site Server is a software application that can reside on the same computer platform as that of the IEN Workstation. It establishes the communications between the IEN Workstation and the IEN Corridor Server for data exchange. The IEN Workstation sends and receives traffic data and requests through the IEN Site Server software application. All participating SGVTF Agencies will receive an IEN Site Server.
- **IEN Workstation** - The IEN Workstation provides a Regional view of the traffic conditions and provides limited control of local traffic signals. All participating SGVTF Agencies will receive an IEN Workstation. It will typically be located in the office of an individual who would be responsible for traffic operations.
- **Command Data Interface (CDI)** - The CDI is a separate computer that will run the required software application to exchange data between the TCS, IEN Site Server, and IEN Corridor Server. The CDI sends and receives its traffic data through the IEN Site Server. The CDI will typically be located in the communication room close to the local TCS central server.

2.3 OVERALL COMMUNICATION NETWORK ARCHITECTURE

In order to develop a suitable communications network architecture for the SGVTF Project, it is important to take a look at the communications network from a high level. Exhibit 2.2 illustrates the functional communications network. The SGVTF network architecture can be divided into three tiers (Tier 1, 2, and 3) with interconnection between the tiers. Tier 1 – Intersections encompasses all the ITS field devices such as field controllers, CCTV cameras, CMS, HAR, etc. Tier 2 – Local Control and Monitoring includes the communication network from the field devices to the LCCS. Tier 3 – Corridor Management is the Sub-Regional operations, through the Sub-Regional TMC, as well as the communication of the LA County Central TCS Server with Level 1 and 2A Agencies.

As presented in Exhibit 2.2, LA County DPW will be “hosting” all ITS field devices for Level 1 and 2A Agencies. Level 2B and 3 Agencies will have a stand-alone central TCS server, which will enable them to control and monitor their own field devices. Each Agency will have an IEN Workstation to communicate with other Agencies through the Countywide IEN network.

Exhibit 2.2 – Functional Communication Network



2.3.1 Field-to-Center (F2C)

The F2C communications network will allow a central TCS server [located either at the Agency LCCS or "host" Agency LCCS – aka LA County] to have control and/or monitoring capabilities of the ITS field devices. The communications network must be designed to accommodate the bandwidth for each individual field device. The bandwidth is the "size" of the communication pipe that is necessary to transfer data signals or video images. The higher the bandwidth required, the larger the pipe is needed to transfer the information. Exhibit 2.3 summarizes the bandwidth requirements for all the ITS field devices.

Exhibit 2.3 – Field Device Bandwidth Requirements

Field Devices	Bandwidth Requirements (Typical)
Traffic Signal Controller*	1.2 Kbps to 19.2 Kbps
CCTV** (less than 2fps)	128 Kbps
CCTV** (less than 10fps)	512 Kbps
CCTV** (less than 25fps)	1.54 Mbps
CMS	9.6 Kbps
HAR	56 Kbps
HAT	56 Kbps

*Note: Traffic Signal Controllers will be connected in a multi-drop topology with no more than eight (8) controllers on a circuit.

**Note: 128 Kbps will provide low-resolution compressed digital video images up to 2 fps (Frames per second. In order to increase the number of frames per second to less than 10 with low-resolution compressed digital video images, the bandwidth has to be increased to 512 Kbps. Furthermore, in order to increase the number of frames per second to less than 25 with medium-resolution compressed digital video images the bandwidth has to be increased to 1.5 Mbps.

The development of the field communications network will be built around communications channels to support the field devices. The current state-of-the-practice provides separate communications channels for different types of field devices (e.g. traffic signals, CMS, etc). For traffic signal controllers, it is possible to interconnect multiple intersections onto a single multi-drop communications channel. A similar architecture is suitable for CMS if the signs are in close proximity to one another. The communications networks for other high-bandwidth devices, such as CCTV cameras, are typically configured with a single device on a communications channel.

2.3.2 Center-to-Center (C2C)

The C2C communications network will provide the means of transferring TCS data, and video images to/from an Agency LCCS to the SGVTF Sub-Regional TMC. The communication network shall be able to support the aggregate sum of all bandwidth required for each field device from the Agency LCCS to the LA County TMC. The second level of C2C communication is the connection between a Local Agency IEN Workstation with the SGV IEN Corridor Server.

Based on the Countywide IEN requirements, the existing Committed Information Rate (CIR) from the IEN Workstation to the SGV IEN Corridor Server will be at least 384 kbps. The CIR may have to be increased based on the recommended technology in order to accommodate the aggregate sum of all the bandwidth required for each field device and the IEN Workstation.

3. REVIEW OF COMMUNICATION TECHNOLOGIES

There are numerous communications technologies that are capable of providing the bandwidth required for the F2C and C2C communications. These technologies cover both wireline and wireless alternatives as well as Agency owned and leased technologies. The recommended technologies will provide the Agencies a proven approach for both F2C and C2C communication infrastructure.

3.1 UNLICENSED SPREAD SPECTRUM RADIOS

Unlicensed Spread Spectrum Radio (USSR) is a very popular communications technology. The ability to install the equipment without the need for an FCC license is one of the strong selling points of this technology. Unfortunately, that same selling point can also be a problem for a large-scale implementation. A system that is installed today may have problems in the future because of new equipment that is installed in the area by other unlicensed users. USSR is a popular technology for cordless phones and wireless LAN equipment. Interference from other users may not be a problem in rural areas, but should be planned for in the urban areas of Los Angeles County. In order to minimize the impact of new users in the area, careful consideration must be given to the design of the network. The use of directional antennas, such as the one shown in Exhibit 3.1 illustrates one method that can be used to minimize the effects of interference from other spread spectrum users.

Exhibit 3.1 - Directional Spread Spectrum Antenna

Some of the most popular types of directional antennas are the yaggi, parabolic dish, and flat panel. Parabolic dishes and flat panel antennas offer a higher level of performance, but will not be necessary for this type of application. The antenna in Exhibit 3.1 is a high gain yaggi antenna. These antennas come in several different sizes and configurations. Larger antennas have more gain and can be used in areas where it is necessary to cover long distances or when installed in areas with substantial background noise.

USSR are available in three frequency ranges, 900 MHz, 2.4 GHz, and 5.8 GHz. The 900 MHz range is popular for applications that require low bandwidths such as cordless phones and traffic signals. The 2.4 GHz range is popular for applications that have a requirement for mid-level bandwidths such as 802.11b wireless LAN equipment. There has been an explosion of equipment in this category and this frequency range can be very busy. The 5.8 GHz range is popular for high-end, high bandwidth applications. The higher cost of this equipment has kept the number of users to a more reasonable level, but it is popular for large corporate and government customers that can justify the cost of this type of equipment.

USSR equipment is designed to operate in the type of environment that is typical for traffic signal equipment. Equipment is available with operating temperatures of -40 C to 80 C. Some manufacturers also provide a variety of mounting options including standalone shelf mount units, or cards designed to plug into, and draw power from a 170/TS1/TS2 detector rack. Models are also available with a NEMA 4X weatherproof enclosure for applications when it is not practical to use an existing equipment cabinet.

3.2 UNLICENSED WIRELESS LAN TECHNOLOGY

Unlicensed wireless Local Area Network (LAN) technology is another popular communication technology. This technology also transmits data between two (2) devices without a physical connection. The main intention of the wireless LAN technology is to provide access infrastructure for an end user. Fixed wireless systems can be used for almost anything that a cable is used for, whether the cable is T-1 circuit, an Ethernet cable, or fiber optic cable. Wireless LAN technology is used for data, voice, and video transmissions.

There are several advantages and disadvantages of using wireless LAN technology. The advantage of using wireless over landline is the low capital cost, faster deployment, and greater flexibility. In general, the cost of wireless technology is much lower, but the cost and deployment has to be evaluated on case-by-case basis.

The disadvantage of wireless LAN technology over USSR is that, wireless technology operates on a specified frequency (MHz, GHz), which does not change with time. For instance, if you are listening to 104.3MHz on the FM radio, the signal stays at 104.3MHz; it does not go up to 105.2Mhz or down to 103.7MHz. The signal stays the same at all times. The frequency of conventional signal is kept constant, therefore it is much more vulnerable for external access. In USSR, the data-signal is spread over a range of frequency-band using a code uncorrelated with that signal. As a result, the USSR bandwidth occupancy is much higher then required. The codes used for spreading have low cross-correlation values and are unique to every user. This is the reason that a USSR receiver, which has knowledge about the code of the intended transmitter, is capable of selecting the desired signal. Therefore, due to the random code generation, it is hardly possible to detect messages of another USSR user.

The use of wireless LAN technology will not require FCC licensing. A wireless LAN is one in which a field device, or mobile users can connect to a LAN through a wireless radio connection. A radio network is a collection of nodes communicating together through radio devices, using radio waves to carry the information exchanged.

In order to provide the coverage needed for each Local Agency, it may be necessary to install equipment at locations with clear line of site. To provide the required line of site, repeater sites may be necessary. It may be practical to consider this technology to provide a F2C communication.

3.3 LICENSED MICROWAVE

The use of this type of equipment will require FCC licenses. Earlier reports have suggested that licensing for the Los Angeles County area can be difficult because of the number of existing microwave users. In addition to the license requirements, the installation of antennas must be addressed. Microwave communications require a clear path between antennas.

In order to provide the coverage that will be needed for a project of this size, it may be necessary to install equipment at locations with a clear line of site. To provide the required line of site, repeater sites may be necessary.

In addition, each of the receive sites must also have a radio tower and an appropriate place for the installation of the equipment. It may be practical to consider this technology to provide a connection between major locations such as the Local Cities and the County.

3.4 SATELLITE

Satellite technology offers 2-way communications via satellite. The field devices or the communication hubs, through a special modem, broadcast requests to a satellite dish, which might be co-located with the field device or the communication hub. The dish sends and receives signals from the satellite that is positioned 22,000 miles above the earth in the geostationary orbit. The amount of time required for the trip to the satellite, down to the controller, back to the satellite, and then down to the field device exceeds the time available when processing time is included. The inherent latency involved with satellite transmission makes it impractical for use in an environment that requires once-per-second polling.

The use of this equipment would also require the installation of a Very Small Aperture Terminal (VSAT) dish at a traffic signal cabinet and at the TCS site. Space may be available at the TCS site, but it may be difficult to find room on a cabinet or on a signal pole. The dish must be mounted on a solid surface to make sure the alignment with the satellite is maintained. If mounted on a pole, deflection because of wind may cause problems with the alignment. Satellite communication works best for the one-way broadcast of video for applications such as television and when no other communication option is available.

3.5 TWISTED PAIR COPPER CABLE

Copper cable is a medium that can be used to transmit data signals. Twisted analog modems support point-to-point and point-to-multipoint communication. This is a very mature technology used by many Agencies to communicate with the field controllers and low speed devices. Typical data rate for analog modems range from 1,200 to 19,200 bps with typical distance about 8 miles for 9,600 bps and 5 miles for 19,200 bps.

There are two (2) common types of copper cable that have been deployed for traffic control systems:

- Straight Conductor Cable
- Twisted Pair Cable

Many of the older traffic signal systems were installed with straight conductor cable. Modems were installed that used a Frequency Shift Keying (FSK) modulation scheme to transmit serial data. Common data rates were in the range of 0.3 Kbps – 1.2 Kbps. Unfortunately, straight conductor cables do not support the higher data rates required of a modern TCS.

Most of the copper cable that is installed today has twisted copper pairs. The twists in the wire make it possible to transmit data at a much higher speed and over much longer distances when compared to straight cable. Traditional modems are available that use conditioned differential phase modulation to transmit data on twisted pair copper cable at data rates of 1.2 Kbps – 19.2 Kbps. Twisted pair can also be used with DSL equipment to provide data rates of 128 Kbps – 7 Mbps.

3.6 FIBER OPTIC CABLE

Fiber Optic cable is quickly becoming the standard for communications networks around the nation. It operates over long distance and offers the bandwidth for high-speed applications such as full motion video. One of the biggest problems with this technology is that it requires conduit, large sweeps, and large pull boxes. The cost of installing new fiber optic cable can be considerable when existing conduit is not available. The installation of new conduit and fiber becomes more expensive when the conduit is installed under a roadway or other paved surface that will need to be repaired, or bored underneath.

The cost of installing Agency owned fiber optic cable may not be easy to justify unless the installation is being driven by a high bandwidth application such as full motion video, or is associated with other Agency interconnect activities. If fiber optic cable were being installed for other applications, it would make sense to use it for both high and low bandwidth applications.

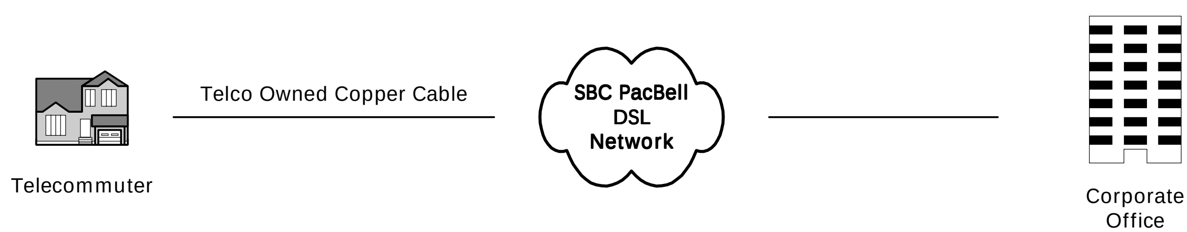
3.7 DIGITAL SUBSCRIBER LINE (DSL)

DSL is a technology that most people associate with high-speed Internet access. This technology has been around for several years and comes in several different types. The type of DSL used is based on the application. DSL allows high speed digital signals to be sent over twisted pair copper cable. Typical ranges vary from 2 to 6 miles and depend on the size of the copper wire and the desired operating speed. Speeds are available from 128 Kbps to 7 Mbps. This type of equipment could be used anywhere that twisted pair copper cable has been installed.

One of the largest users of DSL technology is the local telephone company. They work with Internet Service Providers (ISP) to provide a high-speed connection between the customer's residence or place of business and their Internet Point of Presence (POP).

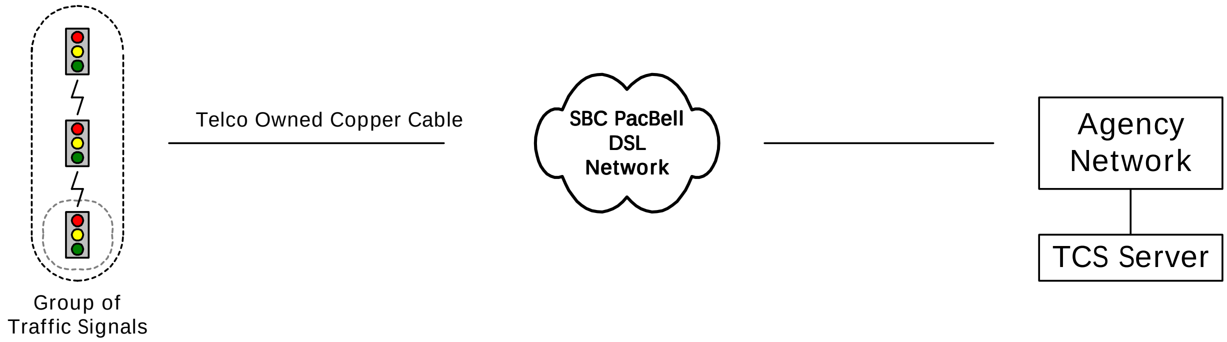
The local telephone companies also work with commercial and government customers to provide what is called "Transport Only" DSL. In this case, the phone company uses their DSL service to provide a connection between a remote location such as a dedicated telecommuter and a central site such as a corporate office as illustrated in Exhibit 3.2.

Exhibit 3.2 – Leased DSL for Remote Telecommuter



It is also possible to use this type of "Transport Only" DSL service to provide a connection between a group of traffic signals and a Traffic Control System (TCS). The concept is shown in Exhibit 3.3.

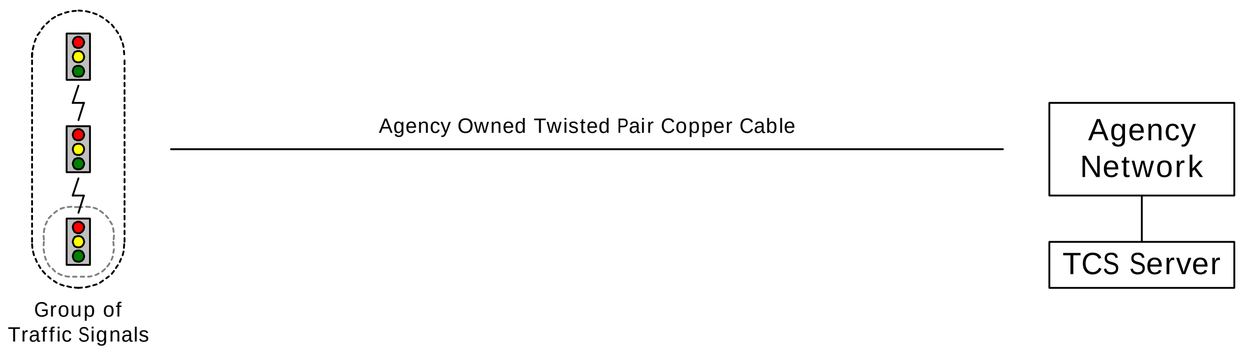
Exhibit 3.3 – Leased DSL for Traffic Signal Application



The cost of DSL service is based on the connection speed into the DSL network at each end and is not based on distance between locations. DSL is widely available in Los Angeles County.

In addition to Leased DSL services, there is also DSL equipment that is also available for purchase by commercial and government customers. A common application would provide a LAN connection between various buildings when fiber optic cable is not available. It would be possible to use this same type of equipment to provide a high-speed connection between a traffic signal cabinet and an Agency owned building as shown in Exhibit 3.4 below. This type of a connection could be used to combine several low-speed connections onto a single high-speed link to minimize the number of copper pairs, or circuits that are needed on a section of cable.

Exhibit 3.4 – Agency Owned DSL for Connection to a Group of Traffic Signals



3.8 BELL 3002 ANALOG DATA SERVICE

A Bell 3002 circuit is an analog data service that provides a 9.6 Kbps connection between two (2) or more locations. The use of this service requires a leased line modem to send a digital RS-232 signal across an analog phone line. There is no need to dial with this type of service since it provides an "Always On" connection. The service is available in two (2) varieties:

- Point to Point
- Point to Multi-Point

A point-to-point implementation provides a connection between two (2) locations. A point-to-multipoint implementation provides a connection between three (3) or more locations. If configured for point-to-multipoint, the 9.6 Kbps is shared among all traffic signals controllers on the channel. This may also be referred to as a multi-drop implementation.

In order to implement a Bell 3002 circuit in a multi-drop configuration, the phone company provides a "Bridging Service" that is comparable to the audio conference bridge. The cost of the bridging service is normally included in the monthly service charge.

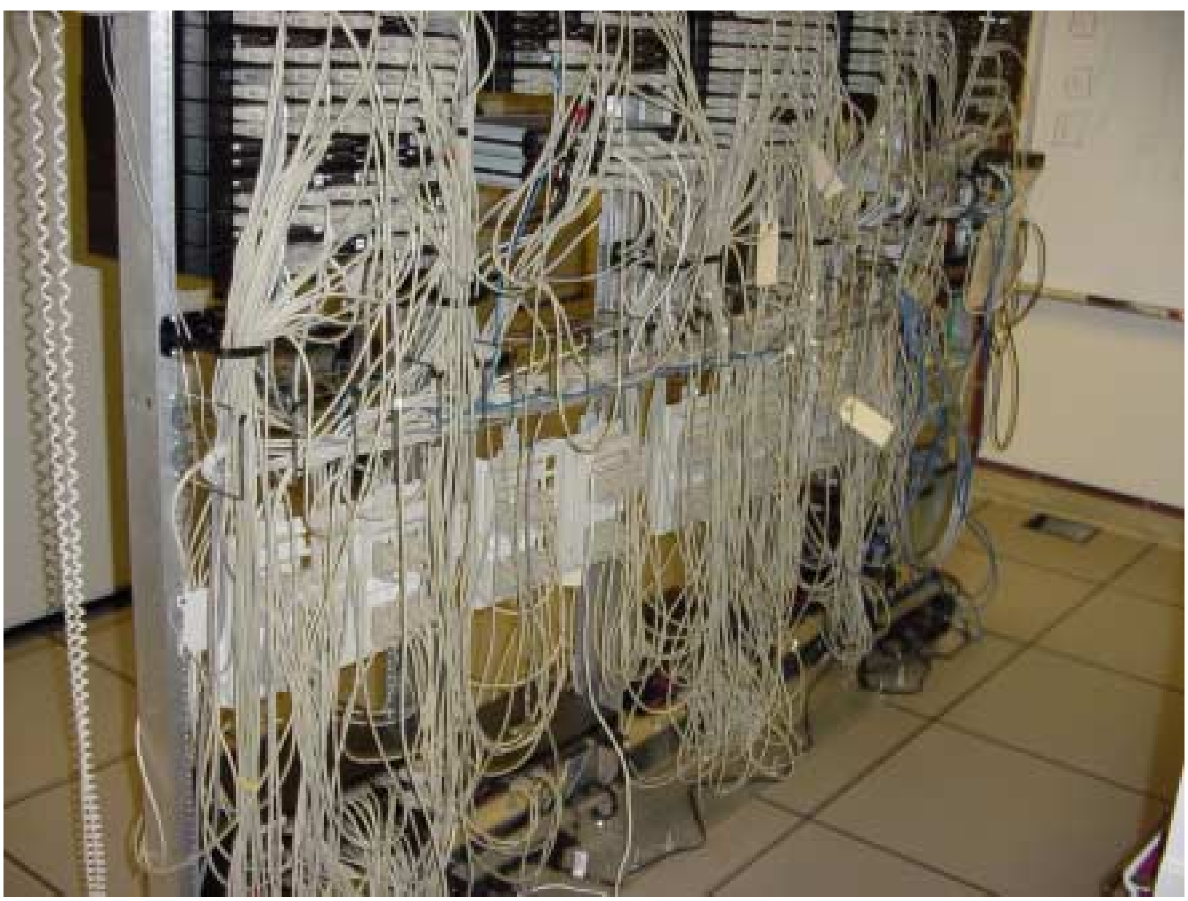
This service is not managed or monitored by the local phone company, which could be an important consideration when comparing this type of service with some of the other alternatives. The customer normally reports outages since the service is not actively monitored.

While this service has been used/implemented by SGVTF Agencies in the past, SBC is no longer accepting new orders for this service. However, it may be possible to continue using this type of service for existing sites.

3.9 DIGITAL DATA SERVICE (DDS)

DDS is a leased point-to-point service for LAN applications with available data rate ranging from 2.4 to 64 Kbps. This type of service is very hardware-oriented, and requires dedicated hardware on both ends for each individual circuit that is installed. This may not be much of a problem when only 2 or 3 circuits are needed, but it can be difficult when scaling up to a large installation that covers a large geographic area. For example, the current project area includes over 1,500 traffic signal controllers and 83 CCTV cameras. Each circuit would require a dedicated CSU/DSU, and a dedicated mux to breakout the low-speed channels. In addition, hundreds of RS-232 or RJ-45 cables are needed to connect these low-speed channels to the TCS computer system. Exhibit 3.5 below presents a typical equipment and cable requirement.

Exhibit 3.5 – Typical Equipment & Cable Requirements for DDS



The major difference between DDS and Frame Relay is the bandwidth capacity. The highest CIR for DDS is 64 Kbps versus Frame Relay that can go up to 1.544 Mbps. In addition, the cost of DDS depends on the mileage between the locations, which in this case would be the distance between the field devices. For instance, a typical circuit termination by Telco would be approximately $200 per circuit and the monthly fee of approximately $125 per circuit. Frame Relay has a flat fee of $550/month for a point-to-point connection, which includes all hardware necessary and also a 1.544 Mbps bandwidth.

3.10 FRAME RELAY DIGITAL DATA SERVICE

Frame Relay is a service that has gained popularity because it is a cost effective way of providing communications between multiple locations. For this type of service, the cost is based on the connection speed into the Frame Relay Network, and not on the distance between the locations as long as it is within the service area and meets other technical requirements. This pricing structure works well when communication is needed between locations that are not serviced by the same telephone Central Office (CO).

Frame Relay is based on the concept of providing a single physical connection to each location. The most common physical connections are a 56 Kbps or T-1 circuit (1.544 Mbps). Once the physical connection is in place, it is possible to create a series of logical connections between each location as needed. These logical connections are called Permanent Virtual Circuits (PVCs), but can be moved around as the needs of the customer change over time.

It is possible to connect a series of remote locations to a single central location if needed. Even though there is only one physical connection to the central location, multiple PVCs can be mapped onto that same physical interface and to a local Data Link Connection Identifier (DLCI). The equipment installed on the end of the physical interfaces can address the local DLCI that is associated with the appropriate PVC. This type of connection might be a little confusing and it may be easier for people to think of it like a multi-drop serial channel with one channel and multiple drops. Each drop is assigned a drop ID to keep everything going to the correct location.

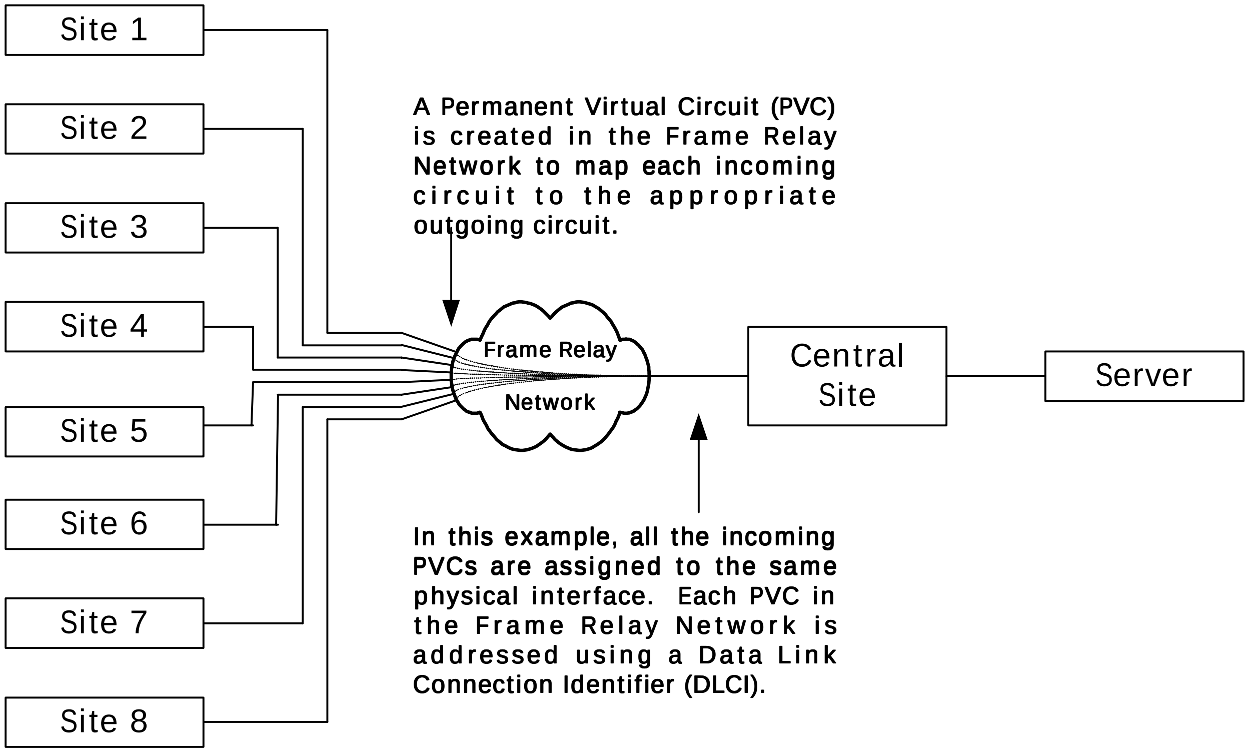
One of the primary advantages of a system based on Frame Relay is that it is easy to monitor and manage. This is a modern digital service that can be monitored by the telephone company. If the circuit goes down for any reason, the telephone company will be automatically notified by their frame relay network management system. If needed, the telephone company can notify Agency personnel.

It is possible to use Frame Relay Service for a number of different services. For example, commercial and Agency customers can use it for voice services over Frame Relay. In the past, voice traffic has been limited to use on dedicated Time Division Multiplexed (TDM) circuits such as T-1 Digital Data Service. This type of service was the only technology that would provide the quality of service necessary for latency sensitive traffic such as voice calls.

This same low latency technology can be used for other applications as well. One of the more common applications of Frame Relay Service is to transport data between Local Area Networks (LAN's). This type of connection is referred to as a Wide Area Network (WAN). In addition, this is the same type of connection that the Countywide IEN will use to connect the IEN Corridor Server (located at the LA County TMC) to all of the IEN Workstations (located at each SGVTF Agency LCCS).

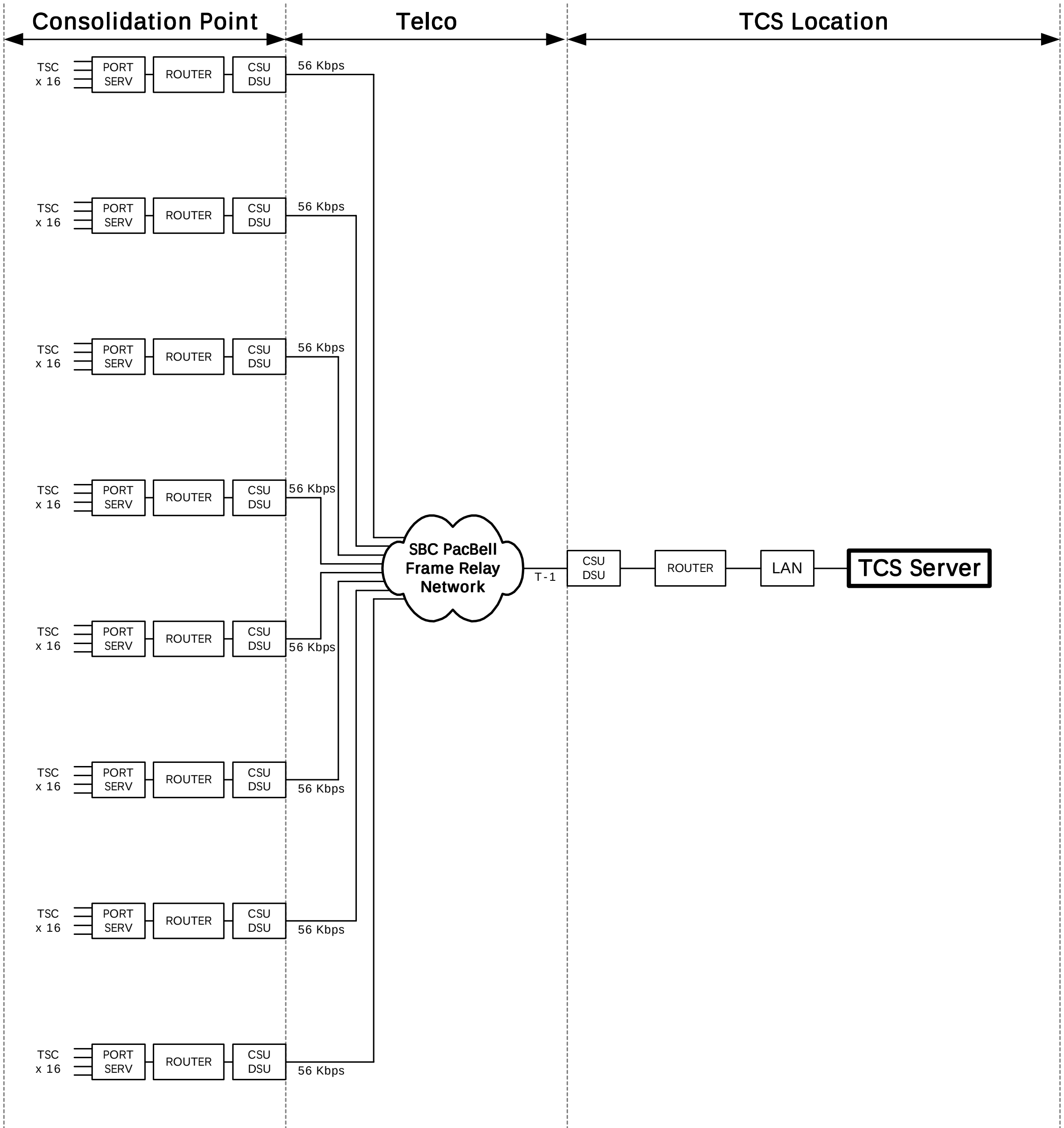
An overview of Frame Relay and the concept of PVCs is illustrated in Exhibit 3.6.

Exhibit 3.6 – PVC Concept on Frame Relay Circuit



This model can also be applied to each connection from a small group of signals back to the TCS. If this model is applied to several locations, the network might look something like the diagram shown in Exhibit 3.7. There is much less equipment required at the TCS location, which can be a real advantage when a system is scaled up to include a large geographic area.

Exhibit 3.7 – Frame Relay Connection to TCS



4. TECHNOLOGY RECOMMENDATIONS

Based on the technology recommendations in the previous sections, TransCore has developed recommendations regarding technologies to be used for different parts of the communications network. Each technology may be appropriate for one (1) segment of the overall communications network, but not another. The recommended technologies are the most economical and robust solutions for both F2C and C2C communications. F2C has been divided into two (2) segments: local-to-consolidation point and consolidation point-to-LCCS.

For the purpose of this report, the local-to-consolidation point is described as communication to and from field device to a consolidation point "hub". Consolidation point is an information collection point for the field devices that are connected to via landline or wireless communication. The existing field devices that are not located within a line of site from the LCCS, will be connected to a selected traffic signal controllers and/or CCTV camera location in order to transfer the data back to the LCCS. The field devices except CCTV Cameras will be grouped together with no more than eight (8) in a multi-drop configuration. The CCTV camera locations and strategically selected traffic signal controllers will be the consolidation points. This approach will be the most economical approach both on cost and bandwidth utilization. Consolidation point-to-LCCS is described as communication between the hub and the LCCS. Exhibit 4.1 presents a summary of recommended technologies for both F2C and C2C communication.

Exhibit 4.1 –Technology Recommendations

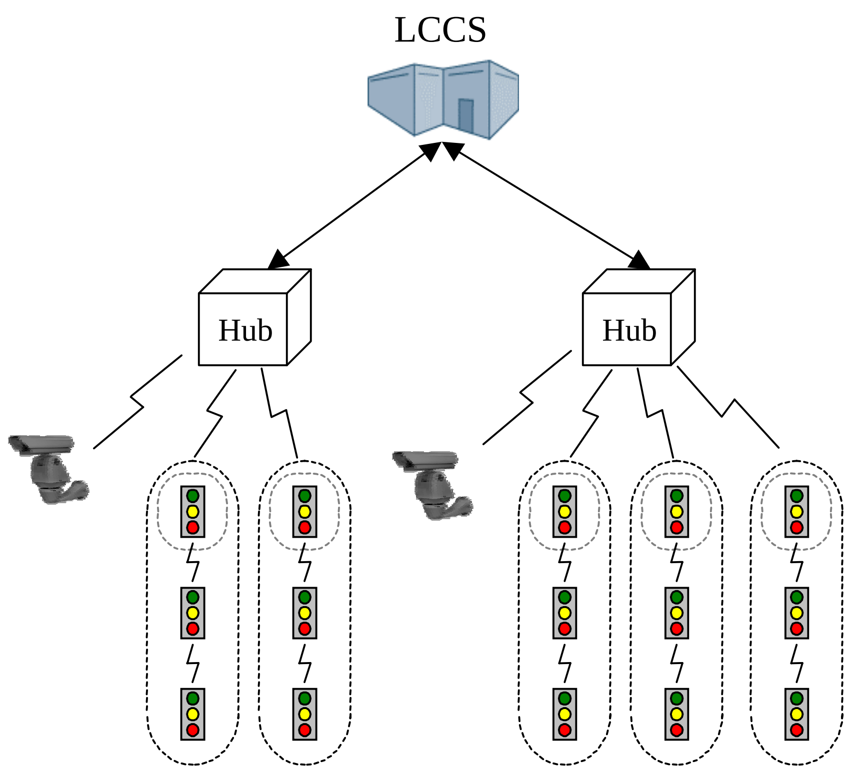
Communication Segment		Agency Owned						Leased Services			
		Unlicensed Spread SpectrumRadio	Wireless LANTechnology	Microwave	Satellite	Fiber Optic Cable	Twisted Wire Pair	Digital Subscriber Line	Bell 3002	Digital Data Service	Frame Relay
F2C	Local-to-Consolidation Point	YES	YES	NO	NO	YES (Existing)	YES (Existing)	NO	NO	NO	NO
	Consolidation point-to-LCCS	YES	YES	NO	NO	YES (Existing)	YES (Existing)	YES	NO	NO	YES
C2C	LCCS-to-Sub-Regional TMC	NO	NO	NO	NO	NO	NO	YES	NO	NO	YES

4.1 UNLICENSED SPREAD SPECTRUM RADIOS – AGENCY OWNED

The use of agency owned Unlicensed Spread Spectrum Radio (USSR) is recommended for both segments of F2C communication.

USSR does not require FCC license and also does not require conduit installation. USSR has limitations with most field devices, that it requires only similar device types be placed on the same communication channel. In addition, this type of technology does not offer the bandwidth needed to support CCTV cameras. Since 15 out of 22 Agencies either have CCTV cameras installed or planning to install in the near future (refer to Exhibit 2-1), CCTV camera locations would be an ideal hub location for all other field devices. Exhibit 4.2 presents a typical local-to-consolidation point diagram.

Exhibit 4.2 –Typical Local-to-Consolidation Point Communication Diagram



Note: The consolidation point "hub" is co-located with CCTV cameras

4.2 UNLICENSED WIRELESS LAN TECHNOLGOY – AGENCY OWNED

The use of Agency-owned unlicensed wireless LAN technology is also recommended for local-to-consolidation point communication where there is no existing fiber optic cable or twisted pair copper cable available. This type of technology also does not require FCC license and conduit installation.

4.3 TWISTED PAIR COPPER CABLE – AGENCY OWNED

The use of Agency-owned twisted pair copper cable is recommend for both segments of the F2C communication. Existing Agency-owned twisted pair copper cable should be used whenever available. Agencies have made significant investments in these conduit and cable infrastructures and they provide a cost effective means of providing communications to the field devices.

4.4 DIGITAL SUBSCRIBER LINE – AGENCY OWNED

The use of Agency-owned DSL equipment is recommended for the second segment of F2C communication (consolidation point-to-LCCS). DSL simply provides a way to use two (2) pairs of twisted pair copper for a high-speed communications link between locations. This could be a benefit when multiple channels are needed between locations.

4.5 DIGITAL SUBSCRIBER LINE – LEASED

The use of leased DSL service is also recommended for the second segment of F2C communication (consolidation point-to-LCCS). The local telephone companies will be able to provide this service to most of the outlying areas. An SBC representative has provided TransCore with detailed pricing in order to provide the 10-year cost analysis for this type of technology. However, the County has negotiated firm fixed costs for bandwidth up to 1.544 Mbps. Also, the state of California has negotiated firm fixed costs from Pacific Bell and MCI; the program is called "CalNet." Additional information on the CalNet program can be found at the following Internet site: www.calnetinfo.com.

4.6 FIBER OPTIC CABLE – AGENCY OWNED

The use of Agency-owned fiber optic cable is recommended for both segments of F2C communication. Existing Agency-owned fiber optic cable should be used whenever available. Agencies have made significant investments in these conduit and cable infrastructures and they should be used whenever practical.

Agencies may want to consider including the installation of conduit in future construction projects when possible. Agencies would need to start with a conduit "Master Plan". Agencies can use the master plan as a guide and include conduit when appropriate. It is much less expensive to install conduit during a major reconstruction project when saw cutting and directional drilling is not required.

It may take several years for the conduit network to be expanded to all project intersections, but it would be a cost effective way to provide an Agency-owned cable infrastructure. The conduit could be used for twisted pair copper or fiber optic cable.

4.7 SATELLITE – LEASED

The use of leased satellite service is not recommended for use in this project. The latency across a satellite link would make it difficult if not impossible to meet the requirement of once-per-second polling.

4.8 LICENSED MICROWAVE – AGENCY OWNED

The use of Agency-owned microwave is not recommended for use in this project. The use of wireless technology will have a significant role in the project, but the cost of licensed microwave equipment is significantly higher when compared to USSR or wireless LAN technology equipment. In addition, licensed radios do not provide any needed features or service that is not available with USSR or other wireless technologies.

4.9 BELL 3002 ANALOG DATA SERVICE – LEASED

The use of leased Bell 3002 Analog Data Service is not recommended for this project. This type of service has been successfully used in the past and could be used for the project, but this type of service does not offer the capacity or any of the advanced capabilities that are available with other digital services. This type of service is normally not monitored by the telephone company, it is expensive to install, and difficult to manage. A change in the network requires a physical move and remapping of circuits. Other services offer the ability to make network configuration changes through software modifications. In addition, this service is no longer available from SBC.

4.10 DIGITAL DATA SERVICE – LEASED

The use of leased Digital Data Service (DDS) is not recommended for use in this project. This type of service is very hardware oriented, and requires dedicated hardware on both ends for each individual circuit that is installed. This may not be much of a problem when only 2 or 3 circuits are needed, but it can be difficult when scaling up to a large installation that covers a large geographic area.

4.11 FRAME RELAY DIGITAL DATA SERVICE – LEASED

The use of leased Frame Relay Service is recommended for the second segment of F2C communications (consolidation point-to-LCCS) and also for C2C communication. High-speed T-1 (1.544 Mbps) frame relay circuits should be installed from each hub to LCCS. Existing T-1 circuits should be utilized wherever possible. Some of the larger Agencies such as Los Angeles County may need to upgrade to support point-to-point communication with other Agencies.

The most common physical connections to the Frame Relay Network are either a 56 Kbps or 1.544 Mbps circuit. Currently, the requirement for the Countywide IEN connection is a CIR of 384 Kbps; therefore the circuits should be upgraded to accommodate the bandwidth required for C2C communication. Many of the Agencies participating in the IEN already have a T-1 frame relay circuit installed. The intent of upgrading the IEN CIR communication link to 1.544 Mbps is to provide adequate bandwidth to communicate with all of the Agency field devices and, more importantly, provide one link "pipe" of communication to the Sub-Regional TMC from the Agency LCCS.

5. PROJECT RECOMMENDATIONS

Based on specific recommendations about which technologies should be considered for use in this project TransCore has refined the recommendations to present how they would apply to each Agency Level. The recommended technologies are going to be an integration of both Agency owned and leased services.

Exhibit 5.1 presents a summary of the recommended technologies for both segments of F2C and also C2C communication.

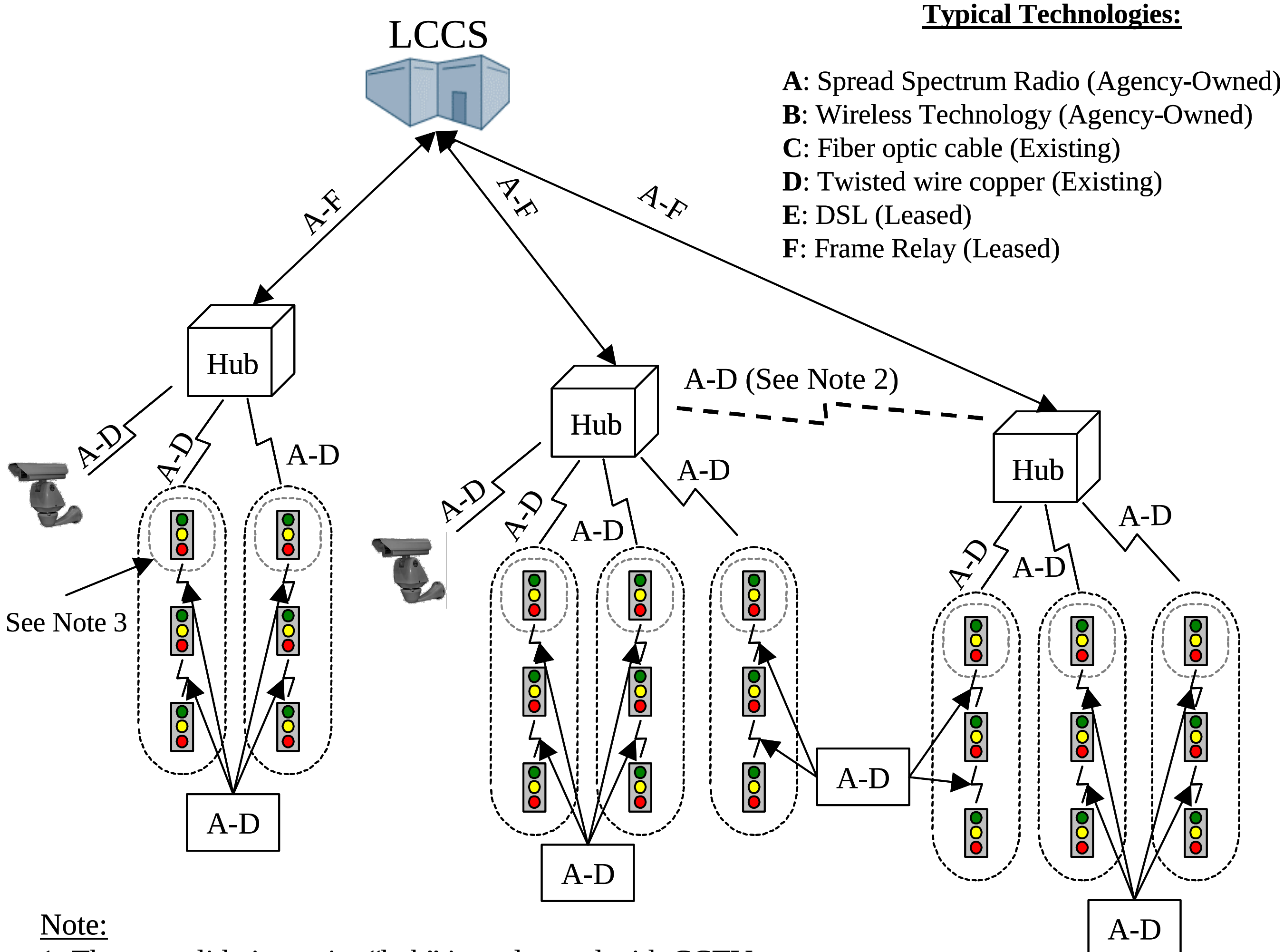
Exhibit 5.1 – Typical F2C Communication Architecture

Communication Segment		Agency Owned				Leased Services	
		Unlicensed Spread Spectrum Radio	Wireless LAN Technology	Fiber Optic Cable	Twisted Wire Pair	Digital Subscriber Line	Frame Relay
F2C	Local-to-Consolidation Point	YES	YES	YES (Existing)	YES (Existing)	NO	NO
	Consolidation point-to-LCCS	YES	YES	YES (Existing)	YES (Existing)	YES	YES
C2C	LCCS-to-Sub-Regional TMC	NO	NO	NO	NO	YES	YES

Since most of the Agencies do not have any existing communication infrastructure in place nor have any future plans, the most economical and technologically sound recommendation for F2C would be the use of Agency-owned USSR and wireless LAN technologies, and leased services such as DSL and/or Frame Relay technologies for the second segment of F2C communication.

If any Agency does have existing fiber optic and/or twisted pair copper cables, those should be the primary means of establishing communication for both segments of F2C communications. The final design for each Agency will be unique based on the number of traffic signal controllers, number of field devices, the City's field device layout, and other variables. Exhibit 5.2 presents a typical F2C communication architecture. It connects several traffic signal controllers together in a multi-drop topology with no more than eight (8) controllers or field devices (except CCTV camera) per circuit. The controllers will be connected via existing infrastructure or Agency-owned recommended technology (i.e. USSR, wireless LAN) or leased services provided by Telco (i.e. DSL, frame relay). The letters next to each communication link presents the type of connection that is a possibility.

Exhibit 5.2 – Typical F2C Communications Architecture



Note:
1: The consolidation point "hub" is co-located with CCTV cameras
2: Hub-to-hub communication in those instances when a hub can NOT directly connect to the LCCS
3. Typical consolidation point for multi-drop configuration

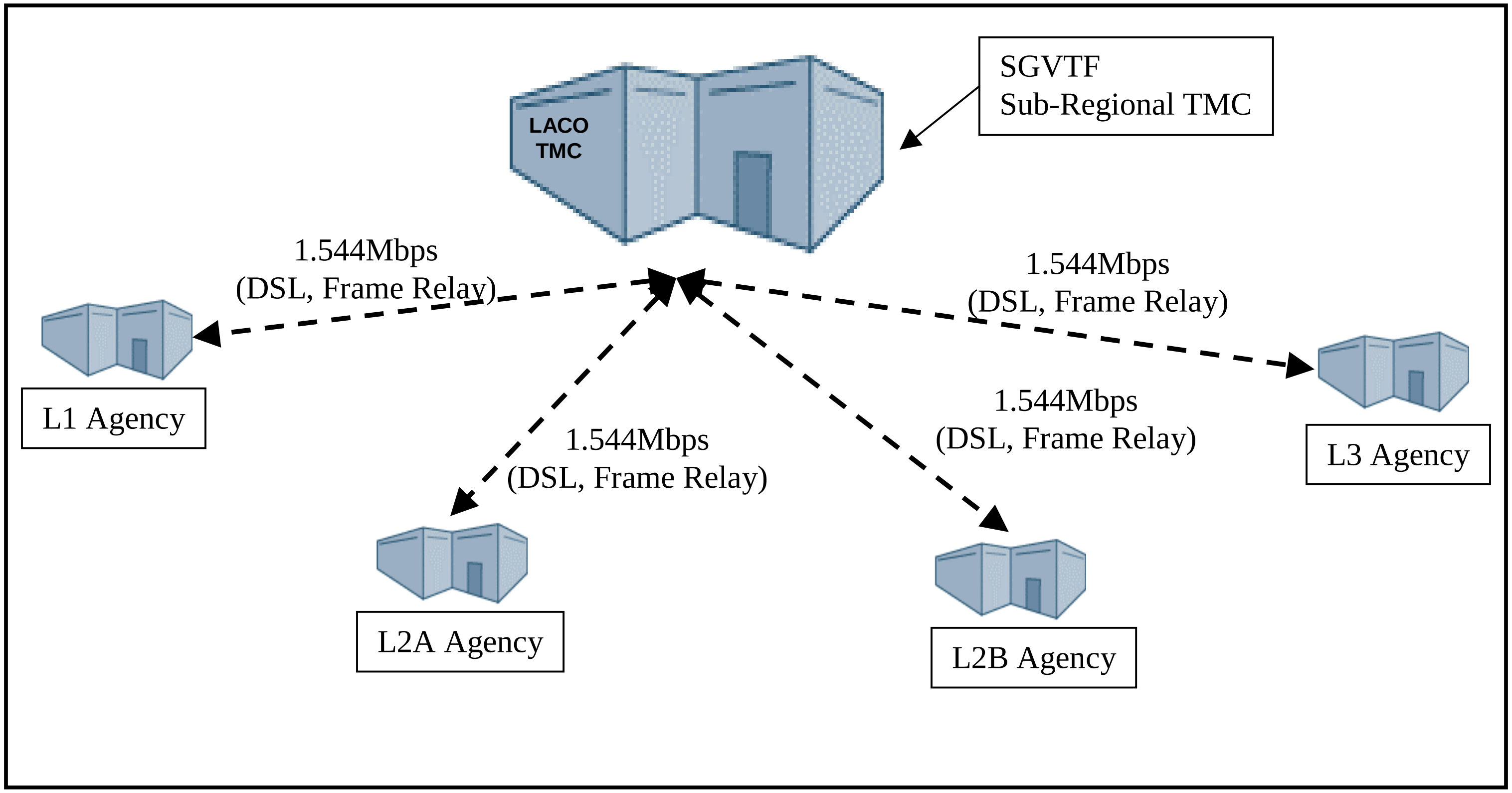
An important element of this proposed communications architecture is that the communications for the local field devices be routed back to the LCCS, even if the Agency is a Level 1 or 2A Agency that will not be controlling its own equipment. From the LCCS, the field device data can be routed to the Sub-Regional TMC along with IEN data as discussed below. The routing of the field communications through the Agency LCCS location is proposed to allow for future growth of an Agency. While an Agency may currently be a Level 1 or 2A Agency, in the future they may grow to a Level 2B Agency, and desire to manage/operate their own traffic signal system. By having the field communications routed through the Agency LCCS, minimal changes to the communications network would be required to facilitate this change.

After evaluating the technologies presented in this document for C2C communication; Digital Subscriber Line (DSL) and Frame Relay technologies are going to be the most economical and technologically sound solution for the SGVTF Project.

In order to eliminate multiple communication links entering the Sub-Regional TMC from LCCSs, it is envisioned that C2C communication would be an addition onto the Countywide IEN network link. The current CIR for an IEN Workstation to/from the SGVTF Sub-Regional TMC is 384 Kbps. It is our recommendation for the link to be upgraded to 1.544 Mbps in order to have adequate bandwidth to communicate and transfer data between the Agency LCCS and the SGVTF Sub-Regional TMC (aka the LACO TMC) to better support the Agency's field devices and IEN Workstation. In addition, this recommendation will ensure that there is only one (1) communications link between the Agency LCCS and the SGVTF Sub-Regional TMC. This recommendation will be the most cost effective and much more manageable solution for C2C communication. This solution will also eliminate multiple communication links entering the Sub-Regional TMC from a particular Agency.

Exhibit 5.3 presents a typical C2C communication architecture. The current connection for each Local Agency should be upgraded to 1.544 Mbps in order to provide adequate bandwidth to communicate and transfer data between the Agency LCCS and the SGVTF Sub-Regional TMC.

Exhibit 5.3 – C2C Communication Architecture



5.1 LEVEL 1

Level 1 Agencies (Duarte, La Puente, San Marino, South El Monte, South Pasadena, Temple City) do not have any communication infrastructure in place nor have any future plans to install any fiber optic cable, twisted pair copper, or any other communication infrastructure for the F2C communication network. USSR and/or wireless LAN technology are the recommended solutions for F2C communication. For the second segment (consolidation point-to-LCCS), in addition to USSR and wireless LAN technologies, leased services such as DSL and/or frame relay are to be considered. A path analysis should provide the infrastructure necessary to determine if the use of radios is a possibility. The final design, location, and number of base stations will be provided in the SGVTF Communications Conceptual Design document report.

The existing seven-conductor copper cable in Duarte should not be used. The cable has straight conductors and will not support the higher speeds needed for a modern traffic signal system. In addition, some of the conductors are damaged between Buena Vista St. and Highland. It is likely that the conduit could be used to support the future installation of twisted pair copper cable or possibly even fiber optic cable under the right circumstances. If the fiber optic cable option was exercised, it is important to note that it is very likely that existing pull boxes would need to be replaced, in order to support the bend radius of the fiber optic cable and also for maintenance purposes.

C2C communication shall be established through the local telephone company from each Agency LCCS to the SGVTF Sub-Regional TMC located at LA County DPW. The C2C connection should have sufficient capacity to handle the aggregate sum of all bandwidth required for each field device and the IEN Workstation.

5.2 LEVEL 2A

Level 2A Agencies (Azusa, El Monte, Glendora, Monrovia, Monterey Park, San Gabriel) do not have any communication infrastructure in place nor have any future plans to install any fiber optic cable, twisted pair copper, or any other communication infrastructure for the F2C communication network. USSR and/or wireless LAN technology are the recommended solutions for the F2C communication. For the second segment (consolidation point-to-LCCS), in addition to USSR and wireless LAN technologies, leased services such as DSL and/or frame relay are to be considered. A path analysis should provide the infrastructure necessary to determine if the use of radios is a possibility. The final design, location, and number of base stations will be provided in the SGVTF Communications Conceptual Design document report.

The Cities of Baldwin Park and Montebello should use the limited amount of twisted pair copper cable that is available where possible for traffic signal controller and field device consolidation point communication. The field devices should be connected in a multi-drop configuration with no more than eight (8) devices on a circuit. In the majority of the remaining locations, USSR and/or wireless LAN technology should be used for F2C communication. A path analysis should provide the information necessary to determine if the use of radios is a possibility. In addition, USSR, DSL, and/or Frame Relay should be considered for the second segment of F2C communication (consolidation point-to-LCCS).

The City of Monrovia should use the limited amount of twisted pair copper cable that is available on Huntington Dr. where possible for their F2C communication network. In the majority of the remaining locations, USSR and/or wireless LAN technology would be the most suitable technology. A path analysis should provide the information necessary to determine if the use of radios is a possibility for all remaining areas. In addition, USSR, DSL, and/or Frame Relay should be considered for the second segment of F2C communication (consolidation point-to-LCCS).

The City of Glendora should use the limited amount of twisted pair copper cable that is available on Lone Hill Ave. when possible for their F2C communication network. In the majority of the remaining locations, USSR and/or wireless LAN technology should be used for F2C communication. A path analysis should provide the information necessary to determine if the use of radios is a possibility for all remaining portions of the distribution network. In addition to USSR and wireless LAN technologies, leased services such as DSL, and/or Frame Relay should be considered for the second segment of F2C communication (consolidation point-to-LCCS).

C2C communication shall be established through the local telephone company from each Agency LCCS to the SGVTF Sub-Regional TMC located at LA County DPW. The C2C connection should have sufficient capacity to handle the aggregate sum of all the bandwidth required for each field device and the IEN Workstation. The following Agencies (Azusa, Baldwin Park, Glendora, Monrovia) currently have a 384 Kbps frame relay connection to the LA County DPW from previous projects. The CIR should be upgraded to 1.544 Mbps in order to have adequate bandwidth to support the communication with all the field devices.

5.3 LEVEL 2B

The City of Rosemead does not have any communication infrastructure in place or have any future plans to install any fiber optic cable, twisted wire copper, or any other communication infrastructure for the F2C communication network. USSR and/or wireless LAN technology are the recommended solutions for the first segment of F2C communication (local-to-consolidation point). For the second segment (consolidation point-to-LCCS), in addition to USSR and wireless LAN, leased services such as DSL and/or frame relay are to be considered. A path analysis should provide the infrastructure necessary to determine if the use of radios is a possibility. The final design, location, and number of base stations will be provided in the SGVTF Communications Conceptual Design document report.

The Cities of Arcadia and West Covina should use the existing twisted pair copper cable that is available at various locations when possible for their F2C communication network. In the remaining areas where twisted pair copper cable is not available, USSR and/or wireless LAN technology should be the most suitable technology for the first segment of F2C communication (local-to-consolidation point). A path analysis should provide the information necessary to determine if the use of radios is a possibility for all remaining areas. In addition to USSR and wireless LAN, leased services such as DSL and/or frame relay are to be considered for the second segment of F2C communication (consolidation point-to-LCCS

The City of Alhambra should use the copper wire available where possible for F2C communication. The multi-cell conduit on Valley and Fremont should be used for installing fiber optic cable for F2C communication. In the remaining areas where twisted pair copper cable is not available, USSR and/or wireless LAN technology should be the most suitable technology for the first segment of F2C communication (local-to-consolidation point). A path analysis should provide the information necessary to determine if the use of radios is a possibility for all remaining areas. In addition to USSR and wireless LAN, leased services such as DSL, and/or frame relay are to be considered. for the first segment of F2C communication (local-to-consolidation point).

The City of Irwindale should use the twisted pair copper cable that is available on Irwindale Ave., and Arrow Hwy. where possible for the first segment of F2C communication (local–to-consolidation point). As an option, this twisted pair cable could be replaced with fiber optic cable to provide greater bandwidth if required. In the remaining areas where twisted pair copper cable is not available, USSR and/or wireless LAN technology would be the most suitable technology for F2C communication. A path analysis should provide the information necessary to determine if the use of radios is a possibility for all remaining area. In addition to USSR and wireless LAN, leased services such as DSL and/or frame relay are to be considered for the first segment of F2C communication (local-to-consolidation point).

The City of San Dimas should use the twisted pair copper cable that is available on Arrow Hwy. where possible for the first segment of F2C communication (local–to-consolidation point). In the remaining areas where copper cable is not available, USSR and/or wireless LAN technology would be the most suitable technology for F2C communication. There is a section along San Dimas Ave. from Gladstone St. to Bonita Ave. that could be a challenge for wireless communication. Aerial photos indicate some potential problems because of trees. A path analysis should provide the information necessary to determine if the use of radios is a possibility for all remaining areas of the F2C communication network. If not, it may be necessary to create smaller groups of field devices with additional consolidations points In addition to USSR and wireless LAN, leased services such as DSL and/or frame relay are to be considered for the first segment of F2C communication (local-to-consolidation point).

C2C communication shall be established through the local telephone company from each Agency LCCS to the SGVTF Sub-Regional TMC. The C2C communication link should have sufficient capacity to handle the aggregate sum of all the bandwidth required for each field device and the IEN Workstation. The following Agencies (Arcadia, San Dimas) currently do have a 384 Kbps frame relay connection to the LA County DPW from previous projects. The CIR should be upgraded to 1.544 Mbps in order to have adequate bandwidth to support the data transfer and communication link with all the field devices.

5.4 LEVEL 3

The City of Pasadena should continue to use the existing twisted pair copper cable for F2C and C2C communication network wherever possible. If expansion is required into an area that is not serviced by the existing twisted pair copper cable, USSR and/or wireless LAN technology should be used to provide a connection until a connection can be made to the copper cable network.

The current network of conduit could be used to support the installation of fiber optic cable in the future if needed. It is likely that pull boxes and sweeps would need to be installed, but the investment in conduit should save a considerable amount of money when compared to the cost of installing new conduit.

5.5 COST ANALYSIS

It is envisioned that the F2C communication will be divided into two segments: local-to consolidation point and consolidation point-to-LCCS. The first segment, which is local-to-consolidation point, USSR and/or wireless LAN technologies are the most economical and robust communication technology. For the second segment, which is consolidation point-to-LCCS, in addition to USSR and wireless LAN, leased services such as DSL and/or Frame Relay technologies are the most economical solution. If any Agency does have existing fiber optic cables and/or twisted pair copper cables, it should be the primary means of establishing communication with the field devices and LCCS.

For the F2C communication, USSR and/or wireless LAN technology were recommended as an Agency-owned system. Since several Agencies do have fiber optic cable and twisted pair copper in place already, and the installation of conduit and cable is too expensive to consider, the integration of USSR and Wireless LAN technology will be discussed for the F2C cost analysis. There are number of different topologies that are available (i.e. Mesh, Star, Bus) for this type of communication link. For the purpose of this exercise, star and bus configuration will be used to create the best coverage area for each Agency. The final system architecture, interface, and specifications will be presented in the SGVTF Communications Conceptual Design document report.

Since USSR and wireless LAN equipment are similar in cost, Exhibit 5.4 will present both technologies as one item. Exhibit 5.4 presents the total number of field devices (i.e. Traffic Signal Controller, CCTV camera, CMS) including the total number of consolidation points necessary to communicate with an Agency LCCS. The field devices will be grouped in no more than eight (8) devices in a multi-drop configuration. Each field device will be equipped with a radio in order to transmit and receive data. Since the cost of field device radios and consolidation point radios vary, the Exhibit presents separate costs for each radio.

Exhibit 5.4 – F2C USSR/ Wireless Communication Cost Summary

F2C USSR/ WIRELESS Communication											
	Field Devices				Consolidation Points		Total Number of Radios		Cost of Radios		
Agencies	Traffic Controller	CCTV Camera	CMS	Total Number of Field Devices	Field Devices Groups of 8	CCTV Camera	Field Devices	Consolidation Points	Field Device	Consolidation Point	Total Cost of Radios per site
Alhambra	99	0	0	99	12	0	87	12			$284,625
Arcadia	71	10	2	83	9	10	64	19			$264,875
Azusa	52	4	0	56	7	4	46	11			$171,500
Baldwin Park	64	5	0	69	8	5	56	13			$211,500
Covina	49	5	0	54	6	5	43	11			$168,375
Duarte	14	3	0	17	2	3	12	5			$56,750
El Monte	70	0	0	70	9	0	61	9			$201,250
Glendora	44	2	0	46	6	2	39	8			$137,500
Irwindale	34	9	2	45	5	9	32	14			$153,000
La Puente	11	0	0	11	1	0	10	1			$31,625
LADPW	200	2	0	202	25	2	175	27			$586,000
Monrovia	35	3	3	41	5	3	33	8	$2,500	$5,500	$125,750
Montebello	78	0	2	80	10	0	70	10			$230,000
Monterey Park	65	0	0	65	8	0	57	8			$186,875
Pasadena	308	18	11	337	40	18	279	58			$1,016,125
Rosemead	52	0	0	52	7	0	46	7			$149,500
San Dimas	33	7	0	40	4	7	29	11			$133,375
San Gabriel	34	5	2	41	5	5	32	10			$131,000
San Marino	18	2	0	20	2	2	16	4			$62,750
South El Monte	22	2	0	24	3	2	19	5			$74,250
S. Pasadena	36	1	0	37	5	1	32	6			$109,000
Temple City	28	5	0	33	4	5	25	9			$108,000
West Covina	112	0	0	112	14	0	98	14			$322,000
									Total cost of Radios		$4,915,625.00
									Yearly Maintenace 5%		$245,781.25
									10 year Maintenace cost		$2,457,812.50
									Total 10 year cost		**$7,373,437.50**

For the C2C communication, DSL technology is recommended as a leased service. DSL will provide a point-to-point connection with 1.544 Mbps CIR. Exhibit 5.5 presents the installation fee, monthly fee, and the CIR per Agency. The yearly maintenance fee is based on the total annual cost without the cost of installation.

A SBC representative provided the information to TransCore, and they informed us that they do not have DSL connection available at the Cities of Azusa and San Marino. In order to communicate with these Agencies Frame Relay would be an option.

The current frame relay connection for an IEN Workstation is 384 Kbps. It is our recommendation that if any Agency that has an existing communication link with the Sub-Regional TMC be upgraded to 1.544 Mbps in order to have adequate bandwidth to communicate with IEN Workstations and field devices. This system upgrade will be the most manageable solution for C2C communication. Exhibit 5.6 presents the monthly cost of frame relay connection with a CIR of 1.544 Mbps. (Note: the monthly fee includes full maintenance of the system by the provider).

Exhibit 5.5 – C2C SBC DSL Connection Cost Summary

Agencies	One Time Installation Fee	Monthly Fee	Connection Rate (Kbps)	Annual Cost w / Installation	Annual Cost w / o Installation
Alhambra	$250	$289.95	1544	$3,729.40	$3,479.40
Arcadia	$250	$289.95	1544	$3,729.40	$3,479.40
Azusa			N/A		
Baldwin Park	$250	$289.95	1544	$3,729.40	$3,479.40
Covina	$250	$289.95	1544	$3,729.40	$3,479.40
Duarte	$250	$289.95	1544	$3,729.40	$3,479.40
El Monte	$225	$289.95	1544	$3,704.40	$3,479.40
Glendora	$250	$289.95	1544	$3,729.40	$3,479.40
Irwindale	$250	$289.95	1544	$3,729.40	$3,479.40
La Puente	$250	$289.95	1544	$3,729.40	$3,479.40
Monrovia	$250	$289.95	1544	$3,729.40	$3,479.40
Montebello	$250	$289.95	1544	$3,729.40	$3,479.40
Monterey Park	$225	$289.95	1544	$3,704.40	$3,479.40
Pasadena	$250	$289.95	1544	$3,729.40	$3,479.40
Rosemead	$250	$289.95	1544	$3,729.40	$3,479.40
San Dimas	$250	$289.95	1544	$3,729.40	$3,479.40
San Gabriel	$250	$289.95	1544	$3,729.40	$3,479.40
San Marino			N/A		
South El Monte	$250	$289.95	1544	$3,729.40	$3,479.40
S. Pasadena	$225	$289.95	1544	$3,704.40	$3,479.40
Temple City	$250	$289.95	1544	$3,729.40	$3,479.40
West Covina	$250	$289.95	1544	$3,729.40	$3,479.40
			Total Annual Cost w/o Installation		$74,513.00
			Installation Cost (One Time Fee)		$4,925.00
			Total Annual Cost		$79,438.00
			Yearly Maintenace 5%		$3,725.65
			10 year Maintenace cost		$37,256.50
			Total 10 year cost		**$782,386.50**

Exhibit 5.6 – C2C Frame Relay Connection Cost Summary

C2C Frame Relay Connection			
Agencies	**Monthly Fee**	**Connection Rate (Kbps)**	**Annual Cost**
Alhambra	$550.00	1544	$6,600.00
Arcadia	$550.00	1544	$6,600.00
Azusa	$550.00	1544	$6,600.00
Baldwin Park	$550.00	1544	$6,600.00
Covina	$550.00	1544	$6,600.00
Duarte	$550.00	1544	$6,600.00
El Monte	$550.00	1544	$6,600.00
Glendora	$550.00	1544	$6,600.00
Irwindale	$550.00	1544	$6,600.00
La Puente	$550.00	1544	$6,600.00
Monrovia	$550.00	1544	$6,600.00
Montebello	$550.00	1544	$6,600.00
Monterey Park	$550.00	1544	$6,600.00
Pasadena	$550.00	1544	$6,600.00
Rosemead	$550.00	1544	$6,600.00
San Dimas	$550.00	1544	$6,600.00
San Gabriel	$550.00	1544	$6,600.00
San Marino	$550.00	1544	$6,600.00
South El Monte	$550.00	1544	$6,600.00
S. Pasadena	$550.00	1544	$6,600.00
Temple City	$550.00	1544	$6,600.00
West Covina	$550.00	1544	$6,600.00
	Total Annual Cost		$145,200.00
	Yearly Maintenace		$0.00
	10 year Maintenace cost		$0.00
	Total 10 year cost		**$1,452,000.00**

Exhibit 5.7 summarizes the 10-year Life cycle cost analysis for the recommended technologies.

Exhibit 5.7 – 10-year Life Cycle Cost Analysis

Technology	Capital Cost	Yearly Maint. Service Fees	10Yr Maint. Cost	Total 10 yr Life-Cycle Cost
F2C				
USSR /Wireless LAN	$4,915,625	$245,781	$2,457,812	$7,373,437
C2C				
DSL	$4,925	$2,350	$23,503	$493,570
Frame Relay		$145,200		$1,452,000