Traffic Signal Preemption for Emergency Vehicles

A Cross-Cutting Study

Putting the "First" in "First Response"

January 2006

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Foreword

Dear Reader,

We have scanned the country to bring together the collective wisdom and expertise of transportation professionals implementing Intelligent Transportation Systems (ITS) projects across the United States. This information will prove helpful as you set out to plan, design, and deploy ITS in your communities.

This document is one in a series of products designed to help you provide ITS solutions that meet your local and regional transportation needs. We have developed a variety of formats to communicate with people at various levels within your organization and among your community stakeholders:

- **Benefits Brochures** let experienced community leaders explain in their own words how specific ITS technologies have benefited their areas.
- **Cross-Cutting Studies** examine various ITS approaches that can be used to meet your community's goals.
- **Case Studies** provide in-depth coverage of specific approaches being taken in communities across the United States.
- **Implementation Guides** serve as "how to" manuals to assist your project staff in the technical details of implementing ITS.

ITS has matured to the point that you are not alone as you move toward deployment. We have gained experience and are committed to providing our state and local partners with the knowledge they need to lead their communities into the future.

The inside back cover contains details on the documents in this series, as well as sources to obtain additional information. We hope you find these documents useful tools for making important transportation investment decisions.

Sincerely,

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Executive Summary

The sudden appearance of an emergency vehicle en route to an emergency can be extremely disruptive to nearby vehicles as individual drivers maneuver to get out of the way. Some drivers become confused and create conflicts that can cause emergency vehicle crashes or block lanes increasing response times. Using Intelligent Transportation Systems to provide emergency vehicles a green light at intersections can reduce driver confusion, reduce conflicts, and improve emergency response times.

This cross-cutting study identifies issues associated with emergency vehicle operations and emergency vehicle preemption. This study reports information gathered during a review of publications and site visits to three jurisdictions operating emergency vehicle preemption systems. The purpose of this study is to increase awareness among stakeholders—including police, fire, rescue and emergency medical services (EMS)—about the benefits and costs of emergency vehicle preemption. Benefits of emergency vehicle preemption systems include the following:

- **Emergency vehicle preemption has allowed Fairfax County, Virginia to reduce its response times.** The system permits emergency vehicles along U.S. 1 to pass through high volume intersections more quickly with fewer conflicts, saving 30 to 45 seconds per intersection.
- **Emergency vehicle preemption in the City of Plano, Texas has dramatically reduced the number of emergency vehicle crashes** - from an average of 2.3 intersection crashes per year to less than one intersection crash every five years.
- **In addition, due to reduced delays at signalized intersections, the City of Plano can achieve the same response times with fewer fire/rescue and EMS stations than would normally be required, providing significant cost savings.** The city has maintained a response time goal achievement rate of over 90 percent, contributing to its Insurance Services Office Class 1 Fire Suppression Rating - the highest possible rating on a scale from 1 to 10.
- **Emergency vehicle preemption installed in St. Paul, Minnesota has permitted police, fire/rescue, and EMS vehicles to reach the scene of an incident faster and with a reduced chance of a crash.** Crash rates per emergency vehicle responses were dramatically reduced in the years following deployment.

This study also identifies major lessons learned to guide others in achieving similar benefits. The following list highlights some of these elements critical to successful emergency vehicle preemption deployment.

- **Emergency vehicle preemption systems can benefit many stakeholders, including police, fire/rescue, EMS, and transit operators (if transit signal priority is also provided).** To make sure that the needs of all these stakeholder groups are met, it is important to involve all stakeholders in a formal and collaborative manner.

- **A champion, be it an individual or an organization, is often key to success.** At all three sites visited, the preemption initiative progressed when one person or one group of people provided leadership and sponsorship of the effort. In some cases, a different stakeholder took the role of champion as the initiative progressed. Therefore, it is important that the role of champion is clearly identified throughout the process.
- **Stakeholders should consider emergency preemption as part of a developing local ITS architecture.** In doing so, it may be possible to leverage funding for the emergency vehicle preemption system by sharing costs with other ITS-based emergency response, congestion management, and clean air attainment programs. Broader stakeholder groups and a wider range of funding options increase the potential for successful deployment.
- **Signals near emergency facilities (i.e., hospitals, trauma centers, and fire/rescue and EMS stations) will be preempted more often than others and drivers may experience delays if multiple preemption events occur during a short period of time.** Each of the sites indicated that the public accepted these delays and that a public awareness campaign highlighting the public safety benefits of preemption was a key factor in reducing preemption-related complaints.
- **It is critical to identify one agency that is responsible for system maintenance.** A clear method for reporting system problems and well known lines of communication among all involved is required to avoid delay in making any necessary adjustments or repairs. Effective maintenance programs ensure that the system provides the highest degree of benefit.
- **A green light is not guaranteed.** Emergency vehicle drivers need to use caution not to over-rely on the system and need to be prepared to stop if provision of the preemption phase is delayed (i.e., awaiting time out of an in-progress pedestrian phase). Emergency vehicle preemption operation and limitations must be a part of initial and recurring emergency vehicle driver training.

The purpose of this study is to enable jurisdictions to benefit from the composite experience of others in an effort to reduce the time required to move from a good idea to real improvements in the delivery of emergency services.

Introduction

A key issue facing localities in the U.S. is the challenge that rapid growth in populated areas places on the fire/rescue and EMS community. Constrained by tight budgets, officials must make decisions on how to provide appropriate levels of service while at the same time coping with increasing demand for services and increasing congestion levels.

Emergency vehicles (EVs) operating in higher congestion levels are at higher risk for involvement in crashes and are subject to unpredictable delays in reaching the scene of a fire or crash. One means to offset the effects of congestion is the installation of emergency vehicle preemption (EVP) equipment at signalized intersections. This ITS technology provides a special green interval to the EV approach while providing a special red interval on conflicting approaches.

The concept of EVP and the potential benefit of preemption control to support emergency response is nearly as old as the traffic signal itself. In 1929, the American Engineering Council published *Street Traffic Signs, Signals, and Markings,*[1] which included a subsection Emergency Control in the section on Street Traffic Signals: "In any coordinated system supplemental arrangements may be provided for breaking the system into small units for emergency operation, such as runs of fire apparatus."

Over the years, various concepts have been developed to provide the emergency control described in the 1929 document. Several systems were deployed that created a pre-programmed "green wave," providing a progressive green display for the EVs based on the station of dispatch, the response location, and the use of pre-determined emergency response routes.

In the late 1960s, technologies became available to provide emergency control using vehicle-based emitters and signal-based detectors that allowed the EVs to preempt the signals as they were approached. Many communities invested in these systems in an effort to reduce the number of EV crashes. Some cities committed to the deployment of EVP on 100 percent of their signals, retrofitting hundreds of signals and including the technology on all new ones. Other growing communities committed to the technology early in their growth cycles and integrated EVP on every new signal as the community grew.

The material presented in this cross-cutting study is derived primarily from two types of sources: written sources and interviews. Interviews were conducted at three sites—Fairfax County, Virginia; Plano, Texas; and St. Paul, Minnesota—that were selected to show a wide range of EVP deployment options, including jurisdiction size, scope of EVP deployment, jurisdictional responsibilities, and the use of the system by police and transit. Individuals interviewed include local policy makers,

[1] American Engineering Council (1929). *Street Traffic Signs, Signals, and Markings.*

fire chiefs, transportation and traffic engineers, fire/rescue and EMS vehicle drivers, police officers, and signal system technicians. This study includes a summary of the experience for the three sites with regard to the benefits experienced, costs incurred, and lessons learned.

The purpose of the study is to enable other jurisdictions to benefit from the composite experience of others in an effort to reduce the time required to move from a good idea to real improvements in the delivery of emergency services.

EVP—What Are the Benefits?

EVP systems are designed to give emergency response vehicles a green light on their approach to a signalized intersection while providing a red light to conflicting approaches. The most commonly reported benefits of using EVP include improved response time, improved safety, and cost savings. These benefits have been realized since the early deployments of EVP and have been documented since the 1970s. Selected key findings are summarized here. Later in this report, these findings are echoed by the jurisdictions that are visited as part of the EVP study.

Improved Response Time

EVP can improve EV response times by reducing the probability that responding EVs will arrive at intersections during the red signal phase and encounter significant queues. In highly congested areas, EVs may encounter extended queues that force them to slow to a crawl, adding seconds or minutes to the time required to reach the scene of an incident. A green light gets the queue moving and the traffic dispersed before the EV arrival allowing the EV to maintain higher average speeds than would be expected given intersection spacing along the route and normal traffic conditions.

In 1978, the City of Denver Department of Safety produced a study[2] reporting changes in EV response times as a result of signal preemption. The study was conducted over a 90-day period in an area involving three fire stations and 75 signalized intersections. Firefighters recorded travel times necessary to traverse typical routes before and after preemption installation. The data showed EV response times decreased by 14 to 23 percent, with savings of approximately 70 seconds per response on a route with three to six signalized intersections.

Improved Safety and Reduced Liability

EVP can reduce the chance of an EV crash at a signalized intersection. Nationwide, over the past 10 years, more than 25 percent of all EV crashes have been found to occur at signalized intersections.[3] These crashes often involve situations where vehicles approaching a green signal cannot see an EV approaching on the intersecting roadway because of line-of-sight problems with nearby buildings, vegetation, or hills. For these situations, EVP provides familiar guidance to private vehicles by showing a red signal at the conflicting approaches, thereby bringing these vehicles to an orderly stop. Safety benefits can be measured by comparing EV crash histories or, as a surrogate, by measuring the reduction in number of and severity of conflict points

[2] City of Denver Department of Safety (1978). *Time Study on the Effectiveness of the Opticom Traffic Control System (Year 1978*), report prepared for the City of Denver by the Denver Department of Safety, FHWA Report No. D-ORTS/78.5.

[3] U.S. DOT (2003). *Fatality Analysis Reporting System (FARS) Web-Based Encyclopedia Queries for Emergency Use Crash Statistics*. http://www-fars.nhtsa.dot.gov.

that may be present at the time when an EV traverses the intersection.[4] A decrease in EV crashes reduces public liability associated with fatalities, injuries, and property damage. Over the past 10 years, there have been approximately 80 EV crashes each year in the U.S. that involve fatalities.[5]

In 1977, at the request of city officials, St. Paul's fire chief conducted a pre-and post-EVP safety impact analysis.[6] The fire chief studied EV crashes before and after the EVP system deployment, and reported on the preemption deployment rate and the crash histories. Over the period from 1967 through 1976, the City of St. Paul deployed preemption on 285 of 308 intersections. During this period, the number of EV crashes decreased from the 1967 high of eight to an average of 3.3 per year in the latter years of the study.

Cost Savings in Fire/Rescue and EMS Planning

As EVP systems have the potential to improve response times and safety, this trend can translate into cost savings for the community. Response times for fire/rescue and emergency medical services are important measures of effectiveness for local public safety departments and are key elements in fire/rescue and emergency medical service planning. In defining service needs, jurisdictions consider fire flashover[7] times (Figure 1) and survival rates for cardiac patients (Table 1) along with a study of local conditions, including development density and loss potential. ITS solutions, such as EVP, can lead to improved EV response times increasing the effective service radius of a single station.

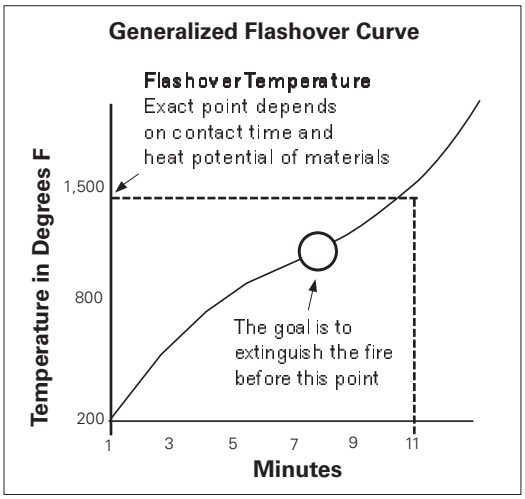

Figure 1 – Generalized Flashover Curve for Residential Construction[8]

[4] Louisell, William C., Collura, John, and Tignor, Samuel C. (January 2003). *Proposed Method to Evaluate Emergency Vehicle Preemption and Impacts on Safety*, Paper presented at the 82nd Annual Meeting of the Transportation Research Board, Washington, D.C.

[5] U.S. DOT (2003). *Fatality Analysis Reporting System (FARS) Web-Based Encyclopedia Queries for Emergency Use Crash Statistics.* http://www-fars.nhtsa.dot.gov.

[6] Fire Chief, Department of Fire and Safety Services, St. Paul, Minnesota, *Emergency Vehicle Accident Study (Year 1977)*, a letter written from the Fire Chief to a City Councilman, 1977.

[7] The *National Fire Protection Association Handbook* defines "flashover" as the point when "all combustibles in the space have been heated to their ignition temperature and spontaneous combustion occurs."

[8] National Fire Protection Association (2001). *NFPA 1710 - Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments.*

Time Until Defibrillation	Survival Chances
With every minute...	Chances are reduced by 7 – 10%
After 8 minutes...	Little chance of survival

Table 1 – Cardiac Arrest Survival Factors as a Function of Time[9]

For example, Loudoun County, Virginia is one of America's fastest growing counties.[10] As such, the county evaluates its current and future fire/rescue and emergency medical service plans given the county's rapid transition from a rural area to a mixed-use area. The influx of new population centers and the increase in congestion on arterial roadways challenge the county. In a January 2003 study,[11] the county examined future fire/rescue and emergency medical service plans identifying the parameters to be considered in selecting the number of stations, the location of the stations, and the required number and type of apparatus that will be required. One of the key considerations in the planning process is average EV operating speed and the effective service radius given response time goals.

Improved response times can lead to an improvement in the insurance industry ratings of a community's fire suppression service, with a corresponding reduction in fire insurance rates for residential and commercial property owners. The Insurance Services Office (ISO), through its Public Protection Classification (PPC) program, assigns insurance ratings to each participating community once every 10 years.[12] By classifying a community's ability to suppress fires, the ISO helps the communities evaluate their public fire protection services and plan improvements. The ratings are very important to communities as they pursue growth and economic development plans. Some communities, such as the Town of Blacksburg, Virginia have reported that its ISO Class had been raised reflecting the response time improvements made possible by EVP deployments.[13]

Blacksburg, Virginia was able to raise its ISO Class, reflecting the response time improvements made possible by EVP deployment.

Cost Savings on Fire Insurance Premiums

[9] American Heart Association Website (2004). http://www.americanheart.org.

[10] U.S. Census Bureau Website (2004). http://www.census.gov.

[11] Loudoun County Public Safety Service Planning (2003), *EMSSTAR Final Service Plan*. http://www.loudoun.gov/fire/index.html.

[12] Insurance Services Office Website (2004). http://www.isomitigation.com

[13] Town of Blacksburg, Virginia (2000). *Annual Report for the Year 2000*.

EVP—Who Is Using It?

EVP systems are deployed and operating across the U.S. In fact, the U.S. DOT ITS Deployment Statistics website,[14] which tracks ITS deployment in the country's largest metropolitan areas, indicates that there are over 30,964 signals equipped with EVP technology in 375 separate jurisdictions. About 20 percent of traffic signals in the 78 largest metropolitan areas are equipped with EVP.

The scale and patterns of EVP deployments seen in individual jurisdictions across the country cover a broad range. The number of signals and the specific signals equipped depend on the issues and problems faced. Some jurisdictions have equipped only a few signals in an effort to provide safe and efficient arterial access from fire/rescue, EMS, and police stations located on side streets. Many others have used the systems to address arterial access as well as to address known problem intersections. Some jurisdictions have adopted policies of 100 percent coverage across the entire jurisdiction or in selected downtown areas.

Most of the jurisdictions that reported 100 percent EVP coverage are located on the fringe of older, major metropolitan areas and report that they own and operate signal systems of 150 signals or less. As these communities began to grow into suburbs, EVP was adopted as an integral component of the public safety and traffic control development plans at any early point in the growth cycle with stakeholders committed to policies to equip 100 percent of the signals. In cases where existing signals were not equipped with EVP, signal systems were brought up to a 100 percent deployment level over several years using bonds or other capital improvement project funding mechanisms. Once at the 100 percent level, these jurisdictions enacted policies requiring that each new signal be installed with EVP.

"Electing to equip 100 percent of the signals was a natural choice for Plano. As a part of its vision and comprehensive development plan, the city committed to using technology as a a cost-effective means to develop the highest possible standards of service across the board. EVP was one of those choices."

– Lloyd Neal
Transportation Engineering Manager, City of Plano

[14] U.S. DOT's ITS Deployment Statistics Website (2005). http://www.itsdeployment.its.dot.gov.

EVP—What Are the Technology Options?

There are many EVP technologies being employed today including light-based, infrared-based, sound-based, and radio-based emitter/detector systems. As such, stakeholders must gather information and consider key operational features and interoperability requirements as they plan deployments and recommend EVP technology approaches. This section provides an introduction to key operational features that may be useful in assessing the available approaches.

Light and Infrared Systems

Light and infrared systems employ emitters that are normally mounted on the roof of the EV and are operated in conjunction with the emergency lights (Figure 2). The photograph on the left shows an early optical emitter mounted just under the windshield. The upper right photograph shows a factory-mounted emitter in front of the light bar. The lower right photograph shows a locally-installed emitter on the roof of a cab. The emitter system includes the light unit and a power supply that is located inside the vehicle.

Figure 2 – Various Light-Based Emitters in Use Today

On the power unit, there is typically a control panel that allows selection of a high priority mode (used for EVP), and a low priority mode (used for transit signal priority). The control panel also includes a feature to assign unique codes to each vehicle operating on the system. The codes provide a record of which operator drove the vehicle, as well as protect against unauthorized use. Light- and infrared-based detectors are generally mounted on the signal arm. Mounting requirements include provisions for power and communications cables. Figure 3 shows both wire and mast arm mounted light-based detectors. Some

jurisdictions install confirmation lights in conjunction with the detectors. This light provides feedback to the EV driver that the request for preemption has been received and that the request will be served according to the local preemption transition protocol.

Figure 3 – Wire and Mast Arm Mounted Light-Based Detectors

Sound-Based Systems

Sound-based systems use the EV siren as the emitter. The waveform of the siren is loaded into the detection and processing equipment such that directional microphones mounted on the signal arm can detect sirens that meet the Federally mandated decibel level of 1,200 db. Once detected, the siren waveform is verified, a preemption request is generated by the phase selector and sent to the signal controller.[15] Figure 4 shows sound-based detection equipment on a signal pole in Loudoun County, Virginia. The system pictured serves a regional hospital with EVP on two approaches.

Figure 4 – Sound-Based Detection Equipment in Loudoun County, Virginia

[15] Collura, J., and Willhaus, E.W. (June 2001). *Traffic Signal Preemption and Priority: Technologies, Past Deployments, and System Requirements*. Paper published in the conference proceedings of the ITS America 11th Annual Meeting, Miami Beach, Florida.

Radio-Based Systems

Radio-based systems utilize a receiver with an omni-directional antenna to detect a digitally coded spread spectrum or narrow band radio transmission from an EV. In these systems, the direction of preemption is selected in the vehicle and direction-unique signal is transmitted to the intersection. Radio-based systems avoid the line-of-sight limitations associated with light- and infrared-based systems. Once a radio frequency pulse is detected and the proper direction of travel is determined, the preemption request is processed by the phase selector and the signal controller.

Table 2 summarizes the technical considerations of the various EVP options.

Technology Consideration	Strobe Activated	Siren Activated	Radio Activated
Dedicated Vehicle Emitter Required	Yes	No	Yes
Susceptible to Electronic Noise Interference	No	No	Yes
Clear Line of Sight Required	Yes	No	No
Affected by Weather	Yes	No	No
Possible Preemption of Other Approaches	No	Yes	Yes

Table 2 – Summary of EVP Technology Features[16]

[16] Collura, J., and Willhaus, E.W. (June 2001). *Traffic Signal Preemption and Priority: Technologies, Past Deployments, and System Requirements*. Paper published in the conference proceedings of the ITS America 11th Annual Meeting, Miami Beach, Florida.

EVP—Who Should Be Involved?

A key step in planning, deploying, and operating EVP systems is the formation of a stakeholder group. The first question is, "Who should be involved?" and the second is, "Who needs to talk to whom, i.e., what are our interoperability needs?"

Forming the Stakeholder Group

Stakeholder group membership depends on the individual jurisdiction—its governmental organization, the division of responsibilities for signal operation and maintenance, jurisdiction membership in regional Councils of Government (COGs), and participation of Citizen Action Committees (CACs). Table 3 lists the potential agencies and groups that may be included in a stakeholder group and indicates the roles each may have in the planning, installation, operations, and maintenance of EVP systems.

Evaluating the Need for Interoperability

Interoperability may be a key consideration in the selection of a particular EVP technology as the stakeholders identify the functional requirements of their own system and the requirement to support other neighboring jurisdictions as part of larger emergency response networks and mutual aid agreements. The following interoperability considerations may be useful to consider in selecting the best technology for a particular EVP application.

- Participation in a regional emergency response network may lead stakeholders to consider how the EVP system would be used within the jurisdiction and across jurisdictional lines in the case of a large-scale regional emergency response. Certain routes within the region may be equipped with a particular technology to support travel to sites for which large-scale emergency response plans have been developed.

Figure 5 – A Bus and a Hook and Ladder Meet in Alexandria, Virginia Without EVP

Stakeholder	Responsibility
City or County Fire/Rescue and/or EMS Departments	• Generally the proponents for the initiative • Often key players in seeking Federal and state emergency response improvement funds
City or County Police Departments	• Potential co-proponents, where police use is considered
City or County Transportation or Public Works Department	• Integration with local transportation planning efforts including transit signal priority • Often a key player in seeking Federal and state transportation improvement funds
City or County Planning Department	• Integration with growth and development plans
City or County Traffic Operations Department (if applicable)	• Planning, integration, testing, and installation • Supporting operations, including system access permissions and system event record keeping • Developing and supporting execution of maintenance concepts
City or County Executive Risk Management (if applicable)	• Identifying the impact on loss rates suffered in EV crashes • Identifying the liability associated with delayed emergency response • Identifying liability issues associated with EVP operations
City or County Disaster Response or Homeland Security Departments (if applicable)	• Potential co-proponents for the initiative • Often key players in seeking Federal and state emergency response improvement funds
State Department of Transportation	For jurisdictions that **do** own and operate their own signal systems: • Integration of local signal operations with state operated and maintained systems For jurisdictions that **do not** own and operate their own signal systems: • Planning, integration, testing, and coordinating for installation • Supporting operations, including system access permissions and system event record keeping • Ensuring development of maintenance memoranda of agreement with the agency that owns the EVP equipment and supporting execution of maintenance concepts
Council of Governments Representative	• Act as coordinator with other jurisdictions within the participating region, identifying interoperability issues and cost-sharing opportunities
Citizens Action Committee Representative	• Act as a proponent for improved public safety • Help promote public awareness

Table 3 – Potential Stakeholders and Roles

- Memberships in mutual aid agreements may require that all users of the system have access to systems in neighboring jurisdictions to facilitate mutual aid coverage in fringe areas or to access specialized apparatus when required.
- Planned or future transit signal priority should be considered as a means to develop a larger stakeholder base and to spread the costs among a wider group that has access to a variety of funding sources such as those committed to congestion management and clean air attainment. Figure 5 illustrates the need for coordination of efforts as public safety and transit agencies work with transportation and traffic officials as they plan signal system enhancements.
- Many localities invest in EVP as a way of speeding access to regional medical facilities. However, these facilities are often served by emergency vehicles from several different jurisdictions. If the purpose of the EVP system is solely to provide access to these medical facilities and will only be installed at intersections approaching them, then a sound-based system may be the best option. Using this technology, EVs' own sirens activate the signal preemption system so no special equipment is required on the vehicles.

Table 4 shows the impact of interoperability conditions on the usability of various EVP technology options.

Will Technology Meet Level of Interoperability Desired?			
Level of Interoperability	Light or Infrared Strobe Activated	Siren Activated	Radio Activated
Emergency Response Route	Yes, equip all participants	Yes	Yes, equip all participants
Mutual Aid Agreement	Yes, equip all participants	Yes	Yes, equip all participants
Transit Signal Priority	Yes, equip all participants	No	No
Regional Medical Center	Yes, equip all participants	Yes	Yes, equip all participants

Table 4 – Summary of Interoperability Considerations

Site Study Descriptions

Site Selection

Three sites—Fairfax County, Virginia; the City of Plano, Texas; and the City of St. Paul, Minnesota—are featured in this section. They represent a range of system maturity, stakeholder relationships, signal operating concepts, and deployment and operational approaches.

As of 2004, Fairfax County was in the process of equipping selected corridors within a large, highly integrated regional traffic signal system. Plano, Texas has a 20-year history of operating EVP across 100 percent of its signals, which were equipped incrementally as part of a comprehensive growth plan. St. Paul has over 25 years of operating experience across 100 percent of its signals, which were equipped retroactively as part of a multi-year EVP deployment plan. Table 5 provides a snapshot of key characteristics of each site.

Site Characteristics	Fairfax County, VA	Plano, TX	St. Paul, MN
Area (Mi^2)	497	76	53
Equipped Signals/ Total Signals	37/1,034*	194/194	368/368
Signal Controller Type	Type 170	Type 170†	Type 170
Central Signal Control Center	Yes	Yes	Yes
Signal Operations Mode	Semi-actuated	Semi-actuated	Semi-actuated
Communication with Signals	Twisted copper phone lines	Wireless	Twisted copper phone lines
Preemption Technology Employed	Vehicle-based light emitter	Vehicle-based light emitter	Vehicle-based light emitter
EV Classes Served	Fire/rescue and EMS	Fire/rescue and EMS	Fire/rescue, EMS, and police
Transit Priority	Yes	No	No

Table 5 – EVP Site Overview

* The signals in Fairfax County are part of the Virginia Department of Transportation (VDOT) Smart Traffic Signal System that is a highly integrated system operating across three Northern Virginia counties.

† The City of Plano, Texas operated Type 170 controllers at the time that interviews and site visits were conducted for this study. However, the City upgraded to Type 2070 controllers in 2004.

This section presents each site's EVP deployment and operations experience in terms of the history of the deployment, the site's traffic operations conditions, the emergency services operational environment, and the operation and maintenance concepts.

Fairfax County, Virginia

Fairfax County is one of four counties that make up the Northern Virginia region. The county covers an area of 407 square miles with a population of approximately one million.[17] The county seat is located approximately 12 miles southwest of Washington, D.C. Development in the county is diverse, ranging from high density office complexes, technology campuses, and commercial development to residential areas that range from medium rise apartments and town homes to single family homes in neighborhoods and rural acreage settings.

EVP Deployment History

Fairfax County has been a leader in the regional push for EVP that first started in the mid-1980s. During this period, fire/rescue and EMS chiefs across Northern Virginia's four counties identified EVP as a means to offset the negative impact that growing congestion was having on EV response times and on EV crash potential. Since the concept was first introduced, EVP in Fairfax County has been deployed in several distinct phases. In the first phase, the county installed EVP on signals that provide arterial access from off-street stations. The second phase consisted of installation of EVP on problem intersections on a case-by-case basis. The third phase consisted of installation of EVP on a small number of intersections located downstream from arterial access points equipped in the first phase (typically one or two intersections). Success in these deployments led to a larger initiative to expand EVP to support EV operations on a corridor level.

"With the extremely high number of emergency calls for the U.S. 1 fire and rescue stations, not to mention the heavy traffic volumes in the background, the corridor was the perfect candidate for emergency vehicle signal preemption."

– Doug Hansen
Senior Transportation Planner, Fairfax County

The proposal to equip arterial signals on a corridor basis emerged in 1997. The initiative did not progress initially because of concerns over the impact on the operation and performance of the Northern Virginia Smart Traffic Signal System, operated by the Virginia Department of Transportation (VDOT). The corridors proposed by fire/rescue and EMS officials were all high interest corridors from a traffic signal system operation perspective, as they operate at near saturation conditions during much of the day. The initiative stalled until the system champions decided to raise the issue on a regional level within the signal operations committee of the Washington D.C. Council of Governments. This action increased the supportive stakeholder base as county transportation officials became interested in the concept as a way to support development of advanced public transportation corridors equipped to provide transit signal priority.

With a broader stakeholder base and increased momentum, VDOT proposed a test plan that involved various technologies and operational concepts. Fairfax County was selected by the U.S. DOT for a test of integrated EVP and transit signal priority using optical emitter and detection systems. The test was conducted on a section of U.S. 1 located just south of Alexandria, Virginia.

[17] U.S. Census Bureau Website (2004). http://www.census.gov.

The test section was a 1.3-mile stretch of roadway that operated under heavy traffic load during rush hours. The section had seven signals operating on six Type 170 controllers. At the mid-point of the test section, a minor side street intersection provided arterial access for Fire and Rescue Station 11, which was the busiest station in the county.

Transit operations on the test section included five fixed-schedule routes. The local Fairfax Connector operated three of these and the Washington Metropolitan Area Transit Authority (WMATA) operated two. During the peak periods, between the two services, buses ran at 10-minute headways through this important transit corridor that serves both point-to-point riders as well as those traveling by bus to transfer to the WMATA operated subway.

In late 2003, the field test results were reviewed. Measures of benefit and impact indicated that EVP and transit signal priority could be operated on the busy U.S. 1 corridor. As a result of this report, VDOT authorized Fairfax County to progress with the installation of EVP and transit signal priority on all signals on the 13-mile portion of U.S. 1 that falls within the county. The installation of the newly approved signals was completed in 2004.

"Our goal with the EVP program is to get our fire and rescue personnel onto the roadway safely and to get them to the scene as quickly and safely as possible."

– Eddie Beitzel, Fire and Rescue Department Planner, Fairfax County

Traffic Operations on U.S. 1

The signals on U.S. 1 in Fairfax County are owned and operated by VDOT and they are operated as part of a network of over 1,000 signals serving Northern Virginia. During most of the day, the signals operate in the semi-actuated mode with offsets programmed to support progression in peak directions. Rush hour cycle times are typically 180 seconds. At the major intersections, the green time split approaches 67 percent on the arterial and 33 percent on the side streets. During the morning peak period, queues on the arterial approaches to major intersections on U.S. 1 typically will be between 12 and 18 vehicles deep across all three travel lanes and the left turn pockets will be full at intersections with major side-streets.

Emergency Service Operations

EV trip generation in Fairfax County is significant with 90,000 emergency response calls per year. These responses originate from 35 stations that house both fire/rescue and EMS units. The response time goal for the county is 5 minutes from the time of dispatch for fire suppression and 6 minutes from the time of dispatch for the arrival of advanced life support. These goals were set based on National Fire Protection Association (NFPA) flashover curves and American Heart Association criteria for responses to cardiac arrest. Fire/rescue and EMS performance against these and other goals is reported to the county Board of Supervisors annually.

At present, the county operates 35 fire/rescue and EMS stations. Each station is responsible for approximately 11.5 square miles. Each station is staffed full time by career fire/rescue and EMS personnel, although 11 of the stations also have volunteers. The county's long-range fire/rescue and emergency medical service plan calls for 40 stations when the

county completes development according to its comprehensive plan. One of the key assumptions in the planning methodology includes maintaining an average EV speed of 32.6 mph. Fire/rescue and emergency medical service performance is periodically reviewed as part of the county's long range planning effort. These reviews have highlighted three corridors, including U.S. 1, for which the county plans to pursue corridor level deployment to offset reductions in average EV speeds caused by congestion.

Fairfax County, Virginia, EVP System Highlights:

- System first proposed in 1987
- Population of 1 million
- One high-use corridor equipped—13 miles of U.S. 1
- Two additional high-interest corridors identified for future deployments
- Used by fire/rescue and EMS vehicles, as well as transit vehicles using low-priority mode for conditional transit signal priority
- 90,000 emergency response calls per year

In Fairfax, only fire/rescue and EMS vehicles have access to the full EVP system. However, transit services operating on the corridor include approximately six buses per hour during the AM and PM peak periods that are equipped with the optical emitters. However, transit vehicle emitters operate on the low priority setting which activates transit priority based on satisfaction of preset conditions, one of which is to yield to any EVP request.

Preemption in Fairfax County is provided only on the arterial approaches because the EV trip patterns generally include a segment of arterial travel followed by turnoff on to collector roads, and then turns on to neighborhood or commercial area streets. The detectors are set to support a detection range of approximately 1,600 feet except in cases of closely spaced intersections or where roadside features cause problems with preemption activation. The goal is to disperse the queues to the point where the private vehicle drivers can move into the middle and right lanes allowing the EV to maintain speed in the left. For preemption, the only condition for request approval is that the signal is not in a pedestrian phase. All other times, the controller will reference the transition plan and move from the current phase while honoring minimum green and amber times.

Once in preemption, the signal displays a green ball or green arrow on all signal heads on the EV arterial approach. All movements on all other approaches are brought to a red interval. This phase design is consistent with displays that drivers normally see on the arterial under normal semi-actuated operating conditions.

Plano, Texas

Plano, Texas, is a suburb located approximately 20 miles northeast of Dallas. Plano is an incorporated city with a population of approximately 220,000.[18] As of 2004, the city size was 74 square miles, although the city experiences a slow but steady growth due to annexation. Within the city, land use varies from moderate density residential to commercial campus development. Light commercial and retail facilities complement the surrounding residential and commercial campus areas. The downtown area consists of approximately 16 square blocks made up of multistory residential apartments, street front stores, and restaurants, as well as private and public office buildings.

EVP Deployment History

EVP deployment began in 1984 as the result of an initiative by the fire chief. The chief had moved to Plano in 1982 from a jurisdiction in Illinois where he led an effort to equip a small corridor with EVP equipment to reduce EV crashes. In Plano, the chief wanted to address a high EV crash rate. Analysis of the EV crash history for the preceding three-year period indicated that nearly 1/3 of the 22 total EV crashes occurred at signalized intersections.

In the early 1980s, Plano had a population of approximately 50,000 and covered approximately 16 square miles. However, growth forecasts and the city's master development plan estimated that in the next 20 years, the population would reach 250,000 and cover approximately 75 to 80 square miles. Keeping this forecast in mind, the fire chief encouraged a capital improvement bond that could serve as a funding mechanism. To develop support, the fire chief worked with a citizens' advisory committee to develop a fire protection master plan. The advisory committee and the chief proposed the retrofit of all existing signals and the inclusion of EVP for all new signals.

The initial deployment to retrofit 46 intersections took three years, resulting in a 100 percent deployment by 1987. As the city grew, 10 to 17 new signals were installed each year. Each new signal was designed, priced, and installed with integrated preemption equipment. Plano continues to have 100 percent preemption coverage.

[18] U.S. Census Bureau Website (2004). http://www.census.gov.

Traffic Operations

Traffic patterns in Plano have grown more complex as peak periods have gotten longer over the past 10 years. Commute patterns have shifted from primarily morning and evening commutes to and from Dallas to more random patterns typical of widely distributed points of origin and destination. The transportation network is made up primarily of arterial roadways laid out in a grid system. The arterial roadways are all built in a boulevard fashion so opposing traffic is separated by tree-lined grass medians bordered by non-mountable curbs (Figure 6). Multilane queues of up to 22 vehicles long are typical.

Figure 6 – Typical Intersection in Plano, Texas, During Morning Rush Hour

Plano owns and operates all 194 traffic signals in its system. Although Plano originally used Type 170 controllers at each signal, the city upgraded to Type 2070 controllers in 2004. The city runs a centralized traffic management and control center that communicates with signal controllers continuously via wireless transmission.

The traffic signal timing plan varies throughout the day. During the peak periods, the signals operate in the semi-actuated mode with offsets to optimize progression in the peak direction. During non-peak periods, the signals operate in a semi-actuated mode, free mode, or flashing mode, depending on the location and the time of day. Major intersections operate on 160-second cycles and, signals at the minor intersections operate on 80-second cycles. During the morning peak period, queues on all four approaches to major intersections will typically be between 18 and 22 vehicles deep with some cases exceeding 30 vehicles.

Emergency Service Operations

EV trip generation in Plano is relatively high with 16,000 emergency response calls per year from 10 fire/rescue and EMS stations. These responses generate an average of one preemption request per day per signal across the city. Some signals, located near hospitals and fire/rescue and EMS stations, are preempted as many as 15 times in a day or, on average, once every 90 minutes.

The response time goal for the city of Plano has been set at 90 percent of calls responded to within 6 minutes, 59 seconds. This goal was set by the

City Council to affirm the city's commitment to responsive public safety services. As part of its continuing commitment, the fire chief delivers an annual summary presentation to the City Council that details the department's performance in the preceding year by zone within the city.

Zones in which the goal is not met are reviewed for potential policy or capitalization initiatives to improve the level of service. The city operates one fire station for every 7.5 square miles of incorporated area. Eight of the 10 stations operate at normal staffing and equipment levels. Two stations have additional personnel and equipment assigned to offset growth and congestion trends in one area of the city under consideration for a new station. It is expected that one more station will be built in the near term.

Preemption System Operations

In Plano, only fire/rescue and EMS vehicles have access to the EVP system. The system was a fire department initiative. Over the 20-year operational period, neither police nor transit officials have expressed strong interest in using the system.

All compatible emitter-equipped vehicles from the surrounding communities are allowed to access the Plano system. Similarly, Plano's emergency vehicles are permitted access to the priority systems of their neighboring communities. As of 2004, Plano is considering moving toward encrypted system use due to the appearance on the retail market of devices that claim to activate EVP for ordinary auto drivers. Enhancing the system with encryption will require coordination with the surrounding communities. All Plano emitters are capable of encryption; however, not all intersections are equipped with detectors capable of operating in an encrypted mode. Encryption is expected to prevent unauthorized users from accessing the system in addition to providing a record of which EVs used the system and when.

Preemption in Plano is provided on all four approaches to each intersection. This configuration supports the EV trip patterns in which EVs can proceed to a destination using the grid-oriented arterial road system. The detectors are set to support a detection range of approximately 1,600 feet unless roadway or roadside features restrict ranges due to line-of-sight problems. The goal is to have a minimum span of 20 seconds between the call and the arrival of the emergency vehicle at the signal. For preemption, the only condition for request approval is that the signal is not in a pedestrian phase. All other times, the controller will transition from the current phase at the expiration of the minimum green time.

Once in preemption, the signal displays a green ball or green arrow on all signal heads on the EV approach. All movements on all other approaches will be brought to a red interval. This phase design is consistent to displays that are generated on the arterial under normal semi-actuated operating conditions.

Plano, Texas EVP System Highlights

- Installation began in the mid-1980s
- Population of 222,000
- 100 percent of signals equipped
- Used by fire/rescue and EMS vehicles only
- 16,000 emergency response calls per year

St. Paul, Minnesota

The City of St. Paul is one of the two Twin Cities of Minnesota that form the heart of the largest metropolitan area in the state, with a total population of nearly 3 million people.[19] St. Paul is an incorporated city, with a population of approximately 288,000 and a land area of 53 square miles. Within the city, land use varies from single-family neighborhoods, to moderate-density residential and commercial, to a high-density central business district. The downtown area of St. Paul consists of approximately 70 square blocks with a variety of multistory residential apartments, street front stores and restaurants, and high-rise office buildings, both privately and publicly owned.

EVP Deployment History

In 1969, EVP was implemented at 28 intersections in St. Paul as the first step in an effort to reduce the number of EV crashes experienced each year. Between 1969 and 1976, the city equipped 285 of its 308 intersections with optical EVP systems. Initially, the deployment was only on the two main approaches to each intersection. This deployment plan was modified in 1972 after a fatal crash occurred between a police car and a fire truck at an EVP-equipped intersection. After this incident, the mayor of St. Paul decided to provide full coverage of the preemption system to all intersections on all approaches. As of 2004, St. Paul operated an EVP system on 100 percent of its 368 traffic signals on all approaches. New traffic signals installed in St. Paul are outfitted with preemption equipment during construction.

Traffic Operations

The transportation network is comprised primarily of major and minor streets laid out in a grid system. A sub-grid of minor streets between the arterials provides access to various neighborhoods and commercial areas. Throughout the city, the streets are bounded on the right side by non-mountable curbs and sidewalks but most do not have raised center medians. As is the case with many central business districts throughout the country, the downtown area of St. Paul has short blocks and several one-way streets.

St. Paul owns and operates all of the traffic signals that serve the city. Each signal is controlled by Type 170 equipment from a centralized traffic management center by the Traffic Operations section of the City of St. Paul Department of Public Works. The Traffic Operations staff can monitor signal operations continuously and can send updated signal timings to intersections through a combination of broadband and twisted copper wire communication connections. Most signals in the city operate on a 60-second cycle length. Some of the more heavily traveled corridors have cycle lengths of 120 seconds. During the peak periods, the signals typically operate in the semi-actuated mode with offsets to optimize progression in the peak direction. During non-peak periods, the signals operate in a semi-actuated mode, a free mode, or in a flashing mode, depending on the location and the time of day.

[19] U.S. Census Bureau Website (2004). http://www.census.gov.

Emergency Service Operation

St. Paul fire/rescue and EMS vehicles respond to approximately 26,000 emergency calls per year from 16 fire/rescue and EMS stations. Fire suppression responses account for approximately 12,500 of these calls; emergency medical services account for the remaining 13,500 calls, with an average of approximately 70 emergency response calls per day, or about one call every 20 minutes.

In contrast to Fairfax County and Plano, the City of St. Paul EVP system is used by the police department as well as fire/rescue and emergency medical services. The inclusion of police as system users places a significantly higher demand on the system. Police receive 263,000 calls annually, with an average of 720 calls per day or, one police response every 2 minutes. In addition to the increased demand, police use of the system differs from fire/rescue and EMS in trip origin and travel route patterns. While fire/rescue and emergency medical services primarily respond from fixed stations and travel along predictable routes, police vehicles respond from random locations and make route choices quickly as police officers select routes considering both tactical advantage and response urgency.

The combination of fire/rescue, EMS, and police use produces a less predictable preemption pattern, but there are still some areas of the city and some signals within the city where the average number of preemption events in a day is higher than others. Signals located near hospitals and fire/rescue and EMS stations are preempted more than five times per day while others are only preempted a few times per week.

The response time goal for the fire department in St. Paul is 3 minutes for both fire/rescue and EMS responses. The police department does not specify a time goal because dispatchers contact officers in the field who respond from various locations to emergency calls.

Preemption System Operations

St. Paul is one of only a few jurisdictions in the country that provides preemption access to every police vehicle, as well as every fire and emergency vehicle, in the city. Additionally, all emitter-equipped vehicles from the surrounding communities are allowed to access the St. Paul system if they are willing to enter a formal agreement with the city. The main elements of this agreement state that outside emergency departments will consent to fully train their employees for use of the preemption equipment, and that they will use the system "as-is," waiving any future legal action against the City of St. Paul for any damages arising from use of the system. Similarly, St. Paul's emergency vehicles are permitted full access to the preemption systems of the neighboring communities, although no formal agreement is required in most adjacent jurisdictions.

In St. Paul, the detection thresholds are all set to the maximum range of approximately 2,300 feet with a 2-second dwell requirement for call acceptance. The policy was developed in 1998 after the city conducted a system performance test in an effort to ensure the maximum benefit to

St. Paul, Minnesota EVP System Highlights

- Installation began in 1969; oldest continuously operating deployment of EVP in the U.S.
- Population of 288,000
- 100 percent of signals equipped
- Used by fire/rescue, EMS, and police vehicles
- 26,000 fire/rescue and EMS calls per year
- 263,000 police calls per year

the entire user community. The range setting accommodates police vehicles, which accelerate quickly and often operate at higher speeds than fire/rescue and EMS vehicles. In addition to the benefit for the police community, maximum range detection thresholds compensate for variation in emitter intensity across St. Paul's several generations of emitter equipment and variation in detection range caused by differences in emitter installation height. The 2-second dwell requirement reduces the number of inadvertent preemptions triggered when preemption equipped vehicles make turns in areas with closely spaced parallel streets.

Once in preemption, the signal displays a green ball on all through lanes for both the concurrent and opposing approaches. Left turn arrows on signals on the concurrent and opposing approach display a red arrow to prevent a motorist from making a permissive left turn across the path of an oncoming EV. Perpendicular approaches are brought to a red interval for movement in all directions.

The confirmation light is an important system feature of the St. Paul EVP system. The lights provide feedback to the EV drivers. The lights indicate that a request has been received and provide information on the precedence level of the request in cases when a simultaneous or near-simultaneous preemption request is made on a perpendicular approach. The approach that will get the green is provided with a solid confirmation light while those that will have to yield the right of way are provided with a flashing confirmation light. Operation of the confirmation light is part of EV driver training and is integral to the effort to reduce the potential for crashes.

Figure 7 shows a St. Paul traffic signal in the preemption phase with an EV crossing right to left through the intersection.

Figure 7– A St. Paul Signal in the Preemption Phase

Cross-Cutting Findings

Key questions in any effort to deploy an EVP system are, "What are the benefits?" and, "What are the costs?" This section provides an overview of the findings of the cross-cutting study.

The benefits of EVP range across a variety of public interest issues. The benefits realized by the three featured sites are summarized in Figure 8. These benefits include improvements at operational, planning, and economic levels.

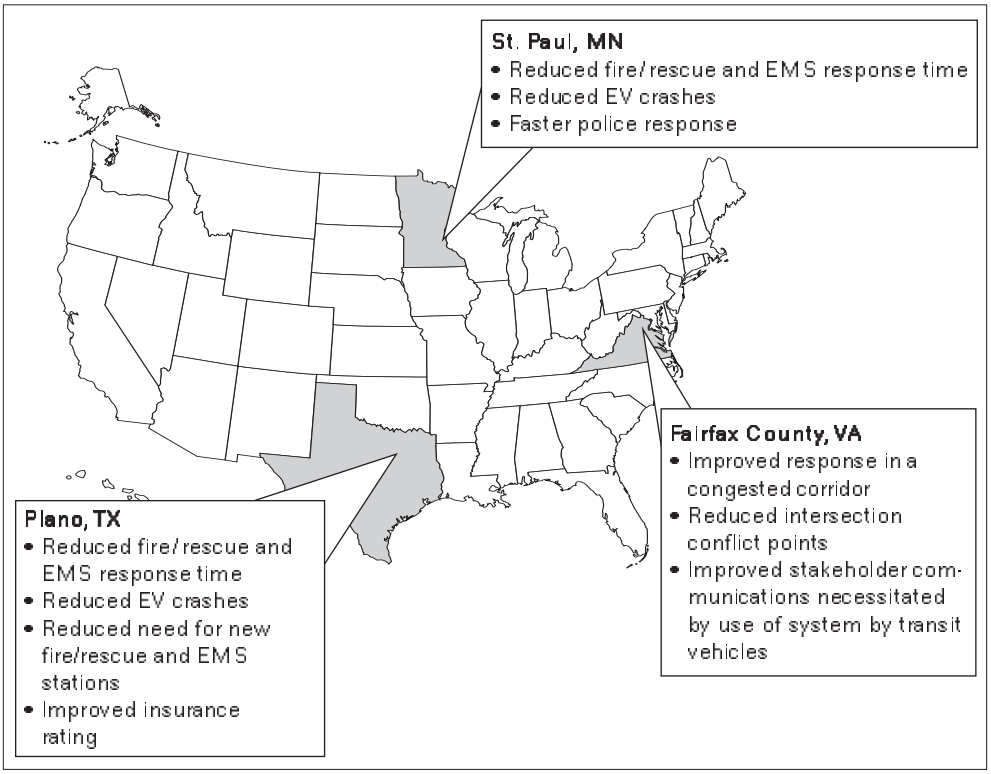

Figure 8 – Summary of Benefits by Site

Specific examples highlighting the benefits are presented below.

Fairfax County, Virginia - In nearly all response runs, the system saves anywhere from a few seconds to a few minutes. Station 11 EV drivers cited savings of 30-45 seconds at a single intersection such as the one at U.S. 1 and South Kings Highway (Figure 9).

Plano, Texas - Plano's need for EVP stems from the combination of the layout of its road network and its traffic signal timing plan. Many of Plano's streets have center medians and narrow shoulders, so that vehicles trying to get out of the way of an EV have no place to go. Therefore, without EVP, it can frequently take two or three cycles to clear an intersection so that the EV may pass. Many of Plano's traffic signals have long cycle lengths of up to 2 or 3 minutes, making it even more important to install EVP at those intersections to reduce clearance time.

The Benefits of EVP

"Reduced response time was an unexpected benefit that we realized. We estimate a 10-20 percent reduction. The system has allowed us to set and achieve a response time goal of 90 percent of arrivals within 6 minutes and 59 seconds even as the traffic levels have grown."

– Bill Peterson
Fire Chief, City of Plano

Improved Response Time

Figure 9 – A Ladder Truck Without EVP Pushes Through a Queue at a Red Signal

Improved Safety

"The system has had a positive impact on the service we provide to the community."

– Captain Lange,
"C" Shift Captain,
Fire and Rescue Station 11
Fairfax County

Plano, Texas - A study conducted by the City of Plano Risk Management Office indicated that there were 22 EV crashes from 1981 to 1983. Of these 22 crashes, seven occurred at signalized intersections and may have been preventable had EVP been in place. Over the 20 years since the installation of EVP, there have been only four crashes involving emergency vehicles at intersections. In three of these crashes, the cause of the crash was failure of the private vehicle involved to stop for the red signal display correctly generated by the EVP system. The fourth was caused by EV driver error.

St. Paul, Minnesota - In 1977, St. Paul conducted one of the most extensive studies of EVP and EV crash rate reduction available.[20] The study documented the rate of EVP deployment across the city's nearly 300 signals and tracked the number of EV crashes and EV responses over the same period. Crashes were reduced from the 1967 high of eight EV crashes to an average of 3.3 EV crashes per year in the latter years of the study. In the report, the fire chief noted that the improvement in crash rates occurred despite an increase in the number of alarm responses and the volume of traffic encountered on the St. Paul roadways. The fire chief indicated that the decrease in the number of EV crashes was due to the dramatic reduction in the conflicts EVs are exposed to at signalized intersections.

Traffic Flow Impacts of EVP

Fairfax County, Virginia - An evaluation of traffic flow impact on U.S. 1, conducted in 2003 by the Virginia Tech Transportation Institute,[21] found that the average duration of a preemption event was 25 seconds and that delay impacts on side streets were minor. Backups normally cleared during the first signal cycle following the preemption event.

[20] Fire Chief, Department of Fire and Safety Services, St. Paul, Minnesota (1977). *Emergency Vehicle Accident Study (Year 1977)*.

[21] McHale, G. and Collura, J. (2003). "Improving Emergency Vehicle Traffic Signal Priority System Assessment Methodologies." Paper presented at the 82nd Annual Meeting of the Transportation Research Board, Washington, D.C. 2003.

Plano, Texas - The degree of impact on traffic flow at a particular intersection depends on the frequency of calls made on a particular signal and the level of congestion on the roadway. In Plano, some signals near hospitals often experience multiple preemption calls resulting in queues that take several cycles to clear. During peak periods, it can take 10 to 20 minutes for the traffic flow to return to normal.

However, citizen complaints about the impact are few because of high public awareness of the purpose of the system. City engineers pointed out that they get almost immediate cell phone call feedback on malfunctioning signals but get very few calls that can be attributed to the impact of a preemption event.

The cost of EVP systems per intersection and per vehicle vary depending upon the technology selected, the number of units purchased, and the baseline intersection and vehicle conditions. Intersection cost variables include the availability of power on the mast arm or signal suspension cable, the need to run new power and communications cables through existing conduit, and the availability of suitable detector placement locations. Vehicle cost variables include whether or not the vehicle was built with provisions to house the power supply and the emitter and the requirement to develop special brackets to mount the emitter to the vehicle.

Equipment costs, by component, reported by the three sites visited are summarized in Table 6. More information about the costs of emergency vehicle preemption is available from the ITS Costs Database available at http://www.itscosts.its.dot.gov.

System Component	Capital Cost ($K in 2003 dollars)	O&M Cost ($K/yr in 2003 dollars)
Equipment Required per Intersection:		
Signal Preemption Receiver w/ optional confirmation light	2 – 3	0.25 – 0.5
Signal Phase Selector	2 – 5	No specific maintenance required
Equipment Required per Vehicle:		
Signal Preemption Emitter Note: Initial cost includes a power supply and the emitter (high end of cost range) while maintenance costs primarily entail optical emitter replacement (low end of cost range)	0.7 – 2.1	Remove and replace the optical emitter upon failure

Table 6 – Typical Costs of EVP Equipment

"The vehicle queues on side-street approaches became slightly longer but would typically clear during the first green phase following the preemption event."

– Doug Hansen
Senior Transportation Planner, Fairfax County

The Cost of EVP

"The public is aware of the preemption system and tolerates the inconvenience as part and parcel to the high quality of emergency services they have grown to expect."

– Lloyd Neal
Transportation Engineering Manager, City of Plano

"For a site, the structure, and the apparatus, the cost is about $3 million (2004 dollars); and the continuous operations and maintenance costs are about $2.5 million per year for each station."

– Bill Peterson
Fire Chief, City of Plano

Fairfax County, Virginia - In Fairfax County, the county is responsible for the cost of equipment purchase and installation on VDOT owned signal systems. Because the Fairfax County deployment involved a retrofit of existing signals, the costs per intersection varied due to a range of signal suspension methods employed along the corridor. Each intersection was surveyed to determine the special design considerations and the impact on the project budget and the deployment schedule. Across seven intersections in the operational test section, the average cost was between $4,000 and $6,000 per intersection (equipping two arterial approaches only).

Fairfax County is responsible for maintenance of the system. The county has employed a maintenance contractor that bills the county directly. As of 2004, experience from the field operational test was being used to develop a county budget line item that will cover the 50 existing or near-term planned EVP intersections. County officials estimated these annual EVP maintenance costs to be between $250 and $500 per year.

Plano, Texas - Plano, Texas does not separate out costs of the EVP system because it is fully integrated into traffic signal operations. However, the traffic engineering department estimates that the cost to install the preemption detection on a new signal at all four approaches is between $5,000 and $8,000 of the $105,000 (or higher) total cost of the signal design, installation, and integration. Differences in cost are dependent upon such factors as the site requirements for power and mast arm installation.

Because Plano owns and operates the EVP systems and the signal systems, the city does not differentiate signal maintenance costs and preemption maintenance costs. EVP maintenance costs are part of the overall signal system maintenance budget. Plano reports that most system failures are traceable to construction and damage to power and signal communications conduits in the vicinity of the intersection.

St. Paul, Minnesota - In the City of St. Paul, the cost of preemption equipment is integral to the cost of new signals. The city estimates the cost of equipping a new traffic signal with preemption capability is approximately $6,000 to $8,000 at all four approaches, provided that the necessary conduits, wiring, and power sources are available.

St. Paul performs regular preventive maintenance on EVP detectors, including lens cleaning and removal of tree overgrowth that prevents the equipment from receiving a preemption call. City maintenance staff trim nearby tree branches and clean the receiver lenses every two years. St. Paul does not differentiate signal maintenance costs and preemption maintenance costs. Both preventive and responsive EVP maintenance are included in the Department of Public Works annual budget.

Plano, Texas - As part of its 20-year growth plan developed in the mid-1980s, Plano estimated that one fire/rescue and EMS stations would be required for every 5.6 square miles to provide the desired level of service. As the city grew, the response time benefit of EVP has been incorporated into the geographical information systems (GIS)-based planning models the city uses to evaluate fire/rescue and emergency medical service expansion needs. As a result, the city is now serving 7.5 square miles per station instead of the anticipated 5.6 square miles. The benefit to the city is that it is currently operating 10 stations compared with the 13 that had been forecast resulting in a capital cost savings for the city of approximately $9 million and an annual operating cost savings of approximately $7.5 million.

Potential Cost Savings

Lessons Learned

This section summarizes the lessons learned reported by the three sites so that those considering EVP can minimize deployment delays and maximize system performance. The lessons presented were common across the three sites. They are presented in terms of institutional issues, public acceptance, EV driver training, system installation, and system maintenance.

Overcoming Institutional Issues

- **Involve all appropriate stakeholders in a collaborative manner throughout the planning, deployment, and operations phases**. EVP systems have the capacity to impact a number of city, county, and state agencies. Successful EVP projects will involve a wide-ranging stakeholder group that should consider a memorandum of understanding outlining the short and long-term roles of each member.
- **Identify a champion and define the role to maintain a consistent advocacy message**. To prevent the effort from stalling, it may prove beneficial for the stakeholder group to designate a specific champion for the system. In a typical EVP deployment, the initial champions come from the fire/rescue and EMS community. Over time, however, local officials become advocates, or maybe even champions, as local governments decide whether or not to support the system financially.

Public Acceptance

- **Launch a public awareness campaign highlighting the public safety benefits of preemption at these and other signals**. An important step in achieving public acceptance is to inform the community of the purpose and benefits of EVP. Extra outreach may be needed in areas surrounding intersections near hospitals or fire/rescue and EMS stations as these intersections experience more preemption calls than other intersections, often resulting in more delays around these facilities.

EV Driver Training

- **Document standard operating procedures and driving techniques and review them in regular training sessions**. Driver training is key to minimizing EV crashes. EV drivers at each site visited stated that the main lesson learned was not to over-rely on the system and to proceed as if preemption would not be granted.

System Installation

- **Bench test the equipment and software in the shop with the same equipment that is found in the field**. Bench testing prevents potential problems in the field. VDOT found that traffic signal controller software required an upgrade to allow dual use of the technology for both EVP and transit signal priority. Prior to the upgrade, testing revealed that transit priority requests would be granted the same level of precedence as EVP requests, whereas VDOT wanted EVP requests to take precedence.

"In nearly every situation, some type of adjustment was needed to clear the way for using preemption and priority…it was not a purely 'plug and play' application."

– Bob Sheehan
Signal Systems Manager, VDOT

- **Wire the vehicle emitter into the EV parking brake or transmission lever to turn the emitter off while the EV is stopped**. When EVs stop in the vicinity of an intersection, a continuously running emitter will hold the signal in the preemption phase indefinitely, causing significant traffic problems. Systems with factory-installed emitters are usually delivered with a power interrupt tied to the transmission shift lever that disables the emitter when the vehicle is in "park." Both the Fairfax County and Plano apparatus shops had to develop custom power interrupt solutions for vehicles with locally-installed emitters.
- **Maintain an open line of communication among stakeholders during the acceptance testing period to avoid poor system performance and perhaps avert a dangerous situation**. Resolving system performance issues requires cooperation and communication between EV drivers and EVP maintenance technicians. Certain signalized intersections may pose problems in terms of emitter-detector line-of-sight reducing detection ranges. Finding the right solution requires detailed problem descriptions.

System Maintenance

The key to maintenance success is identification of a single agency to be responsible for scheduling, coordinating, and funding system maintenance. This agency may be the city traffic engineering department or the fire/rescue and EMS department. If the fire/rescue and EMS department contracts out for maintenance services, a memorandum of agreement should be drafted with the agency that controls signal cabinet access to document service call precedence, cabinet access procedures, service log requirements, and any other necessary site-specific coordination issues.

- **Develop a maintenance problem-reporting channel**. The purpose is to enable the users of the system to easily report problems so that problems can be screened for response priority and the potential for dangerous situations is minimized. Figure 10 shows a VDOT technician in Fairfax County, Virginia overseeing contract maintenance on the EVP system.
- **Ensure a standard fault isolation protocol is in place**. Having a documented system for trouble-shooting will reduce the repeat/recur rate as well as the maintenance call false alarm rate.
- **Perform concurrent maintenance**. In addition to serving maintenance requests, there may be benefit in performing preventive maintenance in conjunction with regular traffic signal equipment maintenance. A task such as detector lens condition inspection can be done in conjunction with signal lamp replacement. St. Paul reports that this practice has helped reduce service calls.

Figure 10 – A Technician Oversees Contract EVP Maintenance

"It's not easy to pin down 'who's doing what' when you have multiple groups entering the controller cabinets…there are far-reaching liability implications should the system malfunction due to human error.
It comes back to communication. As long as we know what's going on in the field with the equipment, we can satisfy everyone's objectives."

– Bob Sheehan
Signal Systems Manager,
VDOT

Conclusion

Communities across the country are striving to provide the highest possible levels of fire/rescue, EMS, and police services. These efforts have gained new meaning as towns, cities, counties, states, and regions improve emergency response in support of homeland security and disaster preparedness.

EVP is one item in the toolkit that improves the responsiveness of public safety services. EVP has the potential to:

- Reduce the potential for an EV to be in a crash en-route to the emergency scene or to the hospital, reducing liability and keeping EVs in service.
- Help to get fire/rescue and EMS apparatus to the scene quickly and to put law enforcement in a tactically advantageous position.
- Reduce emergency medical service response time and patient transport time, saving critical minutes and increasing the chance of survival for the cardiac arrest or trauma patient.
- Be a cost-effective alternative to building new stations by increasing the effective service radius of current facilities.
- Be a catalyst for developing broader cooperation between jurisdictions as they develop or further mutual aid agreements as part of regional emergency response plans.
- Provide the foundation for transit signal priority when deployed on key transit corridors.

When EVP is implemented well, the negative impacts on traffic flow are not significant and public acceptance of the system is high. For example, it is often the case in jurisdictions with EVP that:

- Most signals are rarely preempted and those that are near EV points of origin and destination experience delays that are in line with those experienced in normal peak hour conditions.
- Signal timing plans are generally reestablished in one to three cycles after an EV preemption event.
- Public awareness grows quickly and complaints about the system decrease.

Communities using EVP have experienced significant benefits with minimal negative impacts. Proactive collaboration among informed stakeholders are key to successful deployment of EVP that helps put the "first" in "first response."

Resources

Federal and State Guidelines on EVP Implementation

Federal Highway Administration (2003). *Manual on Uniform Traffic Control Devices (MUTCD) 2003 Edition, Part 4: Highway Traffic Signals*. http://www.mutcd.fhwa.dot.gov.

The *MUTCD 2003 Edition*, includes explicit definitions of preemption and priority at traffic signals. These definitions, combined with instructions for phase transition, reduce some of the issues of concern in EVP deployments by providing the guidance that traffic engineers require to ensure safety and efficiency in operations.

Minnesota Department of Transportation (2005). *Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) Part 4: Highway Traffic Signals*. http://www.dot.state.mn.us/trafficeng/otepubl/mutcd.

This section of the Minnesota Department of Transportation's MUTCD provides guidance on the installation and operation of EVP systems. The document codifies the lessons learned over 30 years of experience with EVP in Minnesota. The guidance includes detailed instructions for the use of EVP, the design of EVP preemption phases, and the use of confirmation lights. The manual also includes requirements for new signal installation and the inclusion of provisions for installation of EVP.

Responsibilities in EVP Deployment, Operations, and Maintenance

Arizona Department of Transportation (2002). *ADOT Traffic Engineering Policies, Guidelines, and Procedures; Section 600 - Traffic Signals*. http://www.azdot.gov/highways/traffic/pgp.asp.

This section of the Arizona Department of Transportation's (Arizona DOT's) traffic engineering policy document outlines responsibilities for the key stakeholders in EVP deployments. The document lays out the Arizona DOT policy on who owns, operates, and maintains EVP equipment for jurisdictions in which Arizona DOT owns the traffic signal system and for jurisdictions in which the jurisdiction itself owns and operates the traffic signal system.

Information on Organizing, Planning, Deploying, and Operating EVP

Collura, John, Rakha, H. and Gifford, J. (2003). *Guidelines for the Planning and Deployment of Emergency Vehicle Preemption and Transit Priority Strategies*. http://signalsystems.tamu.edu/documents/Jan2004AnnualMeeting/SundayWorkshop/GuidelinesEVPandTP_Draft1.0.pdf.

This document provides guidelines on the planning and deployment of both EVP and transit signal priority, including integration of the two. Aspects of the planning process covered in the guidelines include examining institutional issues, conducting an assessment of local needs, determining system objectives and requirements, estimating traffic flow and safety benefits, estimating economic impacts, and obtaining financing. Deployment considerations covered in the guidelines include procurement, pre-installation site surveys, installation, and evaluation.

Additional Resources

Bullock, D., Morales, J., and Sanderson, B. (1999). *Evaluation of Emergency Vehicle Signal Preemption on the Route 7, Virginia, Corridor*. Washington, D.C.

Gifford, J., Pelletiere, D., and Collura, J. (2001). "Stakeholder Requirements for Traffic Signal Preemption and Priority in the Washington, D.C. Region". *Transportation Research Record*. No. 1748. pp. 1-7.

McHale, G. and Collura, J. (2003). "Improving Emergency Vehicle Traffic Signal Priority System Assessment Methodologies". Paper presented at the 82nd Annual Meeting of the Transportation Research Board. Washington, D.C. 2003.

Nelson, E. and Bullock, D. (2000). "Impact Evaluation of Emergency Vehicle Preemption on Signalized Corridor Operation". Paper presented at the 79th Annual Transportation Research Board Meeting. Washington, D.C. 2000.

Obenberger, J. and Collura, J. (2001)."Transition Strategies to Exit Preemption Control: State-of-the-Practice Assessment". *Transportation Research Record*. No 1748.

Skabardonis, A. (2000)."Control Strategies For Transit Priority". Paper presented at the 79th Annual Transportation Research Board Meeting. Washington, D.C. 2000.

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