Reducing Risk Through the Use of Traffic Preemption

Mark A. Lorenzen

Ventura County Fire Protection District

Camarillo, California

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

Limiting risk has been a long-standing objective in the fire service. The development of a tool that can assist in limiting risk while improving efficiency will be beneficial to the community. The problem is that first responders and the community may be exposed to unnecessary risks that are associated with emergency vehicles responding with red lights and sirens. Additionally, response times may be longer in the absence of an emergency vehicle traffic preemption (EVP) system. An analysis of these risks and a comprehensive evaluation of the results have never been completed. The purpose of this research is to evaluate the efficacy of such a system as it relates to response times and risk reduction. This research is only targeted at identifying whether risk and response time can be positively effected through the use of traffic preemption. An evaluative research method will be used to answer the following questions: Will response times decrease if a traffic preemption system is employed? How are intersections identified and prioritized for the installation of a preemption device? Can risk be reduced through the use of a traffic preemption system? An internal time study was conducted to determine whether EVP installation would reduce response times. This study involved the installation of EVP on fire apparatus and measured response times prior to and after installation. The results showed that EVP would not significantly reduce response times. However, data found during the literature review process indicated an overwhelming probability that both risk and response times would be reduced through implementation of EVP. A recommendation was made supporting implementation of an emergency vehicle preemption system.

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Introduction

The community and first responders are exposed to a variety of risks. As a public entity tasked with mitigating emergent situations, first responders must continually evaluate the risks over which they have some element of control. This commitment to mitigating risk is evident in the industry's dedication to fire prevention programs and has come to be expected by the public. It is worth noting that the risks associated with the fire service are not limited to fires alone. These additional risks, once identified, should be analyzed to determine what impact, if any, the fire service can have on reducing the risk and that outcome will have to be balanced with current priorities and constraints.

A number of steps have been taken in recent years to improve service and reduce emergency response times for the constituents of the Ventura County Fire Protection District (VCFPD or the District). This has included conducting time studies based on road speeds and population densities and subsequent relocation of existing fire station locations to areas that better serve the public. In addition, a quick launch dispatch methodology was implemented after an applied research project was completed showing the value of such a change to the system without any corresponding increase in risk to first responders or the public (Lorenzen, 2010). The problem is that first responders and the community may be exposed to unnecessary risks that are associated with emergency vehicles responding with red lights and sirens. Additionally, response times may be longer in the absence of an emergency vehicle traffic preemption system. The possibility exists that, with the lack of improvements to specific components of the emergency response system, efficiencies that could reduce risk to first responders and the public and that might reduce response times, may be overlooked.

The purpose of this research is to evaluate the efficacy of such a system as it relates to response times and risk reduction. This research is only targeted at identifying whether risk and response time can be positively effected through the use of traffic preemption. The research is not designed to select a specific system. An evaluative research method will be used to answer the following questions: Will response times decrease if a traffic preemption system is employed? How are intersections identified and prioritized for the installation of a preemption device? Can risk be reduced through the use of a traffic preemption system?

Background and Significance

Unfortunately, a significant number of firefighters are either killed or injured each year while responding to or returning from emergencies. A similar number of civilians are also killed or injured annually as a result of collisions with emergency apparatus. Accidents with emergency vehicles have been shown to be consistently one of the leading causes of death and injury to firefighters (International Association of Firefighters [IAFF], 2010). Many advances in safety have reduced these numbers over the years, however, a significant risk to both our first responders and the public still exists.

These risks exist within every jurisdiction. The Ventura County Fire Protection District dispatches first responders to over 40,000 incidents every year. With each call for service, first responders and the public are put at risk to accident or injury as a result of either a collision directly with the responding apparatus or a tangential collision with a non-emergency vehicle. The District, which was established as a dependent special district in 1928, has grown to serve a population of approximately 480,000 from 31 fire stations with a work force of approximately 540 employees and a budget of $128 million. The District provides regional fire, rescue and emergency medical services (EMS) to a number of incorporated cities and to unincorporated areas of the county (Lorenzen, 2010). It is important to recognize, due to the complexities of this research project, that services are provided to six independent cities each having their own form of government and a separate decision making body and process. These cities include Thousand Oaks, Moorpark, Simi Valley, Camarillo, Port Hueneme, and Ojai.

Major freeways dissect four of the six cities within the District. All cities have signalized intersections, though design and traffic flow are unique to each jurisdiction. Each city is responsible for the repair and maintenance of its respective roads, intersections and equipment and, accordingly, each has its own roads department and traffic engineers. A number of the signalized roads are state thoroughfares and fall under the jurisdiction of the state's road authority, Caltrans.

The common denominator, across all emergency disciplines, is that intersections are the most likely place for emergency vehicles to be involved in a traffic accident (IAFF, 2010). Safety devices such as airbags, seat belts and crumple zones are part of the reason injury and fatality rates are steadily declining. Engineered devices, such as antilock braking systems, have likely prevented a number of accidents and injuries from ever occurring. Those tools that can actually assist in the prevention of occurrences are the ones which provide the greatest benefit to society. However, engineering advances have also added to the problem. Newer vehicles have more effective soundproofing, which, in turn, serves to further encapsulate the occupants and reduces the effectiveness of emergency warning devices. Not all technological improvements are necessarily beneficial for emergency responders (International Association of Fire Chiefs [IAFC], 2011).

There are two areas of concern that will be addressed in this research project that possibly involve the same solution. The first involves the concept of reducing emergency response times;

the second involves reducing risk to first responders and the public as it relates to accidents involving or that are caused by emergency vehicles responding to calls.

One metric frequently utilized to measure the quality of service in the fire service employs the concept of response times. The National Fire Protection Association (NFPA) and the Commission of Fire Accreditation International (CFAI) both publish standards related to emergency response times. Additionally, fire agencies place fire stations in strategic locations to both minimize response times and maximize the effective population served by those fire stations. The current economic environment, along with prudent governmental business practices; dictate that the most efficient model for service delivery always is at the forefront of the decision makers minds. Accordingly, if tools or technologies become available that could favorably impact response times, it is appropriate for agencies to fully evaluate the efficiencies and cost benefits of such.

Community and first responder risk is harder to quantify and measure as compared to the more easily measured response time metric, yet the value associated with reducing risk could potentially exceed the value of reducing response time. Appropriate weight and consideration should be given to areas where risk to either party can be minimized or mitigated. In its history, the District has had one accident with an emergency vehicle that resulted in a death. In the case of this fatality, the emergency vehicle was not responding to an emergency, but was traveling on an administrative task when the accident occurred. The civilian driver was found to be at fault. Other fire departments within the county have experienced a higher incidence of fatalities involving fire apparatus. There have been a number of accidents, both with and without injuries, where emergency vehicles were involved. While the District's accident history is not unusually high, it could be one accident away from a significant problem. What is truly difficult to measure are the number of near misses that, should a single variable change, could result in significant injury or death and financial liability.

This research supports the content of the NFA's Executive Analysis of Community Risk Reduction course in that it assesses community risk and offers solutions for local risk reduction. Furthermore, it supports the U.S. Fire Administration's operational objective of reducing risk at the local level through prevention and mitigation.

Literature Review

The National Fire Academy's Executive Fire Officer Program encourages leaders in the fire service to also be leaders of change. The fire service has a reputation for being resistive to change, however, that resistance can be overcome with sound reasoning and ample ammunition to support that reasoning. Fire service leaders may be willing to implement change within their respective agencies, though true innovation is infrequent when it comes to change. More often than not, someone has already at least experimented or conducted research in the area of interest. That is the primary purpose of this section. The review of relevant literature provides both the researcher and the users of the data with some level of assurance that professional policy makers and first responders offer some level of support for the recommendations contained herein.

A number of areas need to be addressed before any proposal can move forward. The review of the available literature has been divided into sections that need individual consideration as critical elements to push change forward. The risks and risk reduction section is the core component to this research. It provides a comprehensive look at the available literature as it relates to the risks associated with emergency response and signalized intersections. Identifying and prioritizing intersections provides a review of the available work so that if limited resources are to be allocated to the implementation of emergency vehicle preemption at selected intersections, an appropriate prioritization methodology can be established and risk reduction and associated benefits maximized. The wake-effect is researched and reviewed so that decision-makers can weigh and consider the potential benefit from mitigating a risk that is not typically measured in the risk management industry.

The current economic condition in the United States presents the fire service with some difficult challenges. One such challenge involves providing adequate service in a climate of diminishing resources. As urban streets become more congested emergency vehicles are faced with the test of safely navigating these thoroughfares while still responding in a timely manner. One approach to addressing this problem is the installation of emergency vehicle preemption (EVP) equipment at signalized intersections. This technology, which is now being activated through the use of global positioning system (GPS) devices, triggers a special green interval to the emergency vehicle approach while providing a red signal to conflicting approaches. This concept is by no means new. The U.S. Department of Transportation, in a cross-cutting study, recognized the long-standing idea behind providing relief for emergency vehicles at intersections:

> The concepts of EVP and the potential benefit of preemption control to support emergency response are nearly as old as the traffic signal itself. In 1929, the American Engineering Council published *Street Traffic Signs, Signals, and Markings*, 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." (U.S. Department of Transportation Federal Highway Administration [USDOT FHWA], 2006, p. 2-1).

The Risks and Risk Reduction

The ability to Quantify the existence of a particular risk exists is critical. Without appropriate and concise identification, mitigation is difficult. Sufficient literature and with substantiating data and statistics is available to quantify at least a portion of the identifiable risk. In a white paper prepared for the IAFC it was reported:

> Crashes involving emergency vehicles during emergency service are a significant problem. The United States Fire Administration reports that approximately 7% of all firefighter injuries occur during crashes of vehicles responding to or returning from emergency scenes. In addition, over 200 people are killed each year and thousands are injured in crashes involving all emergency vehicles: fire, police and EMS. Most, if not all, of these crashes could have been avoided.
>
> According to the National Highway Traffic Safety Administration (NHTSA), between 2004 and 2009 an estimated 94,000 people were injured in motor vehicle traffic crashes involving an emergency vehicle. This is an average of nearly 16,000 people a year being injured in crashes involving law enforcement, EMS and fire emergency vehicles. That's nearly 44 people a day that are being injured in these crashes. To put the scope of this injury problem into perspective, the Centers for Disease Control (CDC) reports that in 2009 home fires injured 13,050 people in the United States. In short, more Americans are injured from traffic crashes involving emergency vehicles than are injured by home fires (IAFC, 2011, p. 2).

The IAFC's findings that there are quantifiable risks associated with emergency response are plain. The specific risks associated with this research project are further clarified by Vrachnou, who, in a 2003 report states that intersections were found to be the most common location for crashes involving fire apparatus. In urban areas it was determined that up to 80 percent of accidents occurred at intersections (Vrachnou, 2003). Data from the U.S. Department of Transportation shows that in 2006, of the 42,462 traffic fatalities in the United States, 21 percent occurred at intersections ("Intersection Fatality Comparison," n.d.). The data appears to support the assumption that risk to the community and first responders is present when considering response of emergency vehicles, especially at intersections.

The St. Paul, Minnesota Fire Department found success in reducing risk after conducting one of the most comprehensive studies on EVP and emergency vehicle crash rates available. In 1969, the City of St. Paul implemented EVP at 28 signalized intersections. This was done in an effort to reduce the number of emergency vehicles crashes they were experiencing. Over the course of the eight years, the city equipped 93 percent of its 308 intersections with EVP devices. In 1977, the City performed a thorough analysis of the results of their multi-year EVP installation plan. They found that accidents were reduced from a high of eight crashes in 1967, a pre-EVP year, to an average of 3.3 crashes per year. The reduction became more notable in the later years of the study as more EVP devices were installed at signalized intersections. The fire chief observed that the dramatic reduction was directly due to the elimination of conflicting traffic at intersections where EVP was present (USDOT FHWA, 2006).

At the request of a new fire chief, risk managers from the city of Plano, Texas evaluated 22 emergency vehicle crashes that occurred during a three year period. Seven of those crashes occurred at signalized intersections. This review and the previous experience of the new fire chief with EVP systems led the city to install EVP systems at every signalized intersection over the course of four years. A review of the emergency vehicle crash statistics over a 20 year post-

EVP installation period revealed that only four crashes have occurred, three of which were the result of the civilian driver running a red light (USDOT FHWA, 2006).

The results in the above referenced examples are compelling in the area of risk reduction to first responders and the community, and they are statistically significant.

The risks to the community are not limited only to vehicle accidents as a result of emergency vehicle responses. There are risks associated with the slower response times either caused or exacerbated by intersection delays.

Response times are a generally accepted metric for measuring performance in the fire service. With medical responses, there has been much discussion on the value of an expedited response, however, even those who suggest that a red lights and siren response is not necessary in the majority of circumstances recognize, that in at least ten percent of medical emergencies, a timely response and intervention is critical. Indications are that response time is a more appropriate measurement when considering a fire response (Lorenzen, 2010). The fire propagation curve indicates that 8 minutes after ignition, a structure fire will extend beyond its room of origin. While the 8 minute standard is not necessarily of value in the majority EMS emergencies, the standard is particularly applicable in a fire situation where the problem is compounding over time. NFPA identifies that the two most important elements in limiting fire spread are the prompt arrival of adequate personnel and equipment for the attack and extinguishment of the fire (National Fire Protection Association [NFPA], 2004).

EVP systems serve to accomplish two goals: the reduction of risk and the reduction of response times. In a study comparing responses times before and after EVP implementation, the County of Fairfax, Virginia found that signalized intersections, controlled with an EVP device, resulted in savings of 30-45 seconds per intersection. In the same report, the city of Plano found that their response times decreased in the range of 10-20 percent after the installation of EVP (USDOT FHWA, 2006). Other jurisdictions have seen significant improvements in response time as a result of EVP. Denver, Colorado reported emergency vehicle response time decreases of 14-23 percent; Addison, Texas asserted a 50 percent decrease in response time; and Houston, Texas indicated an average improvement in travel time of 16-23 percent (Collura, Rahka, & Gifford, 2006). In contrast, not all jurisdictions reported marked improvements in response time as referenced above. The Township of Grosse Ile, Michigan conducted a study and found a nominal time savings of just 1.05 seconds per intersection (Wayne State University Transportation Research Group, 2009). The literature from the leading vendor of EVP systems, Opticom, suggests that time savings on the average of 20 percent are realized from the installation of such a system at all signalized intersections (Global Traffic Technologies [GTT] website, n.d.).

Identifying and Prioritizing Intersections

"Across all emergency disciplines the most likely place to be involved in a collision with another vehicle is intersections. This is because intersections are the most likely location for the emergency vehicle to come into contact with other vehicles that are directly in their path of travel." (IAFF, 2010, p. 39).

The reasonable person would arrive at the logical conclusion that intersections are dangerous. However, are they all equally unsafe? This primary question must first be answered when prioritizing intersections for the purpose installing EVP systems. In the case of this project, competing goals are under consideration. First, is the goal of reducing emergency response times and second is the goal of reducing risk to both first responders and the community. On the surface it may appear that achieving the goal of reducing response times via traffic preemption devices will also achieve the goal of reducing risk by eliminating at least a portion of accidents at intersections. The problem is that a list of intersections that cause the greatest delays to emergency responders may or may not be reflective of a list of the most dangerous intersections in a given area. Additionally, those intersections that might be considered dangerous based on the number of crashes may not be controlled (with either signals or stops signs) intersections. This leads to one of the limitations in the literature review. EVP devices can only be installed at signalized intersections. Uncontrolled intersections will not be affected by the installation or use of a preemption device and, accordingly, are excluded from consideration as it relates to prioritization. The purpose of this research was not to identify intersections in need of some form of control. That specific aspect will be left to traffic engineers in the responsible jurisdiction. The simple solution would be to add EVP to all signalized intersections, however, with current budget constraints; such a solution would not likely be feasible. Therefore, it is critical to balance the needs of both goals when determining a prioritization system for the installation of EVP systems to signalized intersections.

The method in which jurisdictions prioritize and outfit signalized intersections varies from area to area. Some have equipped only select intersections in an effort to provide safe and efficient arterial access to emergency vehicles located on side streets. Many other jurisdictions have addressed this problem by introducing preemption devices on arterial access streets and at known problem intersections. Some jurisdictions have adopted a policy of providing coverage via preemption devices at 100 percent of their signalized intersections. Fairfax County, Virginia, took a phased approach in their prioritization of intersections, beginning first with installation of EVPs on signals that provide access to arterial streets from fire stations located on side streets. After the impacts to traffic flows were analyzed and determined to be minimal, they moved to the installation of EVPs on those intersections identified as problems, reviewing each intersection independently. Finally, a small number of intersections located downstream from the intersections identified in the first step above were outfitted with EVP (U.S. Department of Transportation Federal Highway Administration [USDOT FHWA], 2006).

The U.S. Department of Transportation Federal Highway Administration (FHWA) states that, traditionally, the commonly used measure for determining intersection safety is crash history (Do, Carter, Zegeer, & Hunter, 2008). A variety of other methods are also utilized to help in prioritizing the needs of a particular intersection. The Virginia Tech Transportation Institute recommends that intersections be evaluated based on intersection spacing; frequency and duration of preemption; and intersection saturation. Additionally, the Institute recommends using video and field observations to determine crash potential and emergency vehicle response time delay potential (Collura et al., 2006). This is accomplished utilizing Conflict Point Analysis, an analytical approach used by the traffic engineering and safety communities to determine the likelihood that accidents may occur.

The Federal Highway Safety Administration suggests than intersection prioritization take into consideration the following: long delays, queue spillback, poor progression, inefficient signal timing, crash frequency and severity, poor visibility on approach, and high vehicle speed (USDOT FHWA, 2006). General intersection design and dimensions are appropriate considerations when prioritizing for preemption devices. The pure nature of the design and space limitation may cause significant problems for emergency vehicles attempting to pass through an intersection in conflict with the signal. The presence of a center median, narrow shoulders, multiple lanes and significant pedestrian use all point to the need for some sort of intervention system to ensure the safe and timely passage of emergency vehicles.

The Wake-Effect

Much has been written about the risks associated with driving emergency vehicles with lights and sirens to the scene of an emergency. Throughout the research, statistics have been quoted and referenced that discuss the accident rates involving emergency vehicles. However, a relevant point still needing to be addressed deals with the impact that emergency vehicles have on those vehicles that are operating in close proximity to their location when they are responding code to an emergency. Many studies have been conducted on the frequency of emergency vehicle collisions, but there is limited research and information available regarding the increased potential of vehicle accidents and injuries that occur as the result of a code response, yet do not directly involve the responding emergency vehicle. This concept is frequently referred to as the wake-effect. It is appropriately named after the wave that is created by a boat or ship that often wreaks havoc after it has passed. In this case it refers to accidents that are caused by other driver's unsafe reactions to the either the sight or sound of an approaching emergency vehicle. It is quite possible that the costs, in both life and property; associated with wake-effect accidents could be significantly more than those directly involving responding emergency vehicles (IAFC, 2011).

A number of medical professionals have researched the risks associated with the wake-effect. They note that a lights and sirens response can often impact vehicles in the vicinity, causing cars to be forced to move in and out of traffic, further increasing the risk of accidents. As of 1997, this wake-effect theory had never been formally studied, but it has been estimated that a code response results in civilian vehicle collisions in a 5:1 ratio when compared with emergency vehicle accidents (Lacher & Bausher, 1997). In a medical directive to emergency responders, Dr. Jeff Beeson stated that the National Highway Transportation and Safety Administration has conducted studies that have shown that the frequency of wake-effect crashes exceeds emergency vehicles crashes by a ratio of 3:1 (Beeson, 2010). As a result of these statistics, Dr. Beeson's direction was to reduce certain responses to "no code" to minimize the impacts from wake-effect collisions.

It is important that this concept be adequately considered when attempting to reduce risk to the community as a result of emergency vehicle responses. In one study researchers hypothesized that emergency responders would report that wake-effect collisions do occur and that they occur more frequently than do emergency medical vehicle collisions (Clawson, Martin, Cady, & Maio, 1997). Though the small population size in their study created some limitations, Clawson et al, discovered that their hypothesis was likely accurate and that wake effect collisions were five times more likely to occur than collisions involving the emergency vehicle. Regardless of the specific accuracy of the Clawson study, there should be little surprise at the outcome of their research. Certain reactions occur when drivers of private vehicles, who are unprepared for an approaching emergency vehicle, are suddenly faced with a vehicle responding with lights and sirens. It should not be a revelation that the rate of accidents, in the study, is higher for the public than drivers of emergency vehicles who are prepared and who operate at a heightened state of awareness. Having the ability to clear intersections in advance of approaching emergency vehicles should serve to minimize wake-effect collisions.

Procedures

Implementing solutions to problems that have not been identified, verified or validated is not prudent. Suggesting solutions that have not been tested or validated also falls within the lines of imprudence. The District had a perceived problem related to the safety and efficiency of emergency responses. This research was conducted to identify the problem and suggest a solution for a possible change in policy and direction.

A broad review of the available literature was initiated in April 2011 at the Learning Resource Center of the National Fire Academy in Emmitsburg, Maryland. The initial searches included keywords such as: preemption, intersection, and wake-effect. The principal goal during this initial research was to compile information that was not readily available over the internet.

Additional research was conducted between April 2011 and October 2011 utilizing resources available in the Ventura County Fire Protection District's internal resource libraries. Internet searches were conducted using Google and Google Scholar utilizing keywords including: emergency vehicle preemption, traffic preemption, prioritizing dangerous intersections, wake effect, Opticom, intersection evaluation and emergency vehicle accident statistics.

The literature review, time study and statistical analysis described below were conducted to answer the following questions: Will response times decrease if a traffic preemption system is employed? How are intersections identified and prioritized for the installation of a preemption device? Can risk be reduced through the use of a traffic preemption system?

To answer the first question related to a decrease in response times, a time study was initiated in two response sectors. An Opticom ™ traffic system was installed in selected intersections and in two apparatus, an engine and a tillered ladder truck, assigned to different fire stations. Response times were measured and analyzed pre and post system installation. The measurement periods were both six months in length. The purpose of this time study was to determine whether there would be a statistically significant decrease in response time. The results of the study were compiled in a written report (Marino, 2011).

The study was designed to determine if there was any significant difference in response times as well as travel times within two periods: the pre-installation and post-installation periods. The pre-installation period was August 1, 2010, through January 31, 2011, and included incidents that were responded to without the use of the Opticom™ traffic system. The post-installation period covered March 1, 2011, through August 31, 2011, and included only incidents that were responded to with the Opticom™ traffic system installed.

Two District apparatus were selected for the test phase:

-Engine 45 (E45): Out of Station 45, this type of fire engine is the primary response component of an emergency response. This apparatus is a triple-combination pumper and representative of the kind and type of engine currently used by the District. This Type 1 engine is designed for stationary pumping at a water source, normally, a fire hydrant. Staffing levels include 1 Fire Captain, 1 Engineer and 1 Firefighter.

-Ladder Truck 41 (T41): Out of Station 41, the ladder truck performs all of the functions not directly related to extinguishing the fire, but necessary to firefighting operations. This might include, but not be limited to search and rescue, ventilation, salvage and providing to all areas of the structure. Occasionally, based on call volume or District coverage needs, the truck may respond to EMS calls. This ladder truck is representative of the apparatus supplied to the majority of support companies within the District. Staffing levels are comprised of 1 Fire Captain, 1 Engineer, and 2 Firefighters.

Incident data, for the calls analyzed, was retrieved from the District's Computer Aided Dispatch (CAD) system. In order to accurately show the effectiveness, or lack thereof, of the Opticom™ traffic system, incident data was analyzed for incidents designated to be emergency or code incidents only. No data was analyzed for incidents that were labeled as no code responses as the preemption system was only activated when red lights were turned on.

Separate response sectors were determined for each apparatus assigned to the study. Engine 45's sector was identified by the following geographical description (Figure 1):

South of the 118 Freeway

West of Erringer Road

North of Los Angeles Avenue

East of First Street

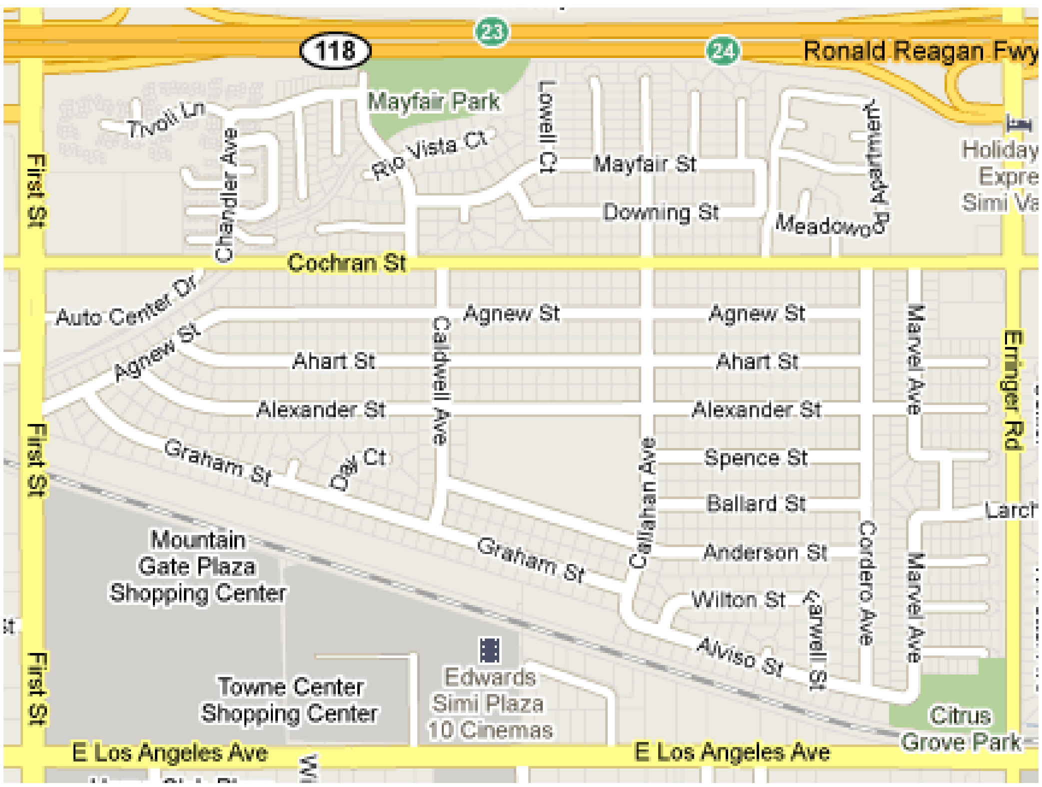

Figure 1: Engine 45 study sector

Truck 41's sector was identified by the following geographical description (Figure 2):

South of the 118 Freeway

West of Erringer Road.

North of Royal Avenue

East of Madera Road

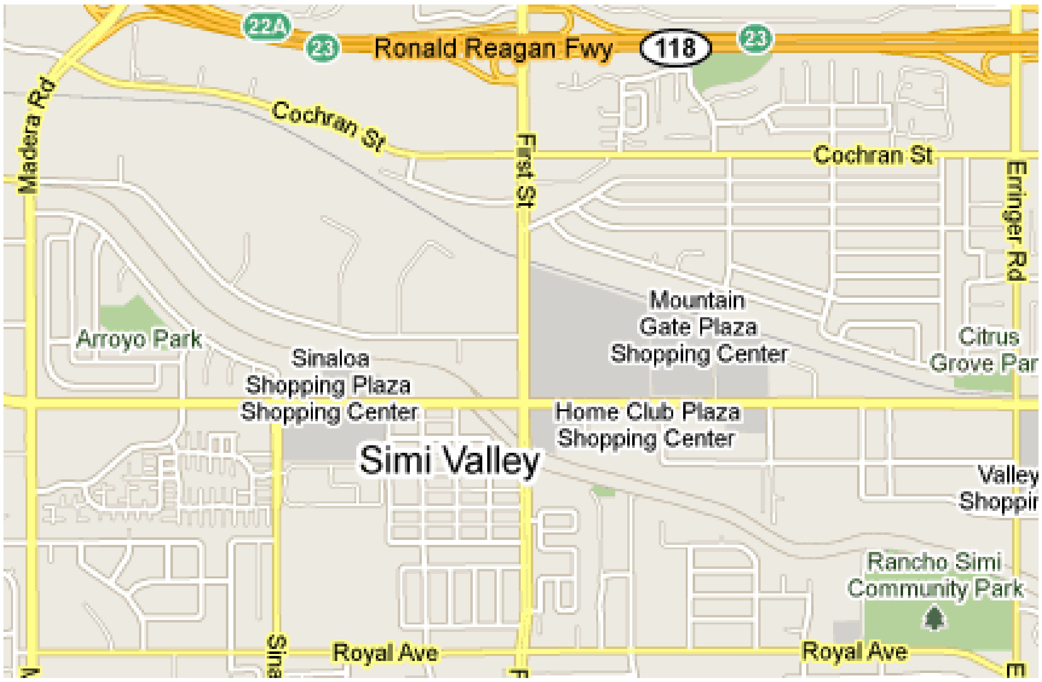

Figure 2: Truck 41 study sector

All Incident data for the specified study periods and testing apparatus was retrieved from the CAD system using Microsoft Query SQL application. An analysis of the data was then conducted utilizing District subject matter experts. To determine whether the results were statistically significant, they were subjected to a two-tailed unpaired t-test with a 95 percent confidence interval. Relevant data was analyzed utilizing Microsoft Office Excel SP3, ©1985-2003 by Microsoft Corporation. The results of this analysis are presented in the tables below.

Data clean-up and organization was performed in order to identify the appropriate variables required for analysis. Data was then sent to the District's Geographic Information

Systems (GIS) unit. Using the specified latitude and longitude coordinates for each incident; GIS intersected the coordinates and identified those incidents which only occurred within the specified study area. Tables 1 and 2 below summarize the number of data points identified.

The study did have some very specific limitations that became apparent during the analysis of the data. The sample size used in comparing data was relatively small in comparison to the total number of calls responded to by the District on an annual basis. With the inadequate sample size (*N*), the outliers, noted in Figures 3 and 4 in the results section, likely skewed the results. Ultimately, another variable besides EVP installation came into play: travel distance. Call location could not be controlled, and accordingly, response and travel time varied with travel distance. It is anticipated that, with a larger sample size, the variations in travel distance would become less significant and have a smaller impact on the outcome of the study.

A portion of the first research question and then the remaining two questions were addressed by a comprehensive and thorough evaluation of the available literature. A number of sources were accessed via the internet and the NFA’s Learning Resource Center and are referenced and discussed in the literature review section.

Results

The results of the analysis of the data collected during the response time study are included below in Tables 1-6 and Figures 3 and 4. For the purposes of this study, travel time is defined as the elapsed time from when an apparatus goes en route to the point when they arrive on scene. These time stamps are created through the use of mobile computers and require the operator to press a button for the start and end points. Travel time has been determined to be the best measure for this study since it eliminates the variables associated with dispatch and turnout times, which, when combined with travel time, comprise response time.

Tables 1 and 2 below represent the sample used in analyzing the data. As noted in the procedures and discussion sections, the sample size that was used in comparing pre and post installation data was determined to be inadequate to get a realistic measurement of the effects of system installation.

	Pre-Installation	Post-Installation
Number of responses	841	719
Responses within sector	133	102
Responses within sector arrived*	129	99

*Data used in analysis

Table 1: Engine 45 data collection summary

	Pre-Installation	Post-Installation
Number of responses	456	445
Responses within sector	55	52
Responses within sector arrived*	46	47

*Data used in analysis

Table 2: Truck 41 data collection summary

Tables 3 and 4 below display the results of the data analysis for both pre and post installation periods for Engine 45. Table 3 represents data for the travel time component, while Table 4 presents the data for overall response time. The median travel time is the statistic given primary consideration in reviewing the results of the study. The average is generally disregarded as it can be significantly affected by outliers producing results that are typically skewed towards the higher range. In the case of Engine 45's travel and response times, the study showed a 1 second increase and no change respectively in the median time for the pre and post installation periods. This indicates that the addition of EVP in the study area did not have a statistically significant impact on any of the measurements and does not support a finding that the installation and use of EVP reduces response and travel time.

	Pre-Installation	Post-Installation
N	129	99
Average	03:47	04:05
Median	03:33	03:34
Standard deviation	01:41	03:04
Coefficient of variance	44.5%	75.2%
90th percentile	05:25	05:34
Range	01:14 – 14:57	00:06 – 22:45
Confidence interval	03:30 – 04:04	03:28 – 04:41

Table 3: Engine 45 travel time

	Pre-Installation	Post-Installation
N	129	99
Average	05:03	05:17
Median	04:45	04:45
Standard deviation	01:48	03:08
Coefficient of variance	35.4%	59.3%
90th percentile	06:42	06:38
Range	01:45 – 16:11	01:09 – 24:05
Confidence interval	04:45 – 05:22	04:40 – 05:54

Table 4: Engine 45 response time

Tables 5 and 6 below display the results of the data analysis for both pre and post installation periods for Truck 41. Table 5 represents data for the travel time component, while Table 6 presents the data for overall response time. As discussed previously, the median travel time is the statistic given primary consideration in reviewing the results of the study. In the case of Truck 41's travel and response times, the study showed a 2 second decrease and 38 second decrease respectively in the median time for the pre and post installation periods. The 2 second decrease is the statistic given greater consideration, as the 38 second decrease introduces other variables, such as turnout time. The fact that the *N* in this study was a relatively small 47 also indicates that the median or mid-point data might be easily skewed. The results indicate that adding EVP in the study area did not have a statistically significant impact on any of the measurements and does not support a finding that the installation and use of EVP reduces response and travel time.

	Pre-Installation	Post-Installation
N	46	47
Average	04:12	04:17
Median	03:56	03:54
Standard deviation	02:47	02:53
Coefficient of variance	66.1%	67.1%
90th percentile	05:23	05:31
Range	00:07 – 20:21	01:37 – 16:36
Confidence interval	03:24 – 05:01	03:28 – 05:07

Table 5: Truck 41 travel time

	Pre-Installation	Post-Installation
N	46	47
Average	05:14	05:09
Median	05:02	04:24
Standard deviation	03:00	02:59
Coefficient of variance	57.5%	57.8%
90th percentile	06:37	06:50
Range	00:07 – 21:49	01:56 – 17:57
Confidence interval	04:22 – 06:06	04:18 – 05:59

Table 6: Truck 41 response time

The graphical information presented in Figures 3 and 4 below is a representation of data using a typical box and whisker plot. The center box represents the 25th, 50th (median), and 75th percentiles. The ends of the whisker are set at 1.5 times the Inter Quartile Range (IQR) above the 75th percentile and 1.5 times the IQR below the 25th percentile. Values outside of this range are typically considered outliers. The normal convention for box plots is to show all the outliers, but for simplification, only the min and max outliers are shown. This information is presented in support of the study limitations related to sample size and the impact the outliers had on the outcome of the study.

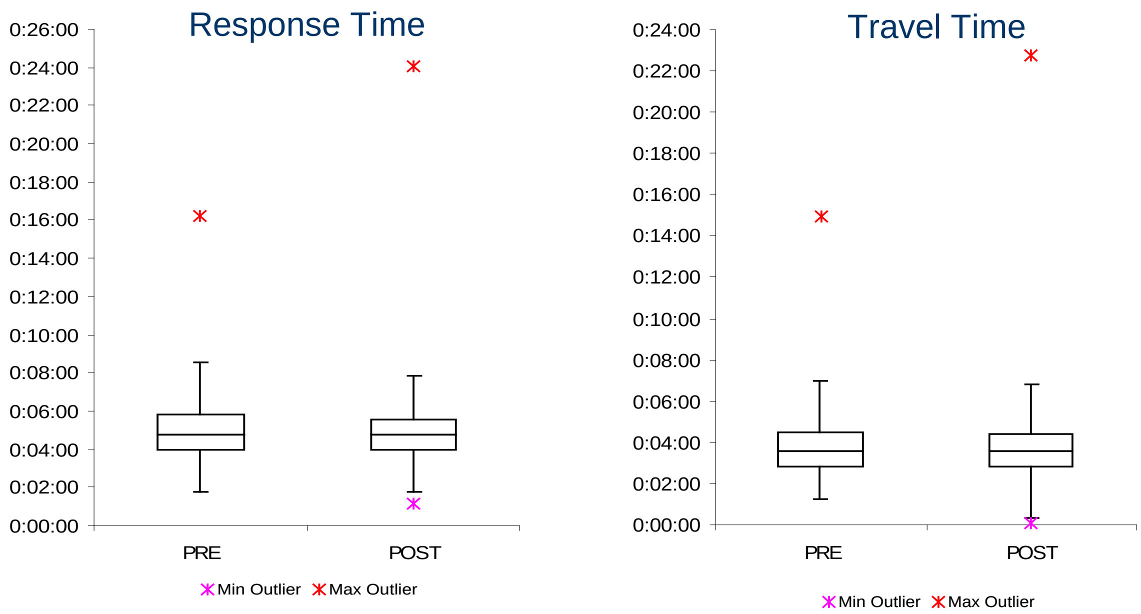

Figure 3: E45 outlier comparison

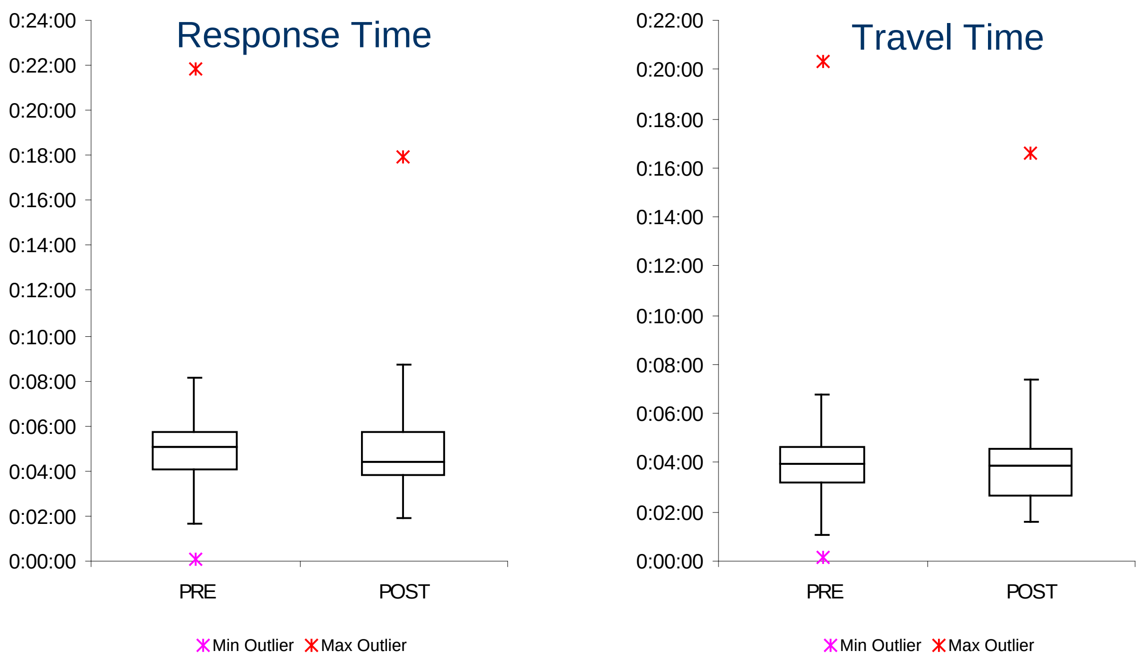

Figure 4: T41 outlier comparison

The time study provided limited data for to answer a portion of one of the research questions. A significant portion of the information, data and statistics supporting this research project was derived from the breadth of the available literature. A comprehensive evaluation of this information and the statistics was thoroughly documented in the literature review section.

The results of the literature review strongly suggest, that, in spite of the time study conducted in conjunction with this paper, the installation of preemption systems will result in a reduction of overall response and travel time. The research overwhelmingly points to the fact that risks, to both the community and first responders, will be reduced after the implementation of EVP at signalized intersections. This reduction in risk can be measured by the reduction in accidents and injuries occurring at intersections controlled by preemption devices.

Discussion

The desire for continuous organizational improvement is critical to the success and sustainability of the District. Areas in which the District can be more efficient or provide a higher level of service with its current resource configuration need to be continually explored. With this study, the objective was to find ways in which the District could reduce risk to the community and to improve service in the form of reduced emergency response times.

The time study conducted in two distinct response areas of the District to measure potential improvement in response times resulted in data that showed that the change in response time was not statistically significant. With Engine 45, the median travel time increased by one second and with Truck 41, the median travel time showed a two second decrease. The limitations noted in the procedures section are likely the cause behind the failure of the data to show a reduction in travel times. Ultimately, the EVP installation was not the only variable. A significant variable that was not considered in the design of the study dealt with the variability of travel distance. The ability to control call location is outside of the control of both this study and the District.

Understanding that the District lacks the capacity to control where calls for assistance originate will help in the design of future studies of a similar nature. Recognizing this limitation will cause future studies to incorporate either a measurement period that is sufficient to establish a large enough sample size (*N*) or identify a larger number of apparatus to participate in the study again with the result being a larger *N*. Outliers tend to skew results when sample sizes are small. In this study, sample sizes of approximately 100 and 50 respectively were used, which are exceptionally small when compared to the approximately 40,000 calls the District responds to annually. A larger sample size would likely have created a smoothing effect and the outliers may not have had as large an impact on the outcome of the study.

On the surface, the results of the study appear to contradict the results of the research as it relates to reducing response time through the use of preemption devices. A review of the literature points to more than just a preponderance of supporting data to sustain the opinion that the installation of EVP will result in a reduction in response time that is statistically significant. The District's response time study, along with its noted limitations, should be compared to the breadth of information and data that is available in regards to the efficacy of preemption devices at controlled intersections. The number of jurisdictions that have reported significant reductions in response times as a result of implementation of EVP and the underlying abundance of data should cause a reasonable person to apply greater weight and consideration to the available literature.

The question was posed as to whether the implementation of EVP would reduce response times. The District's time study indicates that EVP would have little impact, if any, on response times. The review of the literature suggests that implementation of EVP could reduce response times in the range of 10-20 percent (GTT, n.d.). Based a review of the study limitations and the wealth of data and literature in support of response time reductions as a result of EVP installation, preemption devices should be considered as part of a viable solution in the reduction of response times. Significant evidence was presented that EVP installation will, in fact, reduce response times.

Can risk be reduced through the use of a traffic preemption system? No accidents occurred in the two study areas either pre or post EVP installation. The study of accidents rates was not a primary purpose during the District's response time study, nor was the study period of sufficient length or comprehensive enough to provide the user with adequate information to evaluate any sort of change in accident rates. Observations were made by the personnel on both apparatus that participated in the study. Personnel consistently reported that they had a general feeling that both first responders and the public were safer approaching EVP controlled intersections during emergency responses as they were easily cleared of traffic. Clawson, in his research in 1997, utilized a comparable method of personal observation and came to a similar conclusion. Clawson's study verified the presence of a hazard known as the wake-effect. Those personnel that participated in the District's study commented on the positive impact they perceived that EVP had on the wake-effect. The concept of wake-effect vehicle accidents typically applies to all vehicle accidents that occur while vehicles are attempting to move out of an emergency vehicle's path. It is important to note that installation of EVP will not mitigate the majority of wake-effect accidents that do not occur near or around intersections. This is a result of the fact that traffic preemption systems are designed to function at signalized intersections and, accordingly, have little impact on roadway sections not in close proximity to an intersection.

The literature reviewed strongly supported the assertion that risk to the community and first responders was reduced as a result of EVP implementation (USDOT FHWA, 2006). Jurisdictions consistently found statistically significant decreases in crashes involving emergency vehicles.

Virtually every jurisdiction is challenged by the current fiscal and economic environment. Accordingly, it is not always feasible to provide EVP coverage to 100 percent of signalized intersections. When faced with this situation, it is critical for the decision-makers to appropriately prioritize intersections so that those that provide the greatest risk to the community and cause the greatest delays in response time, are addressed first. These priorities should be based on recommendations by the USDOT FHWA to consider long delays, inefficient signal timing, crash frequency and severity, poor visibility on approach, and high vehicle speed as well as video and field observations to determine both conflict frequency and crash potential (Collura et al., 2006).

In spite of the results of the District's internal response time study, the overall results of the research are clear. Implementation of EVP at signalized intersections will provide value and benefit to first responders and the community. These benefits will come in the form of reduced liability exposure and increased safety for emergency responders and the public; improved public safety in the form of reduced response times; and more efficient use of public resources as decision-makers can increase the capacity for coverage of an area by a single response unit (GTT, n.d.). The implications to the District and other uses of the concept could be significant. It is anticipated that EVP implementation will increase the ability for fire apparatus to pass easily through intersections resulting in significant time savings. The District expects that its resources will be able to cover larger areas while still meeting its internal benchmarks for response time.

While the District's accident rate has been low, it is expected that EVP will create an even lower accident experience rate and reduce the District's exposure to liability. A reduction in crash rates will also result in fewer injuries and financial damages to both the public and our personnel (USDOT FHWA, 2006).

Recommendations

The community has very high expectations of those who have been tasked with the stewardship of their safety and the prudent use of the valuable resources to which they have access. Emergency vehicle preemption is a viable solution that addresses a number of concerns of the taxpaying public and first responders while still meeting the fiduciary role that is expected of governmental leaders. It maximizes the efficient use of resources by reducing response times and it quantifiably reduces risk to all parties. Implementation of an EVP system is recommended.

Implementing an EVP system within a special district is a complex issue and deserving of a well planned approach. Once the decision to move forward has been reached, it is critical to determine the stakeholders that will be affected by EVP implementation. Successful EVP implementation will require a wide-ranging stakeholder group and will need to include city, county and state agencies. Especially important in the formation of a single group of stakeholders is the need to identify a single EVP platform that all agencies can support (USDOT FHWA, 2006). This is critical so that the system can be accessed by all responding apparatus. Multiple systems can either cause interoperability problems or require additional expense to ensure cross-compatibility. This stakeholder group must also be an integral part of the process in the prioritization of intersections for implementation. A common methodology for prioritization must be consistently applied across jurisdictional boundaries. It is also important that the stakeholder group identify a champion who will organize the group in a holistic effort to support the implementation.

Training is vital for those that will access the system. Standard operating procedures should be documented and all personnel should be adequately trained. It is of the utmost importance for the users of EVP to understand that a green light is not guaranteed. Apparatus operators must still ensure that caution is their primary mindset as they approach EVP controlled intersections and that they should never over-rely on the system.

Inform the public. Use the opportunity with this new program to inform and share with the public that public safety agencies are continuously seeking ways to make their services more effective and efficient. The public's acceptance of the program will come much more easily if the concept is introduced to them and explained prior to implementation. Ensure that additional outreach occurs in those areas most affected by the new system.

Finally, measure the outcomes. This is frequently one of the most overlooked aspects when implementing a new system. Measurement gives the user feedback. Compare expected outcomes with actual results and research any unexpected discrepancies and results. Regardless of the conclusion, publish the data and information so that those in a similar position can learn and replicate your success.

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