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Executive Development

Analysis of Emergency Vehicle Preemption for EMS in Wake County

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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 writing of another.

Signed: ____

Abstract

The Wake County EMS System is experiencing extended response times due to delays caused by traffic congestion, especially at intersections, where safe navigation is difficult. The purpose of this research is to evaluate whether the implementation of emergency vehicle preemption would effectively serve to address this problem. Research was conducted to evaluate the various preemption methodologies available, what costs were associated with adopting the technologies, what strategies were used for engineering their implementation, and a statistical analysis completed of response time performance of the Cary, NC EMS agency after implementation of emergency vehicle preemption in their community to validate the findings of other published studies.

The results indicated that there is a clear nexus to improving response performance and safety through the implementation of emergency vehicle preemption. The author recommended that Wake County pursue the implementation of an optical emergency vehicle preemption project. This recommendation will require the cooperation of the City of Raleigh since the majority of the traffic light controlled intersections in the County are within that jurisdiction.

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Introduction

Responding to emergency calls while using lights and sirens is one of the highest risk procedures for Emergency Medical Service (EMS) personnel operating in the urban environment. Research by Maguire, Hunting, Smith, and Levick (2002) has identified ambulance crashes as the primary cause of death for on-duty EMS personnel (p. 630). As urban and suburban, the resulting traffic congestion will only intensify this problem. EMS systems have to look for existing and emerging technologies to ensure that resources can respond to emergencies in a timely manner while regarding the safety not only of responders, but also of the general public.

The problem is that as Wake County becomes more densely populated, EMS response times are increasing as a result of delays due to traffic congestion, especially at intersections, where safe navigation is becoming more difficult. The purpose of this Applied Research Project (ARP) is to evaluate whether the implementation of a traffic signal preemption system, commonly referred to as Emergency Vehicle Preemption (EVP), has improved EMS response times and resulted in safer operations in like jurisdictions, culminating in a recommendation for Wake County.

This ARP will use the evaluative research methodology to present a review of the different approaches in place today for performing EVP, including the associated costs with such systems. The research will also include an analysis of an agency's actual experience, through performance data review and personnel interview, after the implementation of EVP within their jurisdiction. The research will serve to answer the following questions:

(1) In like size jurisdictions, how has the installation of traffic preemption devices impacted response times and responder safety?

(2) What are traffic preemption devices and how do the different types of devices work?

(3) What start up costs are involved with implementing a traffic preemption system?

(4) What on-going costs are involved with a traffic preemption system?

(5) What methodology is used for the prioritization of intersections in jurisdictions?

Based upon the conclusions of the analysis, this project will recommend a direction for Wake County in regards to the implementation of traffic preemption for emergency vehicles.

Background and Significance

Wake County, comprising 851 square miles in the Piedmont section of North Carolina, is home to the state capitol in Raleigh. According to the Wake County Planning Department website, the estimated March 2008 population was 868,121 residents. This statistic indicates that the County has grown over 32% during the last eight years (Wake County Planning Department, 2008). Wake County also includes the municipalities of Apex, Cary, Fuquay-Varina, Garner, Holly Springs, Knightdale, Morrisville, Rolesville, Wake Forest, Wendell and Zebulon.

The Wake County EMS system is comprised of six agencies providing paramedic-level prehospital care and transport for 911 medical emergencies countywide. As the population of the county has increased in recent years, so have the demands on the

EMS system. During the same time period that the population of the County increased by 32%, call volume for EMS increased just over 50%. In January 2008, the EMS system upgraded from a station-based unit recommendation dispatch system to the use of a global positioning system (GPS) based recommendations in order to ensure the geographically closest available EMS resource is sent on a call. Each ambulance is equipped with a GPS receiver interconnected to an on-board laptop computer networked into the computer aided dispatch (CAD) system at the dispatch center.

Recent advancements in the EMS system towards enhancing response times have yielded positive results, however combating traffic congestion remains a significant issue. A side effect of the new technology is that EMS units are now responding through unfamiliar intersections and traffic patterns, therefore the potential for ambulance-involved collisions is heightened. The Wake County EMS system Medical Director, Dr. Brent Myers, has adopted as the as the mission statement of the system an adaptation of a quote from General Dwight D. Eisenhower. Dr Myers says that we will make patient care our “single overriding objective, and make all other considerations bend to that one objective” (Jonathan B. Myers, Personal Communication, April 9, 2008). In order to accomplish this, it is of utmost importance that EMS responders expeditiously and safely arrive at the scenes of emergencies. Employee education using curriculums such as Emergency Vehicle Operator, provided by the National Safety Council, are beneficial, but they fail to adequately meet the challenges faced in the streets. A modern, efficient EMS system must evaluate and take full advantage of all available technology to ensure that the “single overriding objective” is fulfilled.

On January 2, 2007 at 6:13 in the morning, Wake County EMS 5 was dispatched for a subject reported to be in cardiac arrest. The route to the call would take them across Capital Boulevard, a major north/south artery in the City of Raleigh. Clearing this intersection required them to cross eight lanes of traffic in order to proceed to the call. As the EMS unit attempted to cross against a red signal light, with all required emergency equipment activated, they were involved in a collision with a small sedan. This case illustrates that even when all due care is exhibited by EMS personnel, unexpected dangers can result in unfortunate outcomes. The end result was several people with injuries, two heavily damaged vehicles, and a response time to the initial call of twenty minutes.

The absence of a safe mechanism to for the emergency responders to cross this intersection had a three-fold impact on the community. First of all, such scenarios jeopardize the safety of both the public and of the EMS personnel. As recently as June 2005, motor vehicle crashes were cited as the leading cause of death in the United States for citizens ages 4 through 34 (NHTSA, April 2008, ¶ 1). Add to that statistic the factor of encountering an emergency vehicle attempting to circumvent normal traffic patterns and control measures and safety will be compromised even more. Secondly, incidents such as these have both direct and indirect costs to the community. From the EMS 5 incident, the County was down a fleet asset for a number of weeks due to the vehicle requiring extensive repair. Additional costs were related to missed work and medical care for the involved employees and civilians. In a 2002 study at the University of Alabama-Birmingham, it was estimated that the initial average cost of treating a single trauma patient to be $16,500. This cost is prior to any rehabilitation or follow up medical care (Bassing, 2002, ¶ 4). The potential cost for this single incident could have been exponentially greater had the collision resulted in a fatality. The final impact to the community was that the "single overriding objective" was missed as the delivery of patient care was delayed due to the collision. Looking at the impact this single collision had on the County, one can clearly see the potential dangers that exist in a system answering nearly 70,000 calls per year. It is a danger to the people that the system is in place to serve, as well as to the people serving within the system.

The Executive Development program curriculum at the National Fire Academy (NFA) uses the text *Leadership on the Line* by Martin Linsky and Ronald Heifetz as the basis for introducing a variety of aspects of change and the change management process within organizations. One leadership strategy the authors discuss at length is the determination by a manager if the solution to an issue is by addressing a technical problem or by a more extensive adaptive challenge, often requiring a change to the culture of the organization. Improving safety in emergency vehicle operation is often accomplished by implementing technical solutions. From computer monitoring systems that provide drivers real-time performance feedback to vehicle preemption systems that control traffic lights at intersections, significant progress towards safety can be achieved by addressing the problem from a technical aspect. This is not to eliminate the benefit of an adaptive approach to changing the cultural behavior of those operating vehicles. However, as documented in a study at Metro Emergency Medical Service (MEMS) in Little Rock, Arkansas, the implementation of a technical solution resulted in an adaptive change to a variety of driver behaviors in less than 18 months (Levick & Swanson, n.d.).

The implementation of an EVP system in Wake County would directly serve to improve the safety of all disciplines of public safety, particularly EMS and the fire service. With the objective of enhancing emergency responder safety, this ARP is dedicated to meeting the United States Fire Administration's objective of reducing firefighter fatalities. The outcome of this project will be a comprehensive analysis of EVP systems and a recommendation on their benefit for improving both EMS response times and responder safety in Wake County.

Literature Review

Since the late 1960's, emergency responders have had available the technology to install equipment on vehicles and traffic signals that would allow them to remotely change the lights in favor of the responding units. Many communities have endorsed this technology, making them standard on all new traffic signal installations as well as converting any existing signals. In a 2006 study conducted by the U.S. Department of Transportation Research and Initiative Technology Administration (RTIA), of 106 metropolitan areas surveyed, 98 had implemented some degree of EVP, representing 31,559 traffic signals (U.S. DOT, 2008).

This literature review will analyze prior research into safety and response time benefits achieved by emergency service agencies that have implemented EVP systems in their jurisdictions and discuss the variety technologies and methodologies currently in existence. The implementation of EVP systems is expensive and it is important to the scope of this project that the technology be explained in order to have an appreciation for the investment in the outcome that they can provide. Literature was gathered for this review from the D.H. Hill Library at North Carolina State University, from various journals cataloged by Wake County EMS, and from the Internet.

Although there have been a number of previous studies conducted to assess the value of EVP for reducing response times and improving responder safety, researchers Collura, Rakha, and Gifford (2003) with the Virginia Tech Transportation Institute estimate that more than 90% of the agencies with EVP systems have not conducted an evaluation of their individual systems performance.

One of the most comprehensive reports to date was released by the Department of Transportation's Federal Highway Administration (FHWA) in January 2006. Entitled *Traffic Signal Preemption for Emergency Vehicles – A Cross-Cutting Study: Putting the "First" in "First Response"*, it presented a compilation of data from several jurisdictions, with two recent studies, from Fairfax County, Virginia and Plano, Texas, looking specifically at response time improvements.

The Fairfax County study indicated that, on the 13-mile segment of U.S. Highway 1 where a total of 37 EVP-equipped traffic signals had been installed by 2004, nearly all responses demonstrated savings in time from a few seconds to a few minutes. Data from a particular fire station reported a savings of 30 to 45 seconds at a single, traditionally congested intersection. The Plano, Texas study reported a reduction in response times of 10 to 20 percent which has allowed them to achieve their established 90th percentile response time standard. The Plano study also focused on the reduction of emergency vehicle related crashes. During the two-year period ending in 1983, Plano suffered 22 emergency vehicle crashes. Since the EVP system was initially completed in 1984, the report states that there have been only 4 emergency vehicle crashes at intersections, 3 of which were determined through investigation to have been caused by a failure of the private vehicle to properly stop for the red light displayed in their lane of travel (U.S. DOT, 2006, p. 8-1).

The Houston Metropolitan Transit Authority published a study in April 1991 that evaluated travel times for emergency vehicles in two fire districts before and after a visual preemption system was installed at 22 intersections. Travel times were recorded for certain street segments with and without the use of emergency equipment prior to the EVP system being installed. The researchers then evaluated a year of response time data from different fire districts to evaluate the impact of the operational EVP system on response performance. One fire district reported a decrease in response times of 23 percent while another reported a decrease of 18 percent (Traffic Engineers, 1991, Summary section).

In January 2005, TEC Engineering, Inc. and Wagner-Smith, Inc. completed a study of an audible preemption system installed for Colerain Township, Ohio. The researchers equipped certain emergency vehicles with video equipment in order to document not only the performance data, but to be able to assess the actual impact the EVP system had on traffic conditions, including how other vehicles on the road reacted to the preemption. The video recordings also allowed them to accurately document how long it took emergency vehicles to clear certain intersections before and after the EVP system was operational. Their findings reported a reduction in response times of 22 percent or 15.7 seconds. When they analyzed the data, isolating the rush hour periods of highest traffic volumes, the response times improved by over 30% (TEC Engineering, 2005).

A variety of different methodologies have evolved into technological solutions by which responding emergency vehicles can today preempt traffic signals. These include the use of optical devices that emit infrared or strobe light beams, acoustic systems that recognize standard siren tones, radio frequency (RF) systems that transmit on a specific frequency, and global positioning system based devices that interface with intelligent transportation systems (ITS) to control the lights. Each of these systems have proven effective, however the literature demonstrates that each has advantages and disadvantages.

The optical technology, commonly known by trade names such as “Opticom” from Global Traffic Technologies or Tomar’s “Strobecom”, utilize specialized equipment installed at both the traffic control point and on the apparatus to preempt light cycles. In 1969, St. Paul, MN began the installation of their optical preemption system. Still in use today, it is the oldest continually operating EVP system in the United States (U.S. DOT, 2006, p 7-10).

The traffic control point equipment consists of a detector, or set of detectors for multiple directions of approach, that recognize the signal from the emergency vehicle. These detectors are commonly mounted on or in close proximity to the traffic lights. Once the signal is recognized, the detector relays the request for preemption to the traffic control box. Within the traffic control box is a signal processor, known as a phase selector. The phase selector receives the request and intervenes the normal cycle of the changing of traffic lights at the intersection in order to move the direction the signal was received from to green after changing all others to red. To prevent unauthorized utilization of the preemption system, the phase selector can be programmed to recognize if the emitter is transmitting a specific encryption code for that system. If the phase selector fails to validate the signal, the normal traffic light pattern is not altered.

Some installations of optical preemption systems use an additional light on the traffic signal as a notifier. The notifier is a floodlight that is aimed in the same direction of the traffic signal to provide the motorists and the emergency responders with the knowledge that preemption has been activated. The notifier will flash if the emergency vehicle is approaching from across the direction of travel and will burn steady if it is in the same direction, or coming straight towards, the direction of the emergency vehicle. Some newer varieties of the notifier have them integrated into the green lens of the traffic light array (Twin Cities, n.d.).

A variety of emitters are available for use on response vehicles. From lightheads installed in independent housings to those integrated into existing emergency warning lights, such as lightbars, the different commercial vendors meet the specific needs of the individual customer. There are even handheld devices available, designed like battery-powered tools, for use in undercover vehicles. The emitter lights are commonly installed to activate in unison with the other emergency vehicle lights on the apparatus. This is a safety mechanism to prevent their accidental omission from activation during responses. The other common installation feature on the vehicular equipment is a shut-off switch that is activated when the vehicle is placed either into park or when a door of the vehicle is opened. This disables the lighthead, eliminating the potential for disrupting intersections nearby the incident scene.

With exception of preventive maintenance, such as lens cleaning or realigning, the traffic signal-based equipment requires no regular attention. Vehicular equipment requires no regular maintenance other than exterior cleaning and ensuring the proper aim of light housings. The primary disadvantage of optical systems is that they require line-of-sight contact with the detectors in order for the system to function properly. Heavy fog, rain, or snow will reduce or eliminate the functionality of the system. High profile vehicles may block emitters that are installed on the roofs of sedans or on the fronts of larger response vehicles as they approach intersections, delaying the activation of the system. Intersections that occur just after curves, underpasses, bridges, or anywhere that a clear approach to the junction is unobtainable, will significantly limit the effectiveness of the optical system.

The acoustic systems, such as the SONEM 2000 from Traffic Systems, LLC, work in a similar fashion to the optical systems. Using an array of directional microphones or sonic sensors, the system detects an oncoming siren from an approaching emergency vehicle. A waveform of the siren's signal is sent through a digital signal processor and matched against stored waveforms of local sirens. Once it has validated the signal and determined the direction of approach, the preemption request is sent to the traffic signal controller and the light cycle is adjusted accordingly. With less than 1,000 systems operational, Traffic Systems, LLC is the only company with an acoustic platform system on the market (Kaul, 2002).

Acoustic systems have three advantages over the optical systems. First of all, since the vehicle siren activates the preemption system, there is no specialized equipment to either install or for the responders to remember to activate during an emergency response. Using the siren to activate the system also minimizes any potential for abuse. Acoustical systems can be outfitted with the notifier lights for activation verification.

Finally, the acoustical systems are not impacted by weather or obstructions such as dirt or debris (Adams, 2003, p. 2).

The acoustical systems do require careful installation in order to ensure proper response of the system. Two key installation points involve the detailed aiming of the sensors and evaluation of local sirens to ensure they are within Class-A siren standards for output. For agencies that utilize mechanical or electronic mechanical sirens, it is often necessary to digitize audio recordings of the local sirens to ensure the system captures the proper frequency range and cycle rates for recognition and preemption activation (Jim Hill, personal communication, June 25, 2008). Audible systems can be problematic when intersections are located amidst tall structures that lead to a canyon-like effect of the siren waves. If the system is unable to correctly discriminate from which direction the emergency vehicle is approaching, its benefit is marginalized.

Preemption systems utilizing RF signals to indicate their approach to the intersection are the newest of the current technologies. These systems incorporate low power radio transmitters on board the emergency vehicle that transmit to a receiver installed at the traffic signal control box. Receiving antennas at the intersections measure the strength of the radio signal to determine the direction of approach and activate the appropriate preemption. Some systems now incorporate GPS into the formula in order to calculate the speed of the vehicle as it approaches the intersection to ensure the roadway has been secured before the emergency vehicle arrives. The RF preemption methodology allows for activation from much farther distances than either the visual or acoustic systems, works around obstructions such as curves and overpasses, and is not hampered by weather conditions. One vendor, Collision Control Communications, Inc. has integrated a secondary capability into their preemption device that monitors for the presence of other vehicles transmitting the encoded RF signal and displays the direction of approach of that vehicle as a collision avoidance measure (Gross, 2007, ¶ 5).

One emerging technology in the EVP market is the integration of a mobile GPS and in-vehicle navigation technology with an existing intelligent transportation system (ITS). The ITS would recognize that an emergency vehicle has been dispatched to an incident and, using it's current location from the GPS, coordinate with the response vehicles mapping software to plot the route the unit will take to the destination. As the vehicle progresses along the route, the ITS will change the signals to green in the direction the unit is responding from. Known as Dynamic Route Clearance, the author was unable to find any currently installed systems, however there has been published research completed on the concepts viability by Eil Kwon and Sangho Kim at the University of Minnesota – Center or Transportation Studies.

The cost of implementing an EVP system is variable based on the technology that is chosen for implementation. As discussed within each of the different technologies, the equipment that is required on the response vehicle varies from highly specialized radio equipment to the audible siren that is present on most every emergency apparatus. An RF-based system that integrated the response vehicles existing GPS system for Palm Beach County, Florida cost an estimated $4000 per intersection and $2000 per vehicle when it was installed in 1997 (Shifrel, 1997).

The major cost center for an EVP system lies in the equipment necessary to interface with the existing traffic control fixtures at the intersection. Citing figures using 2003 dollars, the Cross-cutting Report from the U.S. DOT estimates that a signal preemption receiver and the phase selector to cost between $4000 and $8000 per intersection. Variations in the per intersection cost may 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 (2006). In Junction City, Kansas, an EVP installation project encountered problems when several intersection signal controllers required upgrading to properly interface with the EVP equipment and the preexisting conduit at the traffic signals was insufficient to complete the job. This resulted in several thousand dollars of unanticipated expenditures (Adams, 2003, p. 2).

A review of the available literature provided insight into the methodologies employed as to where jurisdictions installed their EVP systems, with different approaches being used in different communities. For example, in Fairfax County, Virginia, the implementation focused primarily on the U.S. Highway 1 corridor. This was a traditionally problematic artery for emergency vehicles due to traffic congestion and was adjacent to the busiest fire/ems station in the County (U.S. DOT, 2006, p 7-3). In comparison, the deployment of the EVP system in Plano, Texas took a very different approach. They installed EVP on all 46 signal controlled intersections within the City in the first three years of the project and continue to have a 100 percent installation rate. This required an additional 10 to 17 signals per year (U.S. Dot, 2006, p 7-5). When implementing an RF-based system used in conjunction with the vehicles GPS system, Broward County, Florida focused the initial deployment on routes used to access their 3 trauma centers in the community. Subsequent phases of the project addressed routes into the secondary hospitals (El Eid, 2006, p. 73). In addition to determining where EVP equipment should be installed, other factors must be considered as a part of the overall implementation strategy. Seattle, Washington, in outlining the implementation of an optical EVP system, identified the following design elements for consideration:

- At what speed does the system intend to allow emergency vehicles to proceed through roadways with preempted intersections?
- How quickly would intersections need to transition to the preemption phase in order to meet the intended travel speed requirement?
- How far in advance of intersections would the preemption signal require detection to effect the necessary preemption?
- What would be the appropriate detector type and placement to achieve the desired reception range?

By answering each of these questions, the Seattle authorities were able to engineer a system that properly addressed the needs of the emergency responders while ensuring that traffic flow and pedestrian safety were maintained (Holdridge, Yand, & Sittikariya, n.d., p. 4)

The literature review provided the author a clearer understanding of EVP systems, not only to the different technologies available for implementation, but also into the processes used to engineer and evaluate existing systems. With this understanding, the author was better prepared to evaluate the efficacy of an actual local system and the available technologies towards a recommendation for Wake County.

Procedures

While formal study in other jurisdictions has demonstrated that the use of EVP systems can result in improved response times, performing an evaluative analysis on a local agency operating with such a system was essential to prove the concept. This process allowed the researcher to validate the findings as presented in the literature review as well as directly address the first research question and the overall purpose statement of the ARP. Cary EMS, located in Wake County, served as the source agency for evaluative data for this segment of the research project.

The analysis phase of the research consisted of three exercises: collection and refinement of data generated by the CAD system, analysis of general response time data for comparison purposes, and analysis of response time data for specific geographic locations for comparison purposes.

First, the author identified the date in which Cary EMS implemented the traffic preemption technology into their response formula as a basis for collecting data. Using this date, October 2005, the author gathered response time data from two twelve-month periods, one prior to and one post, the implementation date. Twelve months was selected as the time period in order to ensure a statistically significant number of incidents in each data set. Response time as defined for the purpose of this study was the time period starting with unit dispatch and ending with unit arrival on scene. It was calculated at the 90^{th} percentile. Data regarding collisions was not readily available for analysis. One obvious limitation to the analysis was that the available data was rounded down to the whole minute value, introducing a potential variance to each response of up to 118 seconds.

After the required data was collected, it was necessary to review each event in order to ensure that it was a valid, complete, and appropriate record. Those records found to have incomplete data points, for incidents other than emergency responses, and for units that were not regularly assigned to the main station were omitted from the data set.

Once the data was reviewed and finalized, the pre-implementation data set, representing response data from October 2004 through September 2005 contained 6,239 records. The post-implementation data set, representing data from October 2006 through September 2007 contained 7,063 records. In order to present the data in clear and digestible format for the reader, several comparison exercises were completed in order to illustrate the impact of traffic preemption of response time. These exercises were:

1) Determine response time for each day of the week
2) Determine response time for the morning rush hour for each day of the week
3) Determine response time for the evening rush hour for each day of the week
4) Determine response time to two key geographical locations for each rush hour

The rush hour time periods used were 0700-0930 and 1530-1800 hours, Monday through Friday. The time parameters are based on the current definition of rush hour periods as used by the National Occupant Protection Use Survey (NOPUS) staff when completing seat belt compliance research for the National Highway Traffic Safety Administration (NHTSA) (Glassbrenner and Jianqiang Ye, 2007, p.3). To determine specific geographical locations for analysis, the author analyzed address locations that have many repeat events throughout the two data sets and identified those that would have been accessed by way of the corridor where Cary installed the initial build of traffic preemption devices. The two locations chosen for this analysis, illustrated in Appendix A, were those at or near the intersections of Cary Parkway and Tryon Rd and those addresses located on Crescent Green. Both locations have medical facilities that result in heavy call demand for EMS in Cary.

The hypothesis for the statistical analysis, based on the findings of studies discussed within the literature review, would be that response times would show an improvement after the installation of the EVP system, particularly to areas in and around the corridors where the system was installed. The largest variable to note would be the previously stated limitation on the time data. The absence of the second value in a time study limits the ability to state any improvements to a higher degree of accuracy.

The research continued with a literature review to provide the author with a more comprehensive understanding of traffic preemption technology. The basis for this review included journals, vendor materials, and a variety of Internet sources. The vendors provide extensive information on their products through their web sites and many jurisdictions provide their citizens on-line education on the operation of EVP.

The initial literature review focused on the available technology, specifically the equipment and methodology required, external to the traffic control box, in order to effect a preemption of the traffic signals. With an understanding of how the various systems operate, the author researched the costs associated with the implementation and maintenance of these systems. .

The second area of research involved the discovery of methodologies used by communities when determining where traffic preemption equipment will be installed. This involved the direct communication with administrative personnel at agencies where these systems have been deployed.

Results

Research Question # 1: In like size jurisdictions, how has the installation of traffic preemption devices impacted response times and responder safety? From the analysis of the Cary EMS response data, a total of 13,302 records between two data sets, the implementation of the traffic preemption system resulted in an improvement of response times. A complete representation of the data is found in Appendix A. In comparing the response time data by day of the week, there was 14.2% decrease in response time throughout their entire response area. During the morning rush hour period, the response time lengthened by 1 minute and 12 seconds, or 11%, but was decreased by 36 seconds, or 5%, during the afternoon rush hour period. These figures, shown in Appendix B, are representative of several thousand responses outside of areas with EVP installed. When looking at the data from the specific geographical locations (Appendix C), the response time to the Crescent Green addresses (215 total events) decreased by 20%, or two minutes, overall. The morning rush hour period saw response times decreased by one minute, or 13 %, and the afternoon rush hour period decreased by two minutes, or 22%. For responses to the area of Cary Parkway and Tryon Road (265 total events), response times decreased by 20%, or two minutes for all time periods. During the morning rush hour period, there was no statistical change in the response time, however during the evening rush hour period, there was a 14% reduction in response times, from 8 to 7 minutes. An illustration demonstrating the relation between the main EMS station, the initial corridor for EVP installation in Cary, and the two geographical locations used for analysis is provided in Appendix D.

Research Question # 2: What are traffic preemption devices and how do the different types of devices work? The research identified that there are four predominant systems in place today for performing traffic preemption: optical, acoustic, radio frequency, and GPS. The optical systems are by far the most common technology in place in public safety and is the methodology in use by Cary EMS. They operate by use of externally mounted devices, usually configured to operate in conjunction with the vehicles emergency warning equipment, that emit either a clear strobe flash or an infrared pulse, to activate the preemption system at the target intersection. The acoustic systems operate in the same manner as the optical systems, but make use of the emergency vehicle's siren as the triggering device, transmitting sound waves instead of light waves. Radio frequency systems require that responding vehicles be outfitted with a specialized radio transmitter that communicates with receivers installed at intersections. They have the ability to not only preempt the lights, but they can also track the strength at which the signal is approaching to ensure the intersection is secured with enough time for safe passage. GPS systems can either be integrated with an RF system or work in conjunction with an ITS to implement the Dynamic Route Clearance methodology.

Research Question # 3: What start up costs are involved with implementing a traffic preemption system? The cost centers for implementing a traffic preemption system primarily fall into two categories: vehicle equipment and traffic control point equipment. Research data for this question was obtained from personal interview. From the author's personal interview with Chief Cohen at Cary EMS, they invest approximately $1250 per vehicle for equipment and installation (Steven Cohen, personal communication, June 23, 2008). According the Chief Michael Cooper with the Cary Fire Department, the Town incurs approximately $5000 per intersection to install their optical EVP system. This includes $2500 for the hardware and design costs and an additional $2500 for installation (personal communication, Michael Cooper, July 15, 2008).

Research Question # 4: What on-going costs are involved with a traffic preemption system? From the literature review, both the optical and acoustical systems require minimal regular maintenance of the receiving devices installed at the intersections. They can potentially become misaligned due to wind or precipitation, or potentially blocked due to debris such as tree limbs or dust. This has been the experience in the Cary jurisdiction. According the Chief Michael Cooper with the Cary Fire Department, on average once per month they dispatch a maintenance crew to an intersection to realign the receivers after thunderstorms and other wind events. These repairs are based upon reports from company officers stating that preemption systems at those particular intersections are not responding, or are not responding as effectively as they previously were (Michael Cooper, personal communications, July 15, 2008). The vehicular equipment for the optical systems occasionally may require a replacement bulb, however in nearly 3 years of operation at Cary EMS, they have yet to incur any cost due to maintenance (Steven Cohen, personal communication, June 23, 2008). The Cary Fire Department provided similar information with Chief Cooper reporting no significant repairs or replacement of either vehicle-installed or intersection-installed equipment in the past three years. Chief Cooper did cite that an unanticipated cost of the system was an increase in the cost of lightbars for apparatus when specifying that the emitter be integrated into the device. They have found that this decreases the number of respondents in a competitive bidding process due to the limited number of manufacturers that build a lightbar with this option.

Research Question # 5: What methodology is used for the prioritization of intersections in jurisdictions? Cary has no adopted policy for determining where they will install EVP systems, however, according to Chief Cooper, they have used the following considerations in recent installations within their jurisdiction. First, they are working to ensure that all major corridors are equipped. Second, they assess where their areas of high demand are, especially those that are presenting with response time issues, and include EVP systems on intersections along traffic arteries into those areas. Finally, they factor growth within the community when planning future installations. They have established a priority to include new intersections that have been installed within the existing EVP corridors, as well as new intersections that are added in areas with high population density and anticipated traffic congestion issues (Michael Cooper, personal communications, July 15, 2008).

Discussion

The relationship between the current literature and the results of the analysis conducted on data from Cary EMS clearly validates the efficacy of using EVP to reduce response times for EMS in Wake County. The data indicated that response times decreased an overall 14.2 percent throughout the Cary response area. In the two geographical areas that were subjected to a focused analysis, response times improved by 20 percent overall, with improvements during the rush hour periods of between 14 and 22 percent. A comparison of the published studies looking at response time changes after the implementation of EVP mirror those results found through the analysis of the Cary EMS data used in this study. In the Houston, Texas study, the data showed a decrease in response times of 23 percent from one station with another station reporting a decrease of

18 percent (Traffic Engineers, 1991, Summary Information). In Fairfax County, Virginia, the study conducted in 2004 indicated savings of 30 to 45 seconds at a single, traditionally congested intersection, and in Plano, Texas, the 90th percentile response time of the department was reduced between 10 and 20 percent overall after the implementation of EVP (U.S. DOT, 2006, p. 8-1). Each of these systems adopted the same optical emitter technology in place within the Cary EMS response area. Data reported from a study in Colerain Township, Ohio, which implemented an acoustic preemption system showed a decrease in response times of 22 percent or 15.7 seconds, with response times during the rush hour periods improving by over 30% (TEC Engineering, 2005, p. 8).

The author's interpretation of these results was that the improvements shown in other jurisdictions could be duplicated in the local setting, resulting in a more effective and safer response from the EMS system. The data suggests that not only are the improvements in response time beneficial during emergencies that occur during the rush hour periods when traffic congestion is known to heightened, but the benefit is recognized during all other time periods as well.

The organizational implications of this study on the Wake County EMS system are significant. As cited in the case study involving EMS 5 and their collision on Capital Boulevard, responding with lights and sirens through congested traffic is a dangerous task. Having available an adjunct that will not only serve to reduce the time it takes to deliver necessary lifesaving treatment but allow this to be done in a safer manner for the employees and the general public cannot be overlooked. The cost will be significant. As discussed in the literature review, infrastructure costs can be between $4000 and $8000 per intersection (U.S. DOT, 2006) and an additional $1250 per response vehicle (Steven Cohen, personal communication, June 23, 2008). The main corridors alone in the City of Raleigh would encompass upwards of 100 intersections and the EMS system currently operates in excess of 60 response vehicles. However, the cost of not implementing the technology could potentially be much greater. According to the Bassing (2002, ¶ 4), a single visit for a trauma patient now exceeds $16,500. A collision with an ambulance and a passenger vehicle could quickly exceed $50,000 in initial medical costs alone. This is prior to the replacement or repair of the involved vehicles and any subsequent litigation for other damages. Investing in such a system would demonstrate a commitment to the employees that their safety is a priority to the County.

Recommendations

Based on this ARP, it is recommended that the Wake County EMS system pursue the implementation of an EVP system to reduce response times in the increasingly congested roadways of their community. Not only will the implementation of such a program serve to enhance the response capabilities of the EMS system, it will create a safer working environment for employees and for the motoring public through which EMS vehicles must navigate in order to arrive at emergency scenes.

The various technologies available in the marketplace each have their strengths and weaknesses, however the optical system platform, as is currently in use by Cary EMS, has proven its value in both functionality and durabilility for many jurisdictions in the United States. The data generated by studies of optical EVP systems, both from nationally published reports and the local analysis provided within this ARP, clearly prove the concept of optical EVP and demonstrate that it is viable for implementation throughout the County.

While the EMS response vehicles in Wake County currently have GPS technology on-board and could integrate this capability into one of the other EVP technologies, they are currently the only public safety discipline to have globally adopted this technology. Pursuing a GPS based system for preemption would be prohibitive to the other responders who are without that capability and it would be of no benefit to responders from outside of Cary when responding within that jurisdiction.

Planning the implementation of EVP in Wake County will require additional research in order to be successful. A sound strategy for prioritizing key corridors will be needed to ensure that intersections currently experiencing the highest traffic counts are included in the early stages, while developing a long-term plan to expand the system as traffic and population densities increase. The Capital Area Metropolitan Planning Organization (CAMPO) would be a required partner in this project due to their subject matter expertise on traffic corridor assessment and transportation planning in Wake County and the City of Raleigh. Another key component to the implementation of this project will be developing initial and long-term funding streams to support the infrastructure costs, which represent the majority of the expense involved. The scope and cost of the project would involve capital budget planners in order to secure the necessary funding, should outside sources such as grants not be available for this purpose. Since most of the signal-controlled intersections in Wake County reside within the City of Raleigh, the project would require them as a major participant. The City would directly benefit from the project through improved fire and law enforcement response times.

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APPENDIX A

Cary EMS Response Performance Data Analysis: Validated Data

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2004 - 2005								
Total Calls	916	932	918	953	947	827	746	6239
AM Rush	114	117	96	107	78	------	------	
PM Rush	142	130	131	148	149	------	------	

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2006 - 2007								
Total Calls	1028	1021	1032	1007	1063	975	937	7063
AM Rush	116	125	123	114	114	------	------	
PM Rush	146	142	139	143	148	------	------	

APPENDIX B

Cary EMS Response Performance Data Analysis: Response Time Analysis

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2004 - 2005								
RT[1]	13	12	12	12	12	12	11	
AM Rush RT[2]	11	10	12	11	12	------	------	
PM Rush RT[3]	13	12	13	11	14	------	------	

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2006 - 2007								
RT	12	12	12	13	12	11	11	
AM Rush RT	13	13	11	13	12	------	------	
PM Rush RT	12	12	10	14	12	------	------	

[1] Response Time, as indicated in whole minutes at the 90th percentile
[2] AM Rush Hour of 0700 to 0930
[3] PM Rush Hour of 1530 to 1800

APPENDIX C

Cary EMS Response Performance Data Analysis: Geographical Analysis

Crescent Green Location

	Tot Calls	Tot RT	AM Calls	AM RT	PM Calls	PM RT
2004-2005	116	10	11	9	14	11
2006-2007	99	8	16	8	7	9
Difference		20%		13%		22%

Tryon Rd/Cary Parkway Location

	Tot Calls	Tot RT	AM Calls	AM RT	PM Calls	PM RT
2004-2005	133	10	14	8	16	8
2006-2007	132	8	18	8	10	7
Difference		20%		0%		14%

APPENDIX D

Focused Analysis Locations and EVP Implementation