USE OF AUTOMATED ENFORCEMENT FOR RED LIGHT VIOLATIONS

by

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SUMMARY

Traditional police methods cannot safely and efficiently address the increasing frequency of drivers violating (running) red lights. The use of automated enforcement systems offers the potential to decrease the number of red light violations and improve the safety of intersections. Despite the potential benefits of automated enforcement for red light violations, few jurisdictions in the United States have implemented such programs. Included in this report is an evaluation of the operating conditions where automated enforcement was effective, a study of the legal, legislative, and social issues needed to implement a program, a review of the current technology being used for automated enforcement, and a review of previous and current automated enforcement of red light applications in the United States and abroad. A strategy to create and implement an automated enforcement program for red light violations was established. The implementation strategy was then demonstrated using a hypothetical application.

A state-of-the-art literature review was conducted to establish background information on the use of automated enforcement for red light violations. In order to provide more recent and site specific data that are not available in the literature, a diverse group of professionals were interviewed and a survey was conducted. The professionals contacted were automated enforcement program representatives, law enforcement officials, manufacturers of automated enforcement technology and systems, and research engineers and scientists. The interviews and survey were completed through a combination of telephone conversations and fax transmissions.

The results of the survey and the information presented in the literature were incorporated into this report and were used to develop the following strategy for implementing an automated enforcement program for red light violations:

- Demonstrate a need for the program;
- Establish institutional arrangements;
- Review applications in the United States and abroad;
- Create a public education and awareness campaign;
- Establish legislation to allow for the use of automated enforcement technology and processes;
- Advertise a Request For Proposal (RFP);
- Undertake a demonstration project;
- Evaluate the demonstration project;
- Implement selected vendor system; and
- Expand the program.

Based on the results of this study, the use of automated enforcement systems provided police departments and jurisdictions with the ability to consistently enforce red light violations without placing the total responsibility on police departments. By following the strategies presented in this report, agencies will be able to implement an automated enforcement program that may improve the safety of intersections. The automated enforcement program will also be acceptable to law enforcement agencies, highway and traffic engineers, supporting governments, and the general

public.

TABLE OF CONTENTS

INTRODUCTION

The use of automated enforcement is providing governments and police departments with an alternative to address the increasing problem of red light violations. Although each state specifies its own traffic laws, a red light violation is commonly defined as when the front wheels of a vehicle enter the defining boundary of an intersection (usually the stop bar or crosswalk) after the traffic signal changes to the red phase and the vehicle proceeds through the intersection while the signal is red. The common phrase used to describe when vehicles proceed through an intersection after the traffic signal turns red is running a red light.

Drivers who "run" red lights pose a danger to both other drivers using the facility and to themselves. Traditional means of using police personnel to enforce red light violations have several problems. Often, police departments have very limited resources and personnel. Decisions usually are made to allocate resources to other areas of need before supporting increased traffic enforcement.

Enforcing a red light violation places police officers in a very difficult situation. If a red light violation takes place while an officer is present at a traffic signal and the officer does not pursue the violator, the officer will be viewed as indifferent and the message that red light violations are not serious offenses will be portrayed to the public. Pursuing red light violators can also be dangerous to police officers, motorists, pedestrians, and bicyclists.

In order to enforce a red light violation, police personnel often have to go through the red light in pursuit creating a dangerous situation. The high speed necessary to 'catch' a violator and the limited space in urban areas to 'pull a vehicle over' also increase the chance for accidents to occur. Should a driver fail to obey a police officer and a high speed pursuit occur, public injuries and substantial property damage can also occur.

Automated enforcement has been used in several countries to reduce the number of red light violations. In the Netherlands and Australia, it has been reported that automated enforcement technology can reduce red light violations by 35 to 60 percent and reduce right-angle accidents by 32 percent (1). Reductions such as those previously stated have prompted the Federal Highway Administration (FHWA) to support additional applications of automated enforcement technology for red light violations.

Recently, several cities in the United States have begun using automated enforcement in an attempt to reduce red light violations. Preliminary data show that the cities of San Francisco, California, New York City, New York, and Howard County, Maryland experienced between a 20 to 30% reduction in red light violations after automated enforcement and/or warning programs were initiated (2). The cities incorporated different ways to finance the programs, enacted different legislation, and had different opinions on whether or not citations should be sent or warning notices issued.

Problem Statement

The use of automated enforcement for red light violations in the United States has been very limited. Several different programs with varying degrees of success have been used in the past. Because of the potential to decrease the number of red light violations and improve the safety of intersections, a need exists to evaluate the operating conditions where automated enforcement is effective, the legislation needed to implement a program, the public involvement necessary to gain acceptance of the program, and the technology that can be used for such a program.

Objectives

The objectives of this research were as follows:

1. Identify the extent of the problem of red light violations.

2. Evaluate legal, legislative, and social issues associated with automated enforcement of red light violations.

3. Review the current technology being used for automated enforcement and identify its strengths and weaknesses.

4. Review previous and current applications in the United States and abroad using automated enforcement for red light violations.

5. Formulate a strategy for the implementation of an automated enforcement program for red light violations.

6. Demonstrate the implementation strategy using a hypothetical application.

Method of Study

Literature Review

A state-of-the-art literature review was conducted to establish background information on the use of automated enforcement for red light violations. Included in this literature review were reports documenting the creation of automated enforcement programs in the United States and abroad, literature describing the barriers faced in implementation, and reports on the operational effectiveness of automated enforcement programs for red light violations. Information related to the current technology being used for automated enforcement systems for red light violations was also reviewed.

Data Collection

Surveys, telephone interviews, and a review of information provided by professionals were used to collect data concerning automated enforcement programs for red light violations. A group of professionals which included law enforcement officials, city and county representatives, traffic engineers and engineering consultants, technology representatives, and researchers with knowledge about the creation, organization, technology, and operations of automated enforcement programs was targeted to provide more recent and site specific data that is not available in the literature. The professionals targeted for this study were classified into one of the following four categories:

1. Automated enforcement program representatives;

2. Law enforcement officials;

3. Manufacturers of automated enforcement technology and systems; and

4. Research engineers and scientists.

Table 1 lists the organizations and individuals contacted for this study.

Table 1. Individuals and Organizations Contacted For This Study

Automated Enforcement Program Representatives	Law Enforcement Officials	Technology Manufacturers	Research Engineer/Scientists
Rudy Popolizio, Chief of Red Light Camera Program for New York City, NY	Chief George M. Ferris, Fort Meade Police Department, FL	AUTOPATROL™	Richard A. Retting, Insurance Institute for Highway Safety
C. Edward Walter, Chief, Traffic Engineering Division of Public Works of Howard County, MD	Sgt. Glenn A. Hansen, Supervisor, Research and Planning Section, Howard County, MD	CONTROL TECHNOLOGIES	Mila Plosky, FHWA
Tarek Tarawneh, Head of Red Light Camera Program for Lincoln, NE	Officer Anthony Taylor, Bryan/College Station Police Department	EASTMAN KODAK COMPANY	Richard A. Raub, Northwestern University Traffic Institute
Chief George M. Ferris, Fort Meade Police Department, FL	Chief John Wintersteen, Paradise Valley Police Department, AZ	U.S. PUBLIC TECHNOLOGIES INC.	Harold Lunenfeld, FHWA
Susan Law, Associate Project Manager, Nelson Nygaard Consulting, San Francisco, CA		TRAFFIPAX Traffic Surveillance Systems	
Tom Fletcher, Manager of Traffic Management, Ontario, Canada		Truvelo Manufacturers	
		Cohu, Inc., Electronics Division represented by Ruyle & Associates and Pete Schumacher	

Organization of Report

The report is divided into nine sections. Section 1 consists of the introduction to the report. Background information on the extent of the problem of red light violations is provided in Section 2. Legal, legislative, and social issues associated with automated enforcement are evaluated in Section 3. The current technology that is being used for automated enforcement is reviewed in Section 4 . The study design used to complete this paper and the questions asked in the interview process are provided in Section 5. A detailed discussion describing current applications of automated enforcement for red light violations in the United States and abroad is presented in Section 6. Implementation strategies for a program using automated enforcement of red light

violations are formulated in Section 7. The strategies formulated in Section 7 are applied through the use of a hypothetical application in Section 8. Conclusions and recommendations based on the previous sections are provided in Section 9.

BACKGROUND

Motorists driving through an intersection after the traffic signal has turned red are a dangerous problem that is increasing in most states. Several studies conducted by Richard Retting of the Insurance Institute for Highway Safety (IIHS) have defined the magnitude and seriousness of the problem. IIHS defines a violation when a motorist deliberately enters an intersection after the signal light has turned red as a red light run (3). Retting, citing United States Department of Transportation statistics from 1993, 1994, and 1995, stated that more than one million motor vehicle collisions resulting in over one-half million injuries and several thousand fatalities occur at traffic signals. Statistics, also from the United States Department of Transportation, showed that the number of fatal crashes occurring at traffic signals had increased by 15 percent between 1992 and 1995 (4).

A different study also conducted by the Insurance Institute for Highway Safety showed that 22 percent of all crashes in urban areas were the result of drivers running traffic control devices (traffic signals, stop signs, and yield signs). Of those crashes, 24 percent involved running red lights. The same study also showed that a higher percentage of occupants where injured in red light running crashes (45 percent) as compared to injuries resulting from the running of other traffic control devices (30 percent) (5). The economic impact of crashes resulting from red light violations in terms of medical costs, time off work, insurance hikes, and property damage is estimated at $7 billion each year (6).

An example of the problem of red light violations can be seen in the state of Maryland. Currently, running a red light is a cited cause in four percent of all accidents. During the 12-year period between 1983 and 1994, failure to stop for a red light has been the primary cause of approximately 47,000 traffic crashes resulting in more than 250 fatalities. A review of accident records has also shown that the percentage of accidents in which running a red light was listed as the primary cause of the accident has increased steadily since 1983 (7).

Due to the frequency of red light violations and the severity of the incidents that have resulted from them, the Insurance Institute for Highway Safety conducted a study to determine the characteristics of drivers who run red lights (8). In the study it was found that red light violators as a group have significantly more tickets for moving violations, generally poorer driving records, are younger, and are less likely to use safety belts than law abiding drivers. From this study, it was concluded that red light violators are a "higher risk group that merits enforcement resources not only because of the violation itself and its danger, but because of their higher risk characteristics in general" (8).

The process of identifying a driver running a red light and enforcing the violation is time consuming using traditional police methods. Although enforcing red light violations is a high

priority for many police departments, the actual enforcement of the violation is difficult for several reasons. In order for single officer on patrol to stop an individual observed running a red light, the officer has to have a direct view of the traffic signal so that the decision can be quickly made if the suspected vehicle ran the red light or actually was in the intersection before the light turned red.

In some states, such as Florida, the courts require that the officer issuing the citation must see the same face of the traffic light as the violator (9). Such laws have implications that severely limit the ability of a police department to enforce red light violations. In Polk County, Florida, only seven percent of all traffic citations written in the past six months were for red light violations.

By requiring officers to have the same view of the traffic signal as the violator, officers who observe violations from cross streets or the opposing direction of traffic cannot enforce the violation. If an officer does observe a violation while viewing the same face of the traffic signal, that officer will have to follow the violator through the flow of cross traffic that has the green signal, creating a very dangerous situation for both the officer and the crossing vehicles. These factors make it nearly impossible for an officer on patrol to enforce red light violations and force officers to position themselves in a stationary spot to view violations. Most police departments do not have the manpower or resources to allow officers to enforce violations for a long period of time.

To counter the difficulties many areas are having with enforcing red light violations and the danger posed to officers who do enforce red light violations, some areas are using a team approach. The team approach involves having at least three officers present at an intersection together. One officer is positioned upstream of the traffic signal in an unmarked vehicle to observe violations and two officers are positioned downstream of the intersection to pull-over the violators when radioed by the upstream officer. Although the team enforcement method is safer for officers and is successful in citing red light violators, the cost to have many officers at one location is difficult to justify.

In Howard County, Maryland, team enforcement was used during the three peak traffic periods of the day. One operation consisting of a two-hour session done three times a day for three consecutive days was estimated to cost about $1,500. For the seven jurisdictions participating in the program to each enforce five sites, three times a day for three consecutive days, the estimated cost of the program was approximately $52,000 (10). More information about Howard County's team enforcement program can be found in Section 6, Applications of Automated Enforcement Programs.

The amount of time an officer spends preparing and attending court for violations that are challenged depends on several factors. To prepare for court, an officer typically reviews the field notes recorded at the time of the violation. The amount of time an officer will spend in court is determined by the court docket. If the case is slotted for an early time, the officer will be able to quickly complete the case, but if the slot is later in the day, the officer may be required to wait as long as five hours before the case is heard. In Maryland and Florida, officers receive a minimum of two hours of pay to compensate for court appearances.

When violations are challenged in court, the judgement of the police officer will usually be upheld. In Polk County, Florida, only 1.3 percent of violations are dismissed or found not guilty (9). Reasons that may be grounds for a violation being dismissed or a driver being found not guilty include an officer not showing up for the trial, lawyers being able to establish that the officer did not actually see the signal turn red when the violator proceeded through the intersection, and an officer preparing poor field notes.

LEGAL AND SOCIAL ISSUES

An understanding of the legal and social issues associated with the use of automated enforcement is necessary in order for an effective program to be designed and implemented. A review of relevant United States court decisions concerning constitutional issues, privacy rights, and admissibility requirements for automated enforcement is included in this section. Legislation passed in various states and countries was also reviewed to determine what legislation is needed and most compatible with automated enforcement of red light violations. Also included in this section is an examination of public opinions concerning the use of automated enforcement.

Constitutional and Privacy Issues

There is currently no court case which has specifically defined an individual's right to privacy under the First Amendment with respect to operating a vehicle. Although the Supreme Court has protected an individual's right to privacy in matters relating to marriage, family, and sex (California v. Belous, 80 Ca. Rptr. 354, 458 P.2d 194 [1969]; Griswold v. Connecticut, 381 U.S. 479 [1965]), the act of driving would not appear to be protected (11). Because driving is considered a privilege that is not guaranteed to everyone and because of the fact that driving takes place in view of the public, it is not logical to believe that an individual's right to privacy while operating a vehicle would be protected by the Constitution.

Several other Supreme Court decisions have lead to the belief that the use of automated enforcement technology does not violate an individual's right to privacy. Because a vehicle travels public roadways and the vehicle and its occupants are in the public view, the Court decided in Cardwell v. Lewis, 417 U.S. 583, 590 (1974) that a vehicle has little ability to escape public scrutiny (12). In the United States v. Knotts, 460 U.S. (1983), the Court ruled that the defendant had no reasonable expectation of privacy in using public streets and that surveillance by police using a radio transmitter, or beeper, in the vehicle was equivalent to following the vehicle on the public streets (12). In New York v. Class, 475 U.S. 106, 106 S.Ct. 960, 38 CrL 3128 (1986), the Court ruled that a police officer's search for a VIN (vehicle identification number) did not violate an individuals right to privacy because the VIN was considered important in maintaining pervasive government automobile regulations (11).

The decisions previously described are based on the standard established by the Supreme Court that Fourth Amendment protection is based upon whether or not a person has a reasonable expectation of privacy. Because drivers are in the open view of the public when operating vehicles, the expectation of privacy has no basis. Therefore, the use of automated enforcement devices does not appear to violate any constitutional rights (11).

Admissibility Issues

The use of photographs taken by automated enforcement equipment is allowed by the Courts as evidence if a "strong showing" is made establishing the photograph's competency and authenticity (11). The elements of authenticity required by the courts are identification of the defendant as the same person shown in the photograph (if the violation is classified as a moving violation), clear identification of a vehicle's license plate, and verification that the equipment used to take the photograph was properly functioning. Additional information also sought by courts is the training of individuals using the system and expert testimony concerning the scientific reliability of the system.

In 1958, the Supreme Court in People v. Pett 178 N.Y.S.2d (1958) decided that the use of a photographic radar device called Foto-Patrol which recorded a vehicle's speed and photographed the vehicle's license plate was not a violation of an individual's constitutional rights (11). The Court stated that: "We have passed the horse and buggy days and are living in a new era. The question is, did the defendant do it and was there sufficient proof offered to find the defendant guilty beyond a reasonable doubt." After hearing testimony by police officers and viewing tests of the system, the Court found the system was scientifically reliable and allowed the evidence to be admitted.

In the case of using automated enforcement for red light violations, the police must establish that the photograph taken, the position of the vehicle in the intersection while the traffic signal was red, and the time shown were provided by an instrument which has been proven to accurately identify, photo, and synchronize these events. If the violation is going to be treated as a moving violation with points being assessed to the driver's license, the identity of the driver must also be clearly shown.

Enabling Legislation

In order for a program using automated enforcement of red light violations to be successful, legislation should be present that clearly defines the criminal or civil liabilities of the operator or owner of vehicles photographed that are in violation of the law. The major decision that must be made when enacting enabling legislation is whether positive identification of the driver must be made to enforce a violation or if the registered owner of the vehicle can be held responsible for the violation. The remainder of this discussion focusses on the general laws that need to be passed for both of these options. Specific examples of legislation passed in conjunction with automated enforcement applications for red light violations is given in Section 6, Applications of Automated Enforcement Programs.

The legislation needed to accompany any automated enforcement program of red light violations must first authorize enforcement agencies to cite red light violators by mail and not require an officer to be attending the equipment at all times. Most agencies currently require that moving violations be issued by a police officer and be signed by both the enforcing officer and the law violator. By not requiring an officer to be attending the equipment at all times, savings in manpower

hours can be realized.

In order for a red light violation to be classified as a moving violation in most states, the driver of the vehicle must be able to be identified. A moving violation in most states is considered to be a criminal act by the court and require a verdict of either guilty or not guilty (13). In addition to being subjected to a monetary fine, a person found guilty of a moving violation would be assessed points against his/her driver's license and be subject to increases in automobile insurance.

The process of driver identification through the use of automated enforcement technology involves the use of frontal photography. As stated previously, the use of frontal photography as evidence in a court case requires a "strong showing" identifying the defendant as the same person shown in the photograph. The use of frontal photography often results in public concerns over privacy violations and the perceived threat that drivers may be photographed in potentially embarrassing situations (11). Frontal photography of a vehicle also raises the issue of how to address the identification of other occupants in the vehicle.

To avoid the need of identifying the driver through the use of frontal photography, many countries and states enact enabling legislation that would place responsibility for a red light violation detected using automated enforcement on the owner of the vehicle. The most common form of such a civil vicarious liability statute for traffic offenses is a parking violation. The violation would be classified as a non-moving violation and most often require a decision of liable or not liable (11). By classifying a red light violation as a non-moving violation, a fine would be charged to the owner of the vehicle, but no points would be assigned to an individual's driving license.

Opposition to legislation placing responsibility for violations detected using automated enforcement often cite the scenario where individuals will be unfairly charged for a penalty they did not commit. The Insurance Institute for Highway Safety (IIHS) conducted research into this area using a sample of tickets issued for red light violations during a 20-day period in Arlington, Virginia (4). The study found that 72 percent of the tickets matched the name on the registration identifying the owner of the vehicle. From this study, IIHS concluded that drivers who violate red lights are either the registered owner of the vehicle or reside in the same household as the registered owner.

By having legislation that makes the registered owner of the vehicle responsible for red light violations detected through the use of automated enforcement, the need for frontal photography and driver identification is not required. The owner of the vehicle is instead identified by matching the photograph of the vehicle's license plate with registration records. Concerns about the privacy of individuals in the vehicle, the extra cost associated with frontal photography (picture development, additional equipment), and the difficult process of identifying a person who is not the registered owner of a vehicle caught violating a red light are eliminated.

Many other issues also exist when examining the requirements for enacting legislation that allows for the use of automated enforcement technology and processes. Such issues include the adjudication process, non-payment sanctions, and provisions to allow the registered owner of the

vehicle to identify the individual who violated the red light . Although these issues are important, a detailed discussion is beyond the scope of this research.

The National Cooperative Highway Research Program (NCHRP) published a paper discussing the legal issues associated with automated enforcement technology in December of 1996 (14). The report provides a detailed analysis of the precedence that has been set by the Courts concerning the use of automated enforcement technology. Also included in the report is a comparative analysis of the photographic traffic enforcement laws in the United States.

The NCHRP paper can serve as a valuable reference when deciding the context of the legislation that will need to be enacted for the use of automated enforcement technology for red light violations. A research guide is included in the paper to assist individuals in gathering information about State policies that will need to be addressed in the proposed legislation. A model law is also provided as an example that can be used when drafting the proposed legislation.

Public Education and Awareness

In response to the increasing trend of red light violations, the severe accidents associated with red light running, and the high economic impact of such violations, the Federal Highway Administration (FHWA) developed the Red Light Running Campaign Strategic Planning Guide℠[1] (6). The guide provides a comprehensive description of the programs that can be implemented by a community to increase the public's knowledge and awareness of red light violations. The organization of the guide allows users to follow the guide in a step-by-step manner, use it as a reference to improve specific aspects of a program, or to use the guide as a basis to formulate ideas on how to create a public education/awareness program.

The guide is divided into 11 major subject areas: Campaign Overview, Campaign Funding, Organizing Your Staff, Pre-Campaign Assessment, Law Enforcement Participation, Campaign Materials, Media and Public Relations Techniques, Campaign Kickoff, Events and Activities, Post-Campaign Evaluation, and Addenda. Included in the guide are master dubs of video and audio public service announcements (PSAs) and camera-ready art. The strategies presented in the guide were field tested in Charleston, South Carolina and are presently being used in many areas of the United States.

The Red Light Running Campaign Strategic Planning Guide℠ does not provide a great amount of information on using automated enforcement technology. The guide suggests using automated enforcement systems after the conclusion of the public education/awareness program at specific hazardous intersections (6). Because the guide is organized in a manner that is divided by specific subject area, many of the topics can be incorporated into a program to educate the public about the use of automated enforcement technology. Sections such as Campaign Funding, Pre-Campaign

[1]For information about the Red Light Running Campaign Strategic Planning Guide℠, contact Mila Plosky, FHWA Headquarters, 400 Seventh Street, S.W., Washington, D.C. 20590.

Assessment, and Campaign Kickoff all contain information that can be directly incorporated into a program using automated enforcement technology.

An example of a public education campaign being performed in association with an automated enforcement program can be seen in Paradise Valley, Arizona (15). Paradise Valley gained experience using automated enforcement technology by being the first area in the United States to operate a continuous photo-radar program. On August 27, 1996, Paradise Valley expanded its automated enforcement program to include enforcement of red light violations.

In initiating the automated enforcement of red light violations program, Paradise Valley also started a public education and awareness program. The program consisted of a wide variety of techniques used to inform people about the use of automated enforcement technology. Figure 1 shows a handout distributed in Paradise Valley describing the automated enforcement program (15). The handout was given to every school child in town, distributed at city meetings (e.g. City Council and Zoning Board meetings), and mailed with warning notices sent during the first three months of system operation. Other methods that were used to inform the public about the program included having a bumper sticker about the program placed on all city vehicles and showing short advertisements at local movie theaters that donated advertisement time.

The intersections where the automated enforcement system operated where made to look different in an attempt to make the public aware of the program. Red reflective strips where placed at the defining boundaries of the intersection at all approaches. Signs informing the public that automated enforcement technology was being used also were placed before each approach to the intersection.

The news media also played a major role in making the public more aware of the automated enforcement program. Members of the police department frequently appeared on radio call-in talk shows and traffic information channels to answer questions about the program. Information packets for the media containing example photographs taken by the system and operational facts were also distributed. By informing the media about the construction, testing, and operations of the system, Paradise Valley was able to keep the topic of automated enforcement in the news and gain public support for the program.

Public Opinion

Public opinion surveys concerning the use of automated enforcement for red light violations show that the public supports such programs. Sixty-six percent of 1,006 people surveyed across the United States by the Insurance Institute for Highway Safety said they were in favor of using automated enforcement for red light violations as opposed to 28 percent who indicated opposition (16). In a different survey of 500 people in Northern Virginia also conducted by the Insurance Institute for Highway Safety, 47 percent of the people surveyed believed running red lights is a big problem, 30 percent rated it medium, and 21 percent believed running red lights was not a problem. Sixty-three percent of the people in that same survey favored the use of automated enforcement to address the problem of red light violations (16).

The use of automated enforcement for red light violations is also being supported in areas where other uses of automated enforcement is being opposed. The Auto Club of Southern California has supported programs using cameras to photograph red light violators, but has opposed the use of photo radar for speed enforcement (17). In a study conducted in British Columbia concerning an automated enforcement of red light violations program in operation from 1988 to 1990, the profile of drivers who think such programs were unfair was determined. The typical person who opposes automated enforcement programs for red light violations is a young to middle age male, drives more than 10,000 km/year (6,210 mi/year), and has two or more convictions in the last three years (1).

TECHNOLOGY

Automated enforcement systems designed to detect red light violations must have the capability to detect and record violations under varying field conditions and also produce clear images that are easily retrieved and stored. Gary Erickson of Eastman Kodak Company, a manufacturer of automated enforcement technology, cites the following 10 requirements that automated enforcement systems should include (18):

- The ability to capture, transmit, process, store and recover captured images so that data may be managed in an efficient manner;
- Sufficient resolution to satisfy court standards for the image-reading of vehicle license plates, clear detail of the vehicle, and identification of the vehicle operator (if necessary);
- The capability to prevent the spreading of overexposed portions of an image (anti-blooming) that may result from vehicle headlights or sunlight from highly reflective surfaces;
- Adequate differentiation of light to dark areas within an image to provide necessary details (also referred to as contrast latitude);
- The ability to provide blur-free images of moving vehicles;
- The ability to detect at varying levels of light;
- Image enhancement circuitry to eliminate major sensor defects such as bright or dark columns which detract from the visible presentation of an image;
- Continuous read-out of images to support monitoring along with single frame capture capability for recognizing several successive vehicles committing a violation;
- The ability to be moved to different locations or to be mounted into a permanent position; and
- Components that are environmentally friendly.

Currently, three types of cameras are available for use with automated enforcement of red light violation systems. Thirty-five millimeter cameras have been used by most systems to photograph violators. Video cameras have been used to collect data concerning red light violations, but are rarely used for automated enforcement purposes. Digital imaging cameras are currently being introduced for use with automated enforcement systems and show great promise for their applicability to automated enforcement of red light violations.

Each approach to an intersection that is using automated enforcement will usually be equipped with one camera to record red light violations. If a need exists to photograph both the front and rear of a violating vehicle, a two-camera system must be used. An example of the need of a two-camera system would be an area where passenger cars only have a rear license plate and semi-trucks only have a front license plate. The higher cost of two-camera systems has limited the implementation of such applications.

Many different accessories are available with the three camera types used for automated enforcement systems. A variety of camera flash units used to provide special illumination needs and night-time photography and camera filters used to improve the quality of photographs may be incorporated into an automated enforcement system. The addition of flash units and camera filters

is based on site specific requirements, such as the angle the sun hits the intersection and the reflectivity of vehicle license plates, and the financial limitations of the automated enforcement program.

The remainder of this section provides a general description of the three types of cameras and necessary equipment used for the automated enforcement of red light violations. A listing of companies that produce red light violation equipment is included in the Appendix of this report. Description of specific systems and problems encountered at specific locations is provided in Section 6, Applications of Automated Enforcement Programs.

35-mm Cameras

Thirty-five millimeter cameras are the most common cameras used for automated enforcement of red light violation systems. Most automated enforcement systems equipped with 35-mm cameras produce black and white photographs, but some systems may produce color photographs. Although black and white photographs are less expensive than color photographs, it is often difficult to tell which light is illuminated on the traffic signal. In Maryland, color photography is used to eliminate any doubt as to whether the traffic signal is actually red and the use of color photography has been found to be very acceptable by the courts.

The camera system is typically connected to both the traffic signal system controller and to loops or piezoe sensors (19). The traffic loops or piezoe sensors are placed in the pavement to detect on coming vehicles and determine vehicle speeds. Cameras are located in a special unit to protect them from the elements and vandalism and placed atop poles. Poles may be either hinged or contain specially designed “elevator” systems to allow access to the cameras. Figure 2 shows a schematic diagram of a red light automated enforcement configuration used in New York City (20).

In Figure 2, only the first three travel lanes next to the red light camera are equipped with loop detectors. Although vendors of automated enforcement technology will often claim that a single camera can enforce four through travel lanes, experience in New York and other areas has shown that reliable, accurate enforcement can only be performed on the first three travel lanes next to the red light camera. The loop detectors shown are also used only for the automated enforcement system. By having the loop detectors used only for the automated enforcement system, interference and conflicts with other detectors used for the traffic control system can be avoided.

When the traffic signal switches to the red phase, the camera used by the automated enforcement system becomes active (ready to take photographs). Vehicles traveling over the detectors while the camera is active signal the system to photograph the vehicle. A small period of time, referred to as a grace period, and a preset speed necessary to activate the system are usually allowed in order to differentiate between vehicles attempting to stop or turn right on red and vehicles that clearly are running the red light (19). A common grace period is 3/10 of a second and a minimum speed necessary to activate the system ranges from 15 to 20 miles per hour.

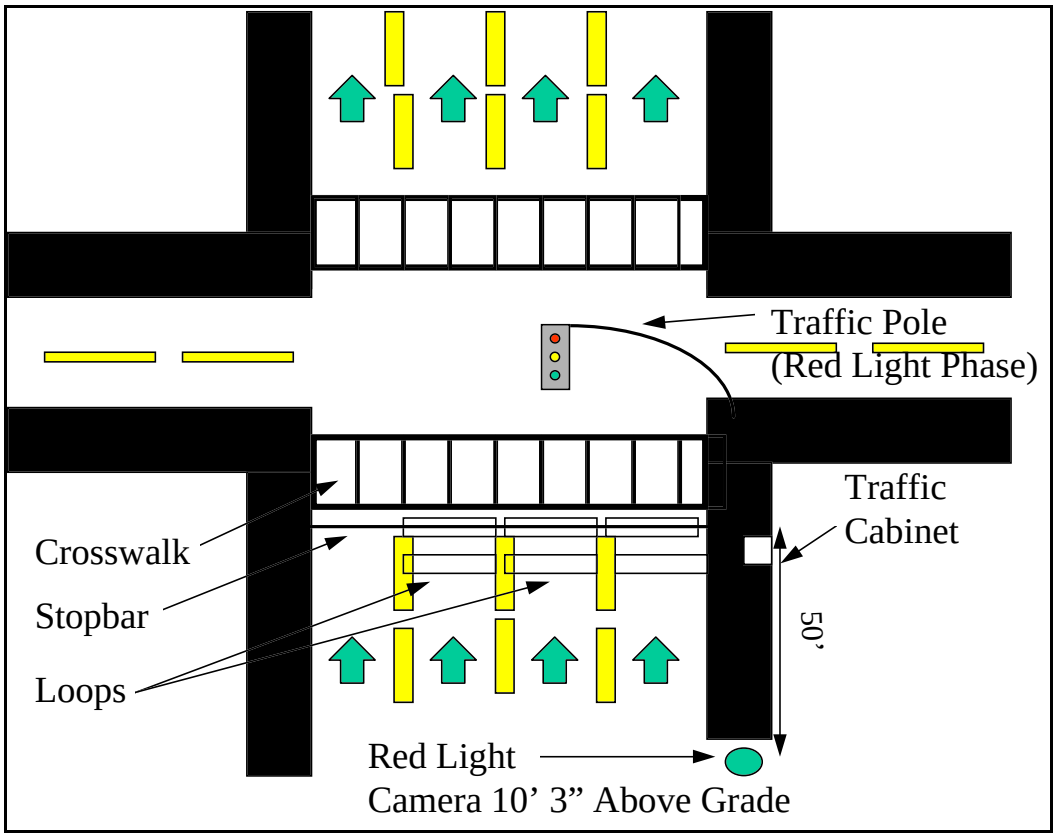

Figure 2. Automated Enforcement Configuration Used in New York City (20)

When the system is activated by a vehicle running a red light, at least two pictures are taken by the camera (21). The first picture shows that the front of the vehicle is not in the intersection when the traffic signal is red. This picture must show the pavement marking defining the intersection (usually the stop bar or the crosswalk), the traffic signal displaying a red light, and the vehicle in question . The second picture then shows the vehicle in the intersection a short time later (0.5 to 1.5 seconds). If driver identification is necessary, a third picture of the driver may be taken. From the pictures taken, the license plate will be magnified to allow for identification of the vehicle.

Two pictures taken by the automated enforcement system in Howard County, Maryland are shown in Figure 3 and Figure 4. The pictures shown were originally in color, but were changed to black and white for reproduction in this report. The magnification of the vehicle's license plate is not shown and all vehicle license plates are blurred for legal reasons. The position of the vehicle behind the stop bar while the traffic signal is red is shown in Figure 3. The first line of the "stamp" placed on the photograph (13^{36}, 02-01-97) is the time (military format) and date that the photograph was taken. The second line shows the length of the preceding yellow phase ($1Y4^{0}$) which was four seconds and the amount of seconds the traffic signal had been red ($R02^{1}$) which was 2.1 seconds. The photograph number (009) and a code for the intersection (0751) are listed on the third line.

Figure 4 is the second picture taken by the automated enforcement system showing the vehicle in the intersection while the traffic signal is red. The first line of the "stamp" placed on the photograph again shows the time in military format and the date the photograph was taken (13^{36}, 02-01-97). The second line again shows the length of the preceding yellow phase ($1Y4^{0}$) which was four seconds and the amount of seconds that the traffic signal has been read ($R02^{7}$), 2.7 seconds. The photograph number (009) is again listed for matching purposes and the vehicle speed (V=53) in miles per hour is shown on the third line. By viewing the photographs shown in Figure 3 and Figure 4, it can be proven that the vehicle entered the intersection 2.1 seconds after the traffic signal turned red and proceeded through the intersection.

The placement of traffic loops or piezoe sensors is very important in determining the accuracy and success of the overall automated enforcement system. Because traffic loops and piezoe sensors have to be placed in the pavement, careful consideration of loop and sensor placement should take place. Extra costs and driver inconvenience associated with the need to adjust sensor locations can cause a program to be canceled before it gets a chance to become functional.

The ability of a system to photograph only red light violators is important in limiting the costs associated with each picture and the amount of resources needed to reduce the data collected by the cameras. The placement of traffic loops or piezoe sensors will often determine how many pictures will be taken by the system and the capability of the system to differentiate between vehicles accelerating to run the traffic signal and vehicles attempting to stop or turn right. In Pasadena, California several problems were experienced with a red light violation automated enforcement system. Ninety-five percent of the photographs taken by the system were of non-violating vehicles (22). The high rate of photographs was attributed to the improper placement of the loops which caused left turning vehicles "trapped" in the intersection making turns after the onset of a red signal and vehicles that would creep forward passed the stop bar to be photographed.

New York City had a similar problem at the beginning of its automated enforcement of red light violation program (21). Original design plans required only one loop per lane of moving traffic to be placed in a location to detect a vehicle before it entered the intersection. The placement of only one loop at the crosswalk required the use of speed/distance calculations to determine where the vehicle may have been "X" amount of time before the photograph was taken (21). The use of any calculation that did not provide absolute information was feared to be susceptible to court challenges.

During a mini-demonstration program using the single-loop configuration, the system photographed too many vehicles that were not committing a red light violation. A second loop was installed which allowed the criteria of a minimum speed to be added to the system before the camera took a picture. The reasoning in adding a minimum speed criteria was that by calculating the vehicles speed, the system can determine if it is possible for the vehicle to stop before entering the intersection. The two loop system was successful in detecting red light violations and nearly eliminated the photographing of vehicles not committing violations.

Figure 3. First Picture Taken By Automated Enforcement System
(Courtesy of Howard County Police Department)

Figure 4 . Second Picture Taken By Automated Enforcement System
(Courtesy of Howard County Police Department)

A study completed in 1995 by Blackburn for the National Cooperative Highway Research Program identified six major manufacturers of red light violation detection systems (11). Fitzpatrick also listed the same six major manufacturers in research conducted at the Texas Transportation Institute in 1991 (22). Table 2 provides a listing of the red light violation enforcement systems identified in the research described above and the companies that manufacture them.

Table 2. Red light Violation Enforcement Systems Identified in Previous Research.

Company {Country} (Source)	Device	Sensor Type	Camera	Comments
Eltraff S.r.l. {Italy} (11,22)	Velomatic 103A	Inductive loops or coaxial cables.	Fujica FTIF	Attachments are used to convert Velomatic Speed Meter for use with red light violations.
[1]U.S. Public Technologies {United States} (23)	AutoPatrol RL-200	Inductive loops or piezoelectric sensors.	TC-1000 Trafficam	Unit may be installed as a single unit, or in conjunction with a second camera to photograph both the front and rear violating vehicles. Cameras can be exchanged with other automated enforcement applications (rail crossings, speed enforcement) that use the same manufacturer.
Traffipax-Vertrieb {West Germany} (24)	Traffiphot III	Inductive loops.	Traffiphot III	System has the capability to take either rear or frontal photographs. System was field tested in New York City.
Trans-Atlantic Equipment {South Africa} (11,22)	Trafficam	Roadway rubber tube sensors.	N.S.	Rubber tube sensors have approximately the same thickness as a pencil.
Truvelo Manufacturers {West Germany} (25)	Truvelo Combi	Inductive loops or piezoelectric sensors.	Robot Motorrecorder 36DCE	System has the capability to take either rear or frontal photographs. Company has been producing automated enforcement technology for 15 years.
Zellweger Uster AG {Switzerland} (11,22)	Multafot	Inductive loops.	Jacknau	System can be installed to take either rear or frontal photographs. The system was field tested in New York City and Pasadena, California.

[1]U.S. Public Technologies is the United States representative of the Dutch company Gatsometer B.V.

The use of 35-mm camera units also have the advantage of being portable. Although each intersection has to be equipped with the necessary sensors and connections to the traffic signal field box, several housing units for the camera can be placed at intersections without a camera actually

being in the unit. By having many housing units placed at different intersections, more areas per camera can be covered and drivers will not know which unit has a camera and which unit does not.

The Metropolitan Police in the United Kingdom apply the principle of rotation to its automated enforcement programs (26). The criteria for judging automated enforcement programs successful is a reduction in accident figures. To satisfy that criteria, 35-mm cameras are rotated with approximately one out of every eight of the 380 housings actually having a camera in it.

Video Cameras

Current technology would allow video cameras to be used as part of an automated enforcement program. When used with applications such as license plate recognition (LPR) to perform automatic vehicle identification (AVI), a central processing unit, and a storage subsystem to record information such as the date, time and location, video cameras will provide documentation in a very similar manner to 35-mm cameras. Video technology has not been used as frequently as 35-mm cameras for automated enforcement of red light violation programs because legislation and court precedence in many states does not support the use of video recordings as evidence (27).

The use of video cameras is very practical for jurisdictions that currently have laws forbidding the use of automated enforcement of red light violations and for areas seeking to establish a need for improved enforcement of red light violations. Intersections can be equipped with traffic surveillance video cameras that record the intersection when the signal changes to red. Recordings of an intersection by video cameras may be in either color or black and white, depending on how specific the data requirements are and the available funding for the project (black and white video cameras are less expensive than color video cameras). By recording intersections and viewing a large number of violations, evidence can be presented to officials about the severity of the red light running problem and a need for the implementation of programs addressing red light running can be established. The relatively inexpensive cost of traffic surveillance video cameras and the ability to move cameras to different locations with little cost will also give jurisdictions with a limited budget a means to begin a red light enforcement program that can be expanded to include automated enforcement using other types of cameras in the future.

Digital Cameras

Manufacturers of digital cameras are predicting new capabilities for automated enforcement of red light violation systems (26). Because the use of digital cameras is very new to the area of automated enforcement of red light violations, little information is available about field tests or implementations of digital camera applications. Although places such as Nebraska and Maryland are conducting or plan to conduct research using digital cameras, at the time this paper was written, results were not available (19, 27).

Due to the lack of digital camera applications at the present time, information from manufacturers of digital cameras will be used to discuss their capabilities and potential (26,28).

Digital cameras have the capability to produce higher resolution, more sharply detailed images of vehicles, and are equipped to prevent reflections or headlights from smearing the image. Photographs produced by digital cameras may be in color or black and white.

Along with producing better vehicle images, the major expected benefit of digital cameras is in improving the processing and distribution of notices of violation (tickets). Digital cameras have the capability to be linked using dedicated lines or existing phone lines to a computer located in a central facility. Once the images have been transferred from the digital cameras to the central facility, pattern and optical character algorithms can be used to determine the owner of the vehicle by cross-referencing the license number with records of vehicle registration databases (28). Once license plate numbers are successfully matched with registered vehicle owners, tickets can be automatically processed and mailed to violators.

The automation of image retrieval, violator identification, and ticket processing streamlines the traditional practice of having to have personnel to remove the film from the cameras, develop the film, run license plate matching algorithms, and prepare and mail tickets. The automation of the processing system that the use of digital cameras permits allows for a savings in the number of personnel needed and also eliminates potential errors made by humans when evaluating and handling the pictures manually. Because the pictures produced by digital cameras are created in a format that can be viewed on a computer screen, the need to have personnel to scan traditional photographs into a computer format is also eliminated. This allows more clear images to be produced and reduces the amount of time necessary to prepare images to be shown on monitors in the court room.

The configuration of digital camera applications will be very similar to the one described for applications using 35-mm cameras. As with 35-mm cameras, digital cameras will be placed in protective housings atop poles. Sensors will be placed in the pavement in the same manner as for 35-mm applications, with two sets of sensors per lane to detect vehicle presence and speeds. The cameras will be wired to the signal controller and the loop sensors so when the signal turns red, the system becomes active. When a vehicle traveling over the allowed range of 15 to 20 miles per hour crosses the sensors, two pictures will be taken. Again, the first picture will be before the entrance to the intersection, usually the cross-walk or the stop bar, and the second picture will be a preset time later, usually 0.5 to 0.9 second later, with the vehicle in the intersection.

Ticket Processing

Computer software packages have been developed or are being developed to assist in the processing and creation of notices of violation (tickets). CITEWARE is a Windows™ based program created by U.S. Public Technologies (USPT) that is designed to be a cost-effective way to process the photographs taken by automated enforcement cameras (23). After the film from the cameras is developed, it is scanned into the program. Once the film is scanned into the program, an operator enters the enlarged picture of the vehicle's license plate and a match of the registration is made using motor vehicle records or other databases. CITEWARE prints the ticket and records the violation so that it can easily be accessed if it is challenged in Court.

CITEWARE also has the ability to generate a statistical analysis of the automated enforcement program. This feature is very useful in measuring the effectiveness of the program and providing interested people (government officials, news media) with detailed information about the program.

STUDY DESIGN

In order to provide current information and fill voids that were present in the existing literature, a survey of state and local jurisdictions with experience using automated enforcement systems in the United States was conducted. The survey was completed through a combination of telephone conversations and fax transmissions. Five of the six areas contacted completed the survey. Survey questions sent to individuals associated with automated enforcement programs for red light violations included the following questions:

1. What type of automated enforcement technology is your organization using and who was the manufacturer of the equipment? How long has the system been in operation?

2. Have there been any operational problems associated with the location of the system, the effects of glare at certain hours of the day, inclement weather, the type of camera being used, the visibility of the camera at intersections, or other factors? If so, please describe.

3. What was the cost of the system? Was the system purchase, leased, or given to the agency in exchange for a percentage of the fines collected?

4. How does your agency process citations? Does your agency use computer software packages (i.e. CITEWARE) for the purpose of license plate identification? Did additional staffing take place as the result of automated enforcement?

5. How much enforcement is done using automated enforcement in relation to how much is done using traditional enforcement methods? (e.g., 30% automated enforcement vs 70% with police officers; 6 automated locations vs 200 enforcement officers)

6. Has a reduction in red light violations occurred since the initiation of the automated enforcement program? (e.g. 30% reduction)

7. Were there any political or social issues that arose due to the use of automated enforcement? Was any legislation required to initiate or operate the red light automated enforcement technology? Was any legislation changed in regard to how red light violations were classified (e.g. civil infraction, misdemeanor offense, vicarious liability provisions)? If so, please describe the required legislation and the process to have the legislation enacted.

8. Were any attempts made to educate or inform the court system about the effects of red light violations on accidents or the public benefits of an automated enforcement program? If so, please describe.

9. Were any attempts made to educate or inform the public about the effects of red light violations on accidents or the public benefits of an automated enforcement program? Are advanced notice signs required at intersections using automated enforcement? If so, please describe.

Little information is available describing the methods used by police officers to enforce red light violations and the emphasis that is placed on red light violations. To gain an understanding of the issue of red light violations from a law enforcement perspective, a small survey of police officers was performed. From the five police departments that were contacted, three completed the survey. The survey was completed through a combination of personal interviews, telephone conversations, and fax transmissions. Survey questions sent to police departments included the following questions:

1. What emphasis, high or low, do you place on enforcing failure to stop at red signals (exclude right-turns on red) and why?

2. What percent of citations issued during the past 6 months were for driving through a red traffic signal? Please distinguish between violations of right-turns on red and other violations.

3. Are officers specifically assigned the task of enforcing traffic signal compliance? If yes, what prompts the assignment: complaints, patterns of high crashes, or special grants?

4. How many officers are normally assigned to enforce red light violations?

5. How many minutes, on the average, does an officer spend enforcing a red light violation from the time of detection, until the officer is finished handling the violator?

6. How many minutes, on the average, are spent by an officer preparing for and attending court for a simple traffic law violation, such as a violation of a red traffic signal?

7. What percent of citations for disobeying a red signal are challenged in court? What percent of these violations are dismissed or found not guilty by the court? What is the most common reason for violations being dismissed or an individual being found not guilty?

Contacting individuals knowledgeable about the use of automated enforcement technology for red light violations also resulted in the accumulation of materials relevant to the subject area such as journal references, newspaper articles, and actual photographs from automated enforcement systems. Information was also collected using the following methods:

- Meetings with members of the Institute of Transportation Engineers (ITE) technical committee on automated enforcement;
- A computerized literature search by the Transportation Research Information Service (TRIS);
- A search of the world-wide-web; and
- Telephone conversations with automated enforcement technology vendors.

The results of the surveys, conversations with individuals knowledgeable about automated enforcement, and the information obtained were incorporated into this report and were used to develop the strategies for implementing an automated enforcement program for red light violations and developing the hypothetical case study used to apply the implementation strategies.

APPLICATIONS OF AUTOMATED ENFORCEMENT PROGRAMS

This section reviews applications of automated enforcement of red light violation systems. The section begins with a review of applications from the United States located in New York City, New York, Polk County, Florida, Howard County, Maryland, San Francisco, California, and Lincoln, Nebraska. The review of applications focuses on public relations and involvement, the type of legislation proposed or enacted to accompany deployment, the technology being used, operational issues that arose from the use of the technology, and the results of the automated enforcement program.

Applications abroad from Ontario, Canada, and Victoria, Australia are also reviewed in this section. Although information for these applications is not as detailed as for the applications in the United States, the information that is provided is very valuable in presenting details and issues that should be addressed when creating and implementing a program for the automated enforcement of red light violations. This section combines information derived from the literature review and telephone interviews and surveys completed by individuals from both the transportation profession and law enforcement profession knowledgeable in the area of automated enforcement for red light violations.

New York City, New York

New York City has the oldest and currently the largest automated enforcement of red light violation program in the United States. The program began operation in 1993 and is installed at 18 intersections. The Chief of the Red Light Camera Program for New York City, Rudolph E. Popolizio, has also published several articles detailing many aspects of the system. The New York City Department of Transportation (DOT) began researching red light camera technology in the early 1980s in an attempt to become educated about the programs being used in Europe and Australia (21).

The primary guideline in establishing an automated enforcement system for red light violations was that the system had to operate in a stand-alone mode that did not interfere with any existing vehicle summonsing or tracking procedure (21). This guideline was viewed as essential because of the need to track each notice of liability and the revenue that was produced. By making the system self-sufficient and trackable, officials reasoned that the number of administrative errors would be reduced and the revenue from the system could be carefully reviewed and recorded.

The contract for the automated enforcement program between New York City and Electronic Data Systems (EDS), the technology vendor, stated that the program would operate “at no cost to the City”. The contract was based on the premise that the revenue gained from the payment of violations would offset the costs paid by the city for the system. A contract of $8,440,000 was agreed upon with the City adding a cost of $5,460,000 for operations bringing the total cost for the three and a half year contract to $13,900,000.

Public Involvement

No efforts were made to educate or inform the public about the effects of red light violations on accidents. The use of automated enforcement for red light violations was also not publicized and advanced notice signs at intersections using automated enforcement technology are not required.

Legislation Enacted

Before the Request For Proposal (RFP) could be advertised, a state law had to be enacted allowing for the use of automated enforcement technology for red light violations. When considering whether to use frontal photography to identify drivers or to use rear view photos, the issue of driver privacy lead to the decision to pursue only rear photography (21). The use of rear photography meant that the violation would be classified in the same manner as a parking ticket. By classifying the violation as a non-moving violation, the enacted legislation had to place responsibility for the violation on the registered owner of the vehicle.

The law passed by the State of New York allowed any city with a population of over one million people to implement and operate a demonstration project limited to 50 intersections using automated enforcement technology for traffic control violations (29). The law contained the provision that the owner of the vehicle would be held responsible for violations recorded by automated enforcement systems, but that the violation would not be a conviction against the owner and would not become part of the owner's operating record. Provisions allowing for notices of liability to be mailed, the owner of the vehicle to be assessed a monetary fine, and the owner of the vehicle to contest the violation were also contained in the law.

A "Sunset Provision" that places a time limit on the program is also written into the legislation. This provision states that the legislation will expire on a specified date unless it is extended by state legislation. The first date for expiration was December of 1996. The legislation has been extended and the expiration date currently stands at December of 1999.

Technology

The company that manufactured the technology used in New York City was Traffipax-Vertrieb from Germany. The camera used for the system was the Robot 35-mm camera. As described previously in Section 4, Technology, and shown in Figure 2, two loops per lane were placed in the pavement, a three tenths of a second (0.3 sec) buffer was allowed, and the minimum speed criterion of 15 miles per hour for vehicles to be photographed was included in the system.

Although cameras have shown some wear, the replacement of gears, bushing rings, and flash units on all the cameras have solved this problem (21). No effects from climate were found on the cameras from winter operation. Modifications to the software used to process violations and track notices of violation have also been made when necessary without disrupting the operating system.

Data Processing

In order to process the information obtained from the automated enforcement system, people were hired to form a photograph viewing staff and additional employees were hired to the adjudicating staff. The photograph viewing staff is responsible for viewing the photographs taken by the system, determining if the photographs are of the quality needed, and preparing notices of violation to be sent. The adjudicating staff is needed to give the public the opportunity to appeal the violations. Because of budget constraints, only one help center, located in Manhattan, is open exclusively for the automated enforcement program. When the program expands, it is expected that more centers will be opened throughout the city.

Operational Problems

The presence of parking lanes affected the ability of cameras to provide a clear picture of intersections (21). Double parked trucks also blocked the view cameras had of intersections. To combat the problem of the intersections being blocked, the cameras were placed on large "mast arm installations" that were sixteen feet high and extended out about eight feet from the curb. This was in contrast to the standard camera set-up that was ten feet in the air and two feet from the curb.

Glare produced from the flash of the cameras has also presented some problems with photograph clarity. To combat this problem, different flash intensities and configurations are being researched. Short term glare problems from rain at night are also a problem.

Program Results

Violations at intersections using automated enforcement technology have decreased by 20 percent since the program was initiated. Statistics about the program show that 65 percent of the violators pay the fine in response to the first notice of violation that is sent. The revenue that was collected during the three year period, $18.5 million, was also greater than the $15.5 million total cost of the project over the three year contractual period.

The success of the program has lead to the extension of the legislation enabling the use of automated enforcement for red light violations. New York City also plans to expand its program by 12 cameras in the near future.

Polk County, Florida

Polk County, Florida began using automated enforcement technology for red light violations in September of 1994 as part of a Federal Highway Administration (FHWA) demonstration project. Systems were placed in Fort Meade, Haines City, and Lakeland. The demonstration was conducted in different environments that included a multi-lane divided highway with heavy concentrations of through traffic, a heavily traveled downtown corridor, a medium size city, and a small rural community. The cameras for the system were leased or placed on loan from the FHWA (9).

Public Involvement

As part of the automated enforcement campaign, a public education program was initiated. The program was funded by the FHWA and followed the suggestions given in the Red Light Running Program Strategic Planning Guide (6). The goal of the program was to reinforce the problems and dangers associated with red light running. Advanced warning signs were placed prior to intersections where automated enforcement cameras were being used.

Legislation Enacted

Florida does not currently have a law which permits the issuance of citations for automated enforcement of red light violations. Legislation has been introduced for five successive sessions of the legislature and has not been successfully enacted. Warning letters are mailed to drivers who are caught running red lights by automated enforcement systems.

Technology

Three vendors originally participated in the demonstration project started in 1994. American Traffic Systems of Scottsdale, Arizona, U.S. Public Technologies of San Diego, California, and Truvelo of South Africa were all assigned location in the participating cities. Currently, only the Truvelo system is still in place. Cameras photograph vehicles from the front and rear and record the time, date, speed, lane location, time since the light was red, and photo identification number (30).

Data Processing

Data processing was completed by members of the County's automated enforcement program. Information to identify violators is obtained by manually matching photographs of license plates with records from the state department of motor vehicles. Additional staffing took place on a temporary basis to assist in processing information and preparing and mailing warning notices. Volunteers were also utilized to assist in data processing.

Operational Problems

Overall, the cameras have performed in a satisfactory manner (9). Because Florida has a high volume of tourist and winter resident population, many different license plate colors and configurations from different states are present. The presence of so many different types of license plates has made it difficult to set the filters to handle the different reflectivity and configuration characteristics. Although the presence of many different types of out-of-state license plates has made the process of vehicle identification difficult, violations are sent to vehicle owners that are able to be matched with registration records. Florida has also experienced some problems with large trucks in the lane closest to the camera blocking the camera's ability to clearly photograph the intersection.

Program Results

Statistics are not currently available concerning if a reduction in red light violations has taken place since the initiation of the automated enforcement program. Because legislation has yet to be passed allowing for the issuance of monetary fines, only warning notices can be mailed to violators. The project has served to heighten awareness among the motoring public about the problems associated with red light running and the increased risk of apprehension at the four intersections (9).

Howard County, Maryland

The State of Maryland has identified vehicles running red lights as a serious problem that must be addressed. The percentage of accidents in which running a red light was listed as the primary cause has increased steadily since 1983 (7). Running a red light is the reported cause of between 3,500 and 4,500 traffic accidents annually, with 20 to 30 of those crashes resulting in at least one fatality (7). In Howard County, Maryland, the Police Department receives the most frequent complaints about traffic violations with citizen concerns about vehicles running red lights being one of the top two reoccurring themes (31).

As discussed in Section 2, Background, the Maryland State Highway Administration joined with State and local law enforcement agencies to address the dangerous increasing trend in red light violations by using the team enforcement method (7). Although the team enforcement concept was successful, it was also very expensive. A recent cost analysis conducted by the Police Department showed that the team enforcement approach resulted in a personnel cost of $25.40 for every red light violation citation issued (31). Experience has also shown that only frequently repeated enforcement efforts have a positive impact on reducing the number of observed violations.

Due to the high cost of the team method and the need for frequent enforcement of intersections, Howard County began exploring other means of enforcement. Through funding granted by the Federal Highway Administration, Howard County field tested two cameras from March of 1996 to March of 1997. Because Howard County wanted to know the true capabilities of the system and the maintenance and manpower associated with operating an automated enforcement system, the decision was made to rent the cameras and equipment only and not to contract out the duties of film loading, unloading, and developing and the issuing of warning notices.

Public Involvement

A significant public awareness and education program was conducted as part of the effort to make drivers aware of the danger posed to both other drivers and to the driver who runs the red light. The television ads and the radio announcements were created by a professional ad firm. To get the message out to many people, the ads were run during major events. An example of this effort was the fact that television ads were run during the National Football League conference championship games. Volvo also participated in the public education/awareness effort by running short announcements about the dangers of red light running at the conclusion of each of its commercials.

The possibility of using automated enforcement technology to enforce red light violations has also been covered by the media and advertised during the camera test period. Signs were posted on roadways that contained cameras, but the exact location of the intersections was not publicized. Many editorials have been sent to newspapers showing strong support for the use of cameras to combat the problem. During the test period, warning notices were sent to vehicle owners informing them that they had committed a violation and showing the photographs taken by the cameras. The warning notices also contained a phone number to address concerns or questions about the program and during the test period reaction to the system was very positive.

The goal of the public education/awareness programs was to change peoples' opinions about the enforcement of red light violations. In a questionnaire issued in 1996, Howard County residents were asked the question: "Out of 100 drivers who run a red light in Howard County, how many do you think will actually be stopped or ticketed by the police?" The majority of the people responded with an answer of two or less people would receive a citation for the violation (31).

Legislation Enacted

An attempt was first made in Maryland to pass a statewide law without a Sunset provision that allowed for the mailing of violations to drivers. Although the bill passed through the House Committee, it failed in a general House vote. A similar bill also failed in Committee of the Maryland Senate. According to a Howard County official, the reason that the bills failed is because the effort to pass the bills was not unified and counties were not aware that the bills were being considered (19).

House Bill 391 allows for the use of automated enforcement technology for red light violations effective October 1, 1997. The Bill states that "the owner of a motor vehicle is subject to a civil penalty if the motor vehicle is recorded by a traffic control signal monitoring system" (32). A traffic signal monitoring system is defined as "a device with one or more motor vehicle sensors working in conjunction with a traffic signal to produce recorded images of motor vehicles entering an intersection against a red signal indication". House Bill 391 also allows for citations to be mailed to offenders and does not contain a Sunset provision. The Bill establishes that the registered owner of the vehicle will be held responsible for the violation and that rear photography of the license plate will be used. Also defined is that the civil penalty may not exceed $100 and that citations must be mailed within two weeks of the alleged violation (32).

Technology

The technology being used is manufactured by Gatsometer B.V. and the specific camera being used is a Robot Industrial High Speed Camera with a 100 foot film pack. U.S. Public Technologies is the representative for Gatsometer B.V. in the United States. The sensor configuration and location is very similar to the configuration used in New York City where two loops per lane were placed in the pavement, a three tenths of a second (0.3 sec) buffer was allowed, and the minimum speed

criterion of 20 miles per hour for vehicles to be photographed was included in the system.

Data Processing

The Police Department had the responsibility of operating the cameras, processing the film, and preparing notices of violation. It was possible to assign the Police Department with those tasks because of the small nature of the demonstration project (only two locations). Even with the small nature of the project, data quickly accumulated and the need for a formal processing technique became evident. Research is being conducted by the Police Department to determine how to best process violations for future programs. It is believed that portions of the data processing task will be contracted out, but that the Police Department will still have a role in determining what constitutes a violation.

Operational Problems

The major problem with the use of the automated enforcement system involved glare from the highly reflective Maryland license plates affecting the quality of the photographs taken from the camera. Glare presented the most significant problems in the winter time with lower angles of the sun hitting the plates and at night. Glare also affected many of the photographs because of the equipment being used in Howard County to identify vehicle license plates. In Howard County, the license plates were being magnified for clarity, whereas the technology exists to use equipment that can change the contrast of the photograph to make the license plate more clear.

Servicing the cameras also presented a significant problem for the program. Being responsible for the operation and maintenance of the cameras and for the loading, unloading, and processing of the camera film was very manpower intensive. Many work hours were also spent matching violations and preparing and mailing notices of violation.

Program Results

Although only warnings were issued in the notice of violations that were mailed to drivers who ran red lights, a significant decrease in the number of violations at intersections equipped with automated enforcement technology resulted. Before the public was made aware of the automated enforcement technology and its purpose, the system was used to gather information about the number of violations occurring at the study intersections. Analysis of the data collected at the study intersections showed that the number of violations remained relatively constant from Monday through Friday with one intersection experiencing approximately 90 violations a day and the other intersection experiencing approximately 24 violations a day. The combination of mailing warning notices to violators and the public education and awareness campaign resulted in a reduction in the number of violations from 90 to 60 per day and from 24 to 18 violations per day. Overall, a 23 percent reduction in the number of violations took place (33).

The positive results of the demonstration program and the passing of legislation allowing for

the issuing of notices of violation that fine the owner of vehicles that are photographed running red lights has lead Howard County to plan on expanding its automated enforcement program. An unsolicited proposal by the Federal Highway Administration has also been answered by Howard County to test the capabilities and limitations of digital cameras for use with other automated enforcement technology.

In planning for the future installation of automated enforcement technology, Howard County is taking steps to ensure that the resources it dedicates to the program will be used in the most efficient manner. Intersections that are candidates for the use of automated enforcement technology to record red light violations include intersections with a high accident rate, locations where public complaints are high, and intersections where highly publicized accidents have occurred. Traffic engineers determine if engineering factors (poor signal timing, bad intersection geometry, limited sight distance) are the cause of high accident rates or if the accident history is the result of red light violations.

San Francisco, California

The city of San Francisco, California estimates that red light violations cause approximately 1,000 reported accidents annually which account for nine percent of all reported accidents and 17 percent of all reported accidents where an injury occurs (34). A conservative estimated cost to the city for the accidents that result from red light violations is $21 million. In enforcing red light violations, the San Francisco Police Department issues over 15,000 citations annually.

In 1996, San Francisco initiated a pilot study to determine the feasibility of using automated enforcement technology to combat the problem of red light violations. Three vendors were invited to compare and contrast the different types of technology and methods used for processing tickets and tracking violations. One vendor quickly declined to proceed, and the two vendors that participated in the program where EDS and US Public Technologies. Currently, US Public Technologies is the only vendor participating in the project.

Public Involvement

In addition to addressing the frequency and costs of the red light running problem in San Francisco, the use of automated enforcement technology to enforce violations resulted from public outcry over a particular incident. The incident involved a vehicle that ran a red light and smashed into a group of people waiting at a bus stop. Several fatalities resulted from the incident and intense pressure was placed upon politicians to address the problem of red light violations.

The high profile accident resulted in subsequent incidents involving red light violations to be magnified. A large scale public education campaign was begun to inform drivers about the dangers of running red lights. The education campaign included billboards, radio announcements, and the creation of slogans such as “RED Means STOP” to draw public attention to the issue.

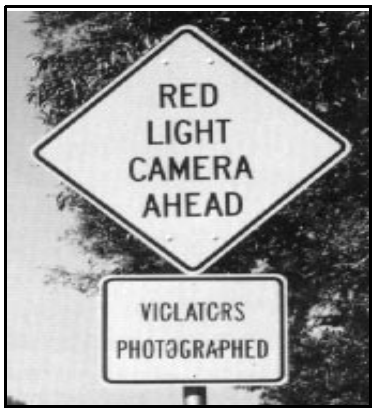

Figure 5. Warning Sign
(36)

The initiation of the automated enforcement program received mostly positive coverage from the newspapers and local television news stations. To test the system and make drivers aware of the program, warning notices showing drivers committing a violation were mailed. Street signs placed in advance of intersections are also required to let the public know that automated enforcement technology is being used at that specific intersection. Figure 5 shows a warning sign placed before intersections (35).

Legislation Enacted

The State Legislature amended the California Vehicle Code in 1996 (SB833) to permit the use of "automated enforcement" for red light violations (34). In amending the California Vehicle Code, the attitude of the State Legislature was that red light violations are a very serious problem and have to be addressed as such. The seriousness of the problem and the political atmosphere resulting from recent fatalities caused the Legislature to decide that red light violations had to be judged as moving violations so that fines could be issued and points could be added to a driver's record.

The decision to enforce red light violations as a moving violation required that the driver of the vehicle be positively identified. To identify drivers using automated enforcement, frontal photography had to be used. Once a driver is positively identified, the Police Department signs the violation and it is mailed to the violator. The violation has to be mailed 15 days from the date of the violation. If a driver does not respond to the violation, the Department of Motor Vehicles is contacted and instructed to withhold the issuance or renewal of the driver's license.

The original amendment to the California Vehicle Code in 1996 (SB833) allotted $17.50 from the fine of $104.00 to the vendor as compensation for the cost of the cameras, film and citation processing, statistical and data analyses, and follow-up court liaison and support (36). In order to expand the current automated enforcement program of four locations, legislation is currently before the State Senate to increase the fine to $271.00 for the violation of a red light. Assembly Bill 1191,

commonly referred to as the Shelley Bill, has been approved by the State Assembly and its enactment is viewed as essential for funding future automated enforcement efforts.

Passage of the Shelley Bill will allow for the revenue received from the automated enforcement program to be distributed in a more balanced manner between the State, County, and City. Specifically, $80 per violation will be set aside for the purpose of furthering the automated enforcement program which will be expanded by approximately 25 intersections (34). It is also believed that the increase in the fine and the publicity generated by the increase will serve as a further deterrent to running red lights. A previous measure in San Francisco of raising the fine imposed on motorists parking at bus stops to $250 was very successful in reducing violations (37).

Technology

As stated previously, two vendors, Electronic Data Systems (EDS) and U.S. Public Technologies, Inc., initially provided the technology for the project. Currently, only U.S. Public Technologies is involved with the project. The technology being used is manufactured by Gatsometer B.V. and the specific camera being used is a Robot Industrial High Speed Camera. The sensor configuration and location is very similar to the configuration used in New York City where two loops per lane were placed in the pavement, a three tenths of a second (0.3 sec) buffer was allowed, and the minimum speed criterion of 15 miles per hour for vehicles to be photographed was included in the system.

Data Processing

The legislative requirement that vehicle drivers must be positively identified using frontal photography in order for a violation to be sent makes the task of data processing very important and very labor intensive. In order to identify drivers, photographs of the driver and the vehicle license plate must be matched against Division of Motor Vehicle (DMV) records. In San Francisco, the vendor, U.S. Public Technologies, is responsible for determining, matching, and printing out violations. To assist in this process, U.S. Public Technologies developed the software package CITEWARE that allows for a more efficient issuing of citations.

The small number of cameras installed for the demonstration project has not resulted in staff increases. Should the Shelley Bill become law, additional staffing of the department of traffic, municipal court, and police department will be necessary to handle the large number of violations that will be recorded as a result of program expansion.

Operational Problems

Several factors have limited the effectiveness of the photographs taken by the automated enforcement cameras. Statistics show that about 20 percent of the photographed violations cannot be matched with vehicle records because the vehicles do not have front license plates (38). Although San Francisco law requires vehicles to have a front license plate, the law is rarely enforced. An

additional 10 to 15 percent of the photographed violations are also not matched because the photographs are affected by glare.

The requirement of frontal photography for driver identification also poses several problems. The use of sun visors and the location of rear-view mirrors in vehicles can prevent the identification of drivers. Gender differentiation has also been very difficult in identifying drivers. Other problems associated with the automated enforcement program include:

- Low quality photographs resulting from the very reflective California license plates;
- Difficulty identifying the driver using night time photography; and
- The inability of the system to operate in the fog (especially near the ocean).

Program Results

The number of vehicles photographed running red lights at intersections using automated enforcement technology has dropped by over 40 percent since police started issuing citations in October of 1996 (34). The 40 percent decrease in violations was calculated using data collected by the automated enforcement system (38). A ratio of the number of vehicles photographed running the red light to the number of vehicles proceeding through the monitored approach (obtained from vehicles passing over loops) is taken for each intersection included in the program and averaged together at the end of each month. At the end of a six month period (in this case from November of 1996 until the end of April 1997) , the averaged ratio of violators to through vehicles for the first month (November) is compared to the averaged ratio for the sixth month (April) to determine the percent reduction of red light violations.

Approximately 30 percent of all violations that are photographed by the automated enforcement system are matched with a driver and result in the issuing of a citation. Of the citations that are issued, 42 percent of the people elect to pay the fine, 30 percent opt to attend traffic school (still have to pay the fine, no points assessed to drivers license), 18 percent are dismissed from court (mostly by claiming they are not the person in the photograph), five percent try to dispute the violation but are found guilty, and five percent of the people cited do not respond (38).

The reduction in vehicles running red lights at intersections with automated enforcement systems has lead officials to submit a request for proposal (RFP) to expand the program by at least 20 intersections by early 1998. The passage of the Shelly Bill will allow San Francisco to continue to operate and expand its automated enforcement program. In an attempt to expand the enforcement capabilities of the program, legislation placing responsibility for red light violations on the owner of the vehicle when the driver cannot be identified is being considered. The violation for drivers that can be identified would remain a moving violation with points being assessed to the driver's license, while the violation when drivers of the vehicle cannot be identified would result in the owner of the vehicle receiving a nonmoving violation that does not assess points to the driver's license.

Lincoln, Nebraska

The automated enforcement system in Lincoln, Nebraska was operational from January of 1997 to April of 1997. The purpose of the system was to collect data only and funding to purchase the system came from the State Department of Roads and the Mid-America Transportation Center at the University of Nebraska. Although the system was intended to only collect data, the high visibility of the cameras resulted in the public being unsure of their purpose. Many people thought that the cameras were being used to identify and ticket violators (39).

Public Involvement

Officials in Lincoln had become increasingly concerned over the number of red light violations that were occurring in the city. To make the public more aware of the severity of the problem and the danger that running red lights presented, a public awareness campaign was initiated. The campaign consisted of public service announcements on television and on the radio and the use of billboards. The intention of the program was to educate the public about red light violations, not to inform them about the use of automated enforcement technology.

Legislation Enacted

Legislation allowing for the use of automated enforcement technology for the purpose of enforcing traffic violations is currently pending in the Nebraska Unicameral (LB 881 - Nebraska Rules of the Road). Under the legislation, the registered owner of the vehicle is held responsible for violations detected from automated enforcement technologies. The original legislation contained a provision allowing the registered owner of the vehicle who claimed that he/she was not driving the vehicle to file an affidavit which identified the driver of the vehicle. By filing the affidavit, prosecution of the registered owner was prohibited. This provision was removed by the adoption of an amendment (40).

Technology

The technology used consisted of purchased video cameras that were configured and installed by the research staff. The video cameras are manufactured by Cohu, Inc. and were purchased from Ruyle and Associates. For this system, no loop detectors or sensors were placed in the pavement. Instead, the video cameras were mounted on the street light poles to capture an overhead view of the traffic lanes as was recommended by previous studies using similar technology (39).

The goal of using the video cameras was to measure the elapsed time when vehicles entered the intersection after the onset of the yellow/red phase and to measure the average speeds at which those same vehicles went through the intersection (39). In order to avoid using two cameras per approach and still be aware of when the signal had changed from yellow to red, the recording unit was located in the signal control cabinet and connected to both the camera and a DC driven logic board that was also located in the signal control cabinet. Each time the signal changed, a sound signal was emitted

(a different pitch was emitted for each signal termination) and recorded by the video recorder through the sound input port. A time/date generator was also connected to the video recording unit to stamp the time and date at the bottom of the video display. Figure 6 shows a diagram of the system used.

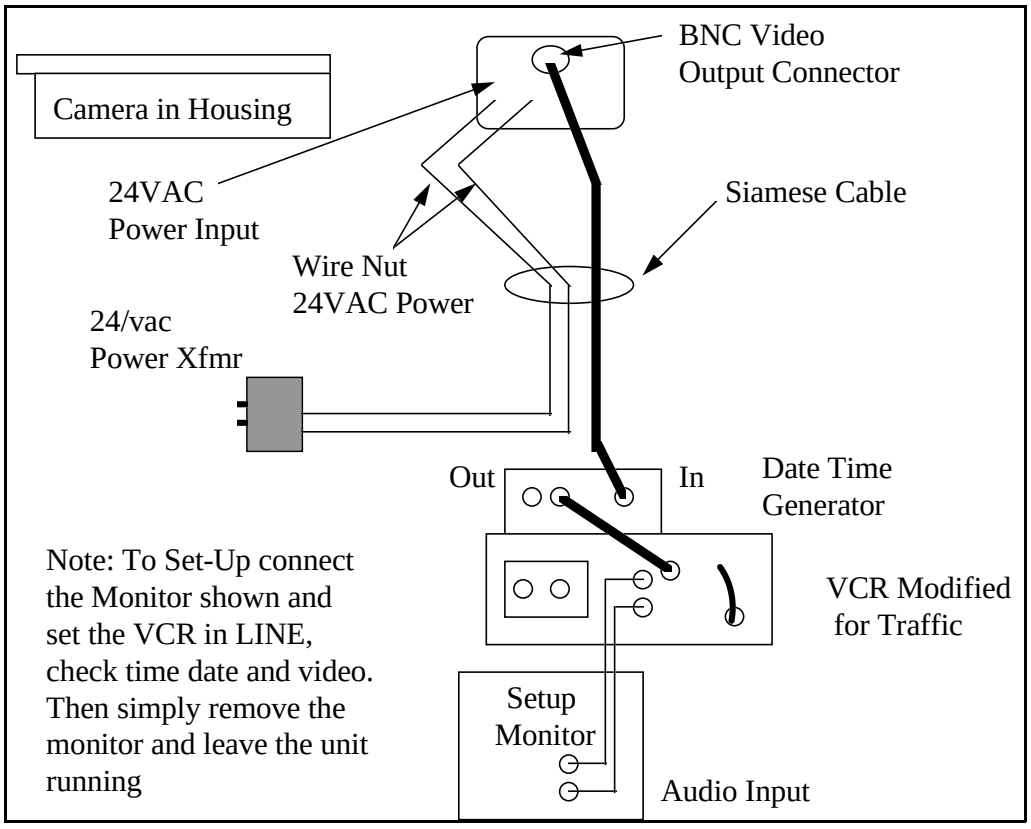

Figure 6. Video Equipment Configuration Used in Nebraska (39)

Data Processing

Data was collected at each of the six study sites during the morning peak period (7:00 am to 9:00 am), the off-peak period (11:00 am to 1:00 pm), and the afternoon peak period (4:00 pm to 6:00 pm). Because of the number of cameras purchased, data was collected for three intersections at a time. At the beginning of each study period, a member of the research team had to activate the system, insert a blank video tape, and turn the recording unit on and at the end of each session, the video tape had to be retrieved and the system was shut off. In order to extract the desired information from the video tapes, an observer had to carefully view the tapes and record several observations.

Operational Problems

Several problems occurred with both the installation and operation of the video camera system. Because the system was installed in January, problems were encountered getting the necessary wires through conduits that were blocked by ice and a concern over the ability of the recording equipment to operate in low temperatures also existed. To ensure that the video recording system would not have to operate in low temperatures, a 300 watt light was added to the field cabinet to produce heat.

Glare problems that did not allow references points to be visible on the tape were also experienced by the system. Glare was especially a problem when recording east-west approaches. Problems with other weather related elements were not documented because the cameras were only operated during dry pavement conditions.

Program Results

Although preliminary results of the study have shown a significant decrease in the number of red light violations (as compared to manual counts performed before the installation of the camera) at intersections where the cameras are present, final conclusions about the study have not been made. The preliminary results of the study have gained the attention of police departments in the area. With the pending passage of legislation enabling automated enforcement for red light violations, police departments are currently researching the possibilities of investing in an automated enforcement system that can issue violations. Research on the use of digital cameras for several applications is also being conducted.

Ontario, Canada

Political Issues

Ontario, Canada began using automated enforcement technology for speed limit violations in 1994 (41). The Highway Traffic Act, which allowed for the use of automated enforcement technology to enforce traffic violations, contained provisions that stated that the government had to approve of the areas where automated enforcement could be used. The use of automated enforcement technology for speed limit violations was not popular with the public and received mixed reviews in the media.

Due to the unpopularity of the use of automated enforcement technology for speed limit violations, a group opposing the acting government in the upcoming political election included the position that automated enforcement programs would be stopped if they won the election. When the group won election in 1995, they quickly revoked the power of the Highway Traffic Act by not approving of any areas for the use of automated enforcement. This action eliminated the possibility of using automated enforcement technology for red light violations.

Victoria, Australia

Australia has used automated enforcement technology for red light violations since 1979 (1). In Victoria, automated enforcement systems were installed to reduce the number of collisions occurring as a result of motorists running red lights (42). The program began with a six month demonstration period in 1981 and was implemented in August 1983 when the Road Traffic Authority purchased ten cameras to be used for an automated enforcement program. Currently, the automated enforcement program for red light violations incorporates 35 cameras that are rotated through 132 sites throughout the Melbourne metropolitan area.

Technology

The technology being used in Victoria is manufactured by Gatsometer B.V. and the specific system is the Type 36 MSG (42). The sensor configuration of the system uses vehicle detection induction loops that are set in the pavement. The loops are placed as close as possible to the stop line, usually between the stop line and the first pedestrian crossing line.

The system becomes active when a vehicle crosses a loop 0.9 seconds after the traffic signal has changed to red. When a violation is detected, two photographs are taken one second apart. The first photograph is taken of the rear of the vehicle as it crosses the sensor and the second photograph shows if the vehicle stopped or if it continued through the intersection.

Data Processing

After unloading the film from the camera, a police officer seals it in a secure bar coded canister and takes it to the Traffic Camera Office (T.C.O.). The T.C.O. forwards the sealed canisters to a photographic laboratory for the photographs to be developed and printed and then reviews the photographs to ensure that no interference with the pictures took place. Details from the photograph that are stamped by the automated enforcement system are then entered into a computer and the photographs are reviewed by a Verification Officer.

If the decision is made that a violation has occurred, the information is retrieved from the database of the Roads Corporation Victoria. When information from the photographs is matched with registration information, a Traffic Infringement Notice (T.I.N.) is processed. T.I.N.s are processed using the Traffic Infringement Management System (T.I.M.S.©).

Program Results

An independent evaluation of the automated enforcement program was performed in 1988 by David Souths in order to judge the effectiveness of the program (42). The report stated that the use of automated enforcement technology resulted in over a 30 percent reduction in right angle accidents. A 10.4 percent reduction in the number of casualties resulting from accidents was also reported.

A different evaluation of the program reported that red light cameras reduced the incidents of red light violations by 35 to 60 percent (1). The same report also stated that right-angle accidents were reduced by 32 percent, right-angle turning accidents decreased by 25 percent, rear-end accidents decreased by 30.8 percent, and an increase in rear-end turning accidents of 28.2 percent occurred.

Summary of Applications

Based on the findings of this research, the use of automated enforcement technology for red light violations was effective in reducing the number of red light violations that occur at intersections. Although each application reviewed for this study is unique in its operating conditions, all of the applications that maintained statistics about the effectiveness of the program reported a decrease in the number of red light violations occurring at intersections equipped with automated enforcement technology. Table 3 provides a description of the applications reviewed for this research.

Table 3. Description of Automated Enforcement Applications

Location	Number of Locations	Year Installed	Legislation Present	Type of Photography/ Individual Responsible	Reduction in Violations
New York City, NY	18	1993	New York State Law Section 111-a	Rear photography/ Owner responsible	20%
Polk County, FL[1]	4	1994	None	Front & rear photography/ Owner responsible	N/A
Howard County, MD	2	1996	House Bill 391	Rear photography/ Owner responsible	23%
San Francisco, CA	4	1996	State Bill 833; Shelley Bill Pending	Frontal photography/ Driver responsible[2]	40%
Lincoln, NE[3]	3	1997	Legislative Bill 881 Pending	N/A	N/A
Victoria, Australia	132[4]	1983	Road Safety Strategy	Rear photography/ Owner responsible	30%

[1]Only warning notices issued, statistics about program not available.
[2]Driver must be positively identified from photograph to be held responsible.
[3]System used only to collect data.
[4]Thirty-five cameras rotated through 132 sites.

The following conclusions can also be made from the applications reviewed for this research:

- The implementation and continued operation of automated enforcement programs for red light violations in Victoria, Australia (since 1983) and New York City, NY (since 1993) has proven that the overall benefits of an automated enforcement program are acceptable to local governments, law enforcement agencies, and contracted vendors who support the costs of implementing, operating, and maintaining such programs.

- The programs in Polk County, FL and Ontario, Canada are examples of the importance of legislation allowing for the use of automated enforcement technology and processes. Because legislation has failed to be passed in Polk County, the system is limited to issuing warning notices. After the authority of the legislation passed in Ontario was revoked, the use of automated enforcement systems was prohibited.

- The program in Lincoln, NE shows how the use of video cameras recording a high number of red light violations can lead police to consider the use of automated enforcement systems.

- More recent programs such as Howard County and San Francisco also show that the use of automated enforcement for red light violations is becoming a publicly accepted method to address the problem of red light violations at intersections.

IMPLEMENTATION STRATEGIES

Strategies developed to assist jurisdictions in the creation and implementation of programs for the automated enforcement of red light violations are presented in this section. In order for an automated enforcement of red light violations program to be successful, many political, economic, and social issues must be addressed. A listing of the strategies for the creation and implementation of programs for the automated enforcement of red light violations is provided in Table 4 and is followed by a description of each strategy.

Table 4. Strategies for Implementing an Automated Enforcement Program

Step	Strategy
1	Demonstrate a need for the program.
2	Establish institutional arrangements.
3	Review applications in the United States and abroad.
4	Create a public education and awareness campaign.
5	Establish legislation to allow for the use of automated enforcement technology and processes.
6	Advertise a Request For Proposal (RFP).
7	Undertake a demonstration project.
8	Evaluate the demonstration project.
9	Implement selected vendor system.
10	Expand the program.

1. **Demonstrate a need for the program.** Due to the limited budgets of most police departments and transportation agencies and the high costs associated with traditional enforcement methods, the use of automated enforcement technology is providing governments and police departments with an alternative to address the increasing problem of red light violations. In demonstrating the need for an automated enforcement program of red light violations, many methods can be used. Several studies completed by Richard Retting at the Insurance Institute for Highway Safety provide statistics that document the problem on a national level. These reports also provide information on the characteristics of red light violators, summaries of methods to address red light violations, and public opinions concerning red light runners and the use of automated enforcement technology (4,5,8).

   Information from local police departments and transportation agencies concerning the severity of the problem of red light violations and the history of different enforcement methods attempted

is necessary to bring the issue of red light violations "close to home". Statistics such as the percent of all accidents where running a red light is the cited reason, the number of accidents and fatalities caused by red light runners, and the trends in the number of red light violations that have occurred over a long period (10 to 15 years) of time often define the problem in terms the public can understand. Having police departments describe the various enforcement methods used (assigning officers to intersections, team enforcement) and the limitations and high cost of such programs will further show that traditional enforcement methods are not the most efficient solution and new programs should be tried.

Sometimes the need for an automated enforcement program is demonstrated by a highly publicized accident or incident. Events resulting from a red light runner causing the death of pedestrians or fatal vehicle collisions often receive substantial coverage in the media. Publicity from such events often results in public outcry demanding action from the government.

2. **Establish institutional arrangements.** In order for an automated enforcement program of red light violations to become a valid alternative for a jurisdiction, strong partnerships between the police department, political leaders, citizen safety organizations, and transportation officials must exist. The responsibilities of each agency should be understood and program leaders should be identified. A strong partnership will result in resources being used more efficiently through a combination of engineering, education, and enforcement (3E) principals. An example of the benefits resulting from institutional arrangements will be better site selection (using a combination of police knowledge and traffic engineering principles) and the ability to share knowledge and capital. Strong institutional arrangements will also be essential in the passage of enabling legislation.

3. **Review applications in the United States and abroad.** Knowledge gained through the study of applications of automated enforcement technology for red light violations used in the United States and abroad will provide a basis to determine the feasibility of using such systems in a given area. Conducting a literature review will provide an understanding of how the technology works and give statistics about the effectiveness of various programs and methods. To gain a true understanding of the limitations of the technology and the barriers that were faced in implementing and operating an automated enforcement program, individuals who participated in such programs should be consulted.

   A review of the state laws enacted to allow the use of automated enforcement technology and processes should also be performed to gain an understanding of the legal requirements of automated enforcement programs. As discussed previously, the paper entitled Photographic Traffic Law Enforcement, published by the National Cooperative Highway Research Program (NCHRP), contains an analysis of the precedence that has been set by the Courts concerning the use of automated enforcement technology, a comparative analysis of the photographic traffic enforcement laws in the United States, and an example model law that can be used when drafting proposed legislation.

4. **Create a public education and awareness campaign.** Making the public and government aware of the danger of red light violations is very important in both helping to reduce the number of violations that occur and gaining support for the use of automated enforcement technology. An effective program will serve the purpose of publicizing the importance of the issue and emphasizing the need for action to be taken. The Federal Highway Administration recently has published the Red Light Running Campaign Strategic Planning Guide which provides recommendations and materials to plan and implement a public education and awareness campaign (6).

5. **Establish legislation to allow for the use of automated enforcement technology and processes.** One of the most important aspects of an automated enforcement program is the legislation that is passed allowing for its use. The legislation determines if automated enforcement will be allowed in a given area, specifies if the violation will be a moving violation requiring driver identification or if the violation will be treated in a manner similar to a parking ticket in which the owner is held responsible, establishes the adjudication/appeals procedure, and defines the processing procedure. Legislation can also address how revenue from tickets issued will be distributed between the State, County, and jurisdiction operating the program.

   The most important decision to be made when presenting the need for legislation is whether violations detected using automated enforcement technology will be treated as moving violations or if the owner of the vehicle will be held responsible for the violation. As explained previously, if the violation is going to be treated as a moving violation, positive identification of the driver is required and the penalty will usually consist of a fine and points assigned to the driver's license. If the registered owner of the vehicle is going to be held responsible, driver identification is not required.

   Although the penalty imposed is greater when the violation is classified as a moving violation, the process of driver identification requires frontal photography and is very labor intensive. Frontal photography also has a lower percentage of violations to which citations are sent. The use of rear photography where the license plate of the vehicle is used to be matched with motor vehicle records usually does not allow for points to be added to the driver's license. Rear photography also does not raise as many questions about privacy, does not face the public opposition, and is not confronted with many of the operational problems associated with driver identification. As stated previously, the high cost associated with the need for a two-camera setup severely limits the use of both frontal and rear photography.

   When the bill is being introduced into committee and the classification of the violation is being determined, the police department and transportation groups should make every effort to educate the legislatures about the problem and inform the public about the purpose of the bill. By working with the legislature, drawing media attention to the issue, and getting the public to become involved, the bill has a greater chance of being passed.

6. **Advertise a Request For Proposal (RFP).** The RFP for an automated enforcement program is very important in stating the provisions that are expected from the program and establishing the relationship that will exist between the vendor of the automated enforcement system and the jurisdiction. If possible, the RFP process should follow a procedure that allows for the selection of the system that is believed to offer the best match for the jurisdiction, not necessarily the system that is submitted by the lowest bidder. Potential bidders would submit both a technical proposal and a cost proposal and would be judged on predefined criteria. Possible criteria could include:

   - Experience and qualifications of the proposer;
   - Type of camera being used in the system;
   - Process and equipment used to load and unload, develop, and view film;
   - System used to identify, construct and mail, and track violations; and
   - Maintenance and support capabilities for the system.

7. **Undertake a demonstration project.** The initiation of a demonstration project is a good mechanism to determine if an automated enforcement system will be applicable to a given area. By showing that automated enforcement systems work, future projects will receive more support. Demonstration projects may also receive special grants from the FHWA and other transportation agencies to assist with financing the project.

   In conducting the demonstration project, goals and criteria should be established before the program begins so participating vendors can be fairly evaluated. The demonstration project should operate for a period of time long enough to allow for a variety of weather patterns and other events to take place so that the performance of the system can be judged under many conditions.

   Site selection for the demonstration project should be based on recommendations made by both enforcement agencies and traffic engineers. The enforcement agency should create a list of high accident intersections and intersections where citizen complaints are high. After creating the list of potential sites, a traffic engineer should evaluate the sites to ensure that the red light violations and accidents are not a result of engineering deficiencies such as poor signal timing or limited sight distance. Proper site selection for an automated enforcement program is essential because the public will quickly lose respect for and demand the termination of a program that enforces violations at intersections where poor engineering is the reason for drivers violating red lights.

   Consideration should also be given to whether the contracting agency will want to be responsible for the maintenance of the system and the processing and issuing of violations or if the agency will contract these duties out. Should an agency desire to operate the system "in-house", the demonstration project should be designed to leave all responsibility to the agency so that a thorough understanding of the responsibilities associated with running the system can be obtained.

8. **Evaluate the demonstration project.** By thoroughly evaluating the demonstration project, many decisions about the use of an automated enforcement system for the detection of red light violations can be made. Based on the criteria and goals established in Strategy 7, choices can be made regarding if the use of automated enforcement technology should be further pursued and, if so, which vendor should be selected for the project. A cost to benefit analysis should also be conducted as part of the evaluation. The analysis should calculate how much each violation produced by the automated enforcement system costs the operating agency and be compared to the use of methods such as team enforcement.

   The evaluation of the demonstration project and the cost to benefit analysis will serve as the basis to gain both public and governmental support for the implementation of an automated enforcement program. When presenting the evaluation of the demonstration project and the results of the cost to benefit analysis to the public and local governments, it should be emphasized that automated enforcement programs provide the advantages of constant enforcement, shows the public that steps are being taken to address the problem of red light violations, and that the program enforces a much larger number of red light violations than traditional methods.

9. **Implement selected vendor system.** The implementation of the automated enforcement program by the vendor selected in Strategy 8 should be done soon after the expiration of a successful demonstration project. Implementation should be done soon after the expiration of the demonstration project because that is the time when public and political support will be highest. By showing people and legislators that programs using automated enforcement for red light violations can be successful in their community, support for implementation will be strong.
   In implementing the selected automated enforcement program, detailed statistics and information about the system should be maintained. Such information will allow legislators and the public to see the effectiveness of the program and will provide a basis for future program expansion.

10. **Expand the program.** After the selected vendor system has been operational for a given period of time and is working to the satisfaction of both the city and the public, the expansion of the program should be considered. Additional intersections should be added to the program based on the list developed in Strategy 7. Again, the potential intersections should be reviewed by a traffic engineer to ensure that poor engineering is not the cause of the violations.

    The expansion of the program should be done at large intervals, for example the addition of five or ten intersections to the program, so that the event will be publicized by the media. When expanding a program, provisions in the enabling legislation should be rechecked. Caution should also be taken so that all parts of the program stay in balance. If more intersections are added to the program, maintenance and violation processing will increase as will the need for more people and locations to hear appeals. The size of an automated enforcement program should be based on the success of the demonstration project, available funding and the contract

with the vendor, and the public acceptance of the program.

HYPOTHETICAL APPLICATION

The hypothetical application will be set in the fictional city of Anywhere. Anywhere has a population of over four-hundred thousand people and is rapidly expanding due to economic prosperity. As with most cities, the police department is under a strict budget that leaves limited resources for traffic law enforcement. Due to the rapid rise in population of Anywhere and the increase in the number of vehicles using the City's infrastructure, the main roadways experience heavy traffic throughout the day. The presence of traffic signals on many of these roadways further limits the ability of vehicles to travel quickly through Anywhere.

Over the past five years, the police department has noticed a disturbing increase in the number of accidents where failure to obey a traffic signal is listed as the primary cause of the accident. Recent public complaints about an increase in red light violations has also gained the attention of the police department. To combat the problem, a program using team enforcement concepts was initiated. Although the program heightened the publics' awareness about the dangers of red light violations and was successful in catching many red light violators, the high cost of the program did not allow it to operate with the frequency necessary to change the attitudes of most drivers. To further combat the problem, the city of Anywhere is interested in the use of automated enforcement technology.

The following section contains a description of the use of automated enforcement technology for red light violations by the city of Anywhere. The purpose of this section will be to apply the implementation strategies presented in this report. Each of the ten strategies listed in Table 4 will be addressed individually in the application.

1. Demonstrate a need for the program.

As stated previously, the police department of Anywhere has noticed an increase in the number of accidents where failure to obey a traffic signal is listed as the primary cause and has received frequent public complaints about red light violations occurring at several major intersections throughout the City. Due to the limited personnel and resources available to the police department, the use of traditional enforcement methods are not able to provide the frequent enforcement necessary to lower the number of violations taking place. After reviewing accident records for the past 10 years, it was found that an increase in the number of red light violations per registered vehicle has occurred every year and that red light violations have been cited in an increasing number of accidents over the period.

To analyze the problem of red light violations on a national level, several reports from the Insurance Institute for Highway Safety were reviewed. By reviewing the reports, an understanding about the severity of the problem was gained as was a description of the typical red light violator. The reports also identified the use of automated enforcement as a publicly accepted method to combat red light violations.

2. Establish institutional arrangements.

After gathering and organizing the information described in Strategy 1, the police department presented the need for the use of automated enforcement technology to several institutions with the purpose of establishing strong partnerships for the support of an automated enforcement program. By emphasizing the goal of using automated enforcement technology to make the City's intersections safer, partnerships with State Department of Transportation officials, State Police, and other vehicle safety groups (Anywhere Safety Council, Organization for the Improvement of Roadway Safety) were made. The decision was made to appoint an individual from each organization to form the Council for the Use of Automated Enforcement of Red Light Violations.

By establishing strong institutional partnerships, the Council was able to convince the City's mayor and other political figures that the use of automated enforcement technology was an effective method to improve the safety of intersections that would be accepted by the public. Gaining the support of the local government and all the agencies that would participate in the program allowed the Council to further research automated enforcement technology.

3. *Review applications in the United States and abroad.*

To understand the requirements and technology necessary to create and implement an automated enforcement program for red light violations, the Council conducted a thorough review of the relevant literature. From the literature review, the Council was able to study several applications in the United States and abroad and find contacts with working knowledge about those applications. By contacting individuals associated with automated enforcement programs, members of the Council were able to obtain a true understanding of the limitations of the available technology and gain valuable insight as to how to further plan their program to overcome institutional barriers that will be faced in the implementation stage. The literature review and information gained by contacting individuals associated with automated enforcement programs convinced the Council that automated enforcement programs for red light violations could improve the safety of intersections, make the public more aware of the danger associated with red light violations, and can be implemented and operated at a cost that is acceptable to the government officials of Anywhere.

4. *Create a public education and awareness campaign.*

In order to make the public more aware of the dangers of red light violations, a public education and awareness campaign was created and implemented. Because the Council was very inexperienced in organizing such programs and was under a very strict budget, they decided to use the FHWA's Red Light Running Campaign Strategic Planning Guide instead of hiring an outside advertising agency. The Council used the public service announcements, both audio and video, that were included in the guide and followed the step-by-step instructions on how to create and implement a public education program.

The program also served the purpose of making government officials more aware of the problems of red light violations. By educating the public and the government, the Council was able to make running red lights a serious issue that was discussed in the media. The goal of the public education campaign was to first make people aware of the problem of red light violations and then to follow the message with frequent law enforcement.

5. *Establish legislation to allow for the use of automated enforcement technology and processes.*

After completing the first four strategies presented in Table 4, the Council had the information and support necessary to approach local state representatives about introducing a Bill that would allow for the use of automated enforcement technology in the City of Anywhere. Based on the research about other automated enforcement programs for red light violations and the concern of government officials that the use of frontal photography would be viewed as an invasion of privacy by the public, the decision was made to draft legislation that treated violations detected using automated enforcement technology as a nonmoving violation. The classification of the violation as a nonmoving violation required that the legislation place responsibility for the penalty on the registered owner of the vehicle. This provision eliminated the use of frontal photography and the need for positive identification of the vehicle's driver.

In presenting its view of what needed to be included in the legislation, the Council used the paper published by the National Cooperative Highway Research Program (NCHRP) discussing the legal issues associated with automated enforcement technology. Copies of the legislation from other states, such as New York and Maryland, that held the registered owner of the vehicle responsible for violations detected using automated enforcement technology, were also carefully reviewed.

Before the Bill allowing for the use of automated enforcement technology was introduced to the State Committee, the Council made sure that all of the members of the Committee where aware of the seriousness of the red light running problem in the City of Anywhere. This task was accomplished by preparing fact sheets containing the information gathered in Strategy 1 and by assigning members from the partnerships formed in Strategy 2 a specific Committee member to contact. By being organized and unified, the Council was able to successfully work with the legislature and get a Bill passed allowing for the use of automated enforcement technology for red light violations.

6. *Advertise a Request For Proposal (RFP).*

By having legislation enacted that allowed for the use of automated enforcement technology, the Council was able to advertise Request For Proposals (RFPs) from vendors that supplied automated enforcement systems. The RFP was structured to allow the City to select the system that it believed would provide the best service within the overall city funding and budget, not necessarily the system that was the least expensive. The RFP procedure yielded three vendors, Company A, Company B, and Company C, that were willing to participate in a demonstration project. All three vendors proposed the use of 35-mm cameras and the two sensor per lane configuration traditionally

incorporated into an automated enforcement system for red light violations.

7. *Begin a demonstration project.*

The City of Anywhere, with the assistance of a grant from the FHWA, initiated a demonstration project that would last one year using the three vendors selected in Strategy 6. Potential sites for the demonstration project were first chosen by law enforcement officials. A list of potential sites was created based on accident frequency and public complaints. A traffic engineer than reviewed the list to ensure that the red light running problem was not being caused by factors such as poor signal timing, geometric deficiencies, or a lack of signing. Each vendor was then assigned two specific intersections to implement its automated enforcement program.

Because Anywhere did not want to be responsible for the daily operations of the automated enforcement system, the decision was made to have the vendors be responsible for the system operations. The duties that the vendor would be responsible for included maintenance of the system, the daily loading, unloading, and developing of film, and the processing and tracking of notices of violation. The vendor would also be responsible for preparing photographs to be shown in court should a violation be contested.

8. *Evaluate the demonstration project.*

After the year long demonstration project, the results of the program showed a 25 percent decrease in the number of violations occurring at intersections where automated enforcement technology was present. The 25 percent reduction was based on a ratio where the number of violations photographed by the automated enforcement system is divided by the total number of vehicles traveling through the intersection approach(es) being monitored. The ratio was calculated for all six intersection and an average ratio was then calculated for the program. The average ratio for the first full month of system operation was compared to the same ratio taken one year later to determine the percent reduction in violations. All data necessary to determine the percent reduction was obtained from the automated enforcement system.

Public opinion and media coverage about the project were also positive. The large decrease in red light violations and the positive opinions about the project resulted in support and funding being given by the City for the implementation of an automated enforcement system.

9. *Implement selected vendor system.*

Following the conclusion of the demonstration project and based upon the evaluations conducted in Strategy 8, the decision was made to implement Company B's automated enforcement system at all of the intersections included in the demonstration project. The installation of the technology began one month following the conclusion of the demonstration project. This time period was chosen in order to maintain the positive public and government support gained from the demonstration project. The period of installation also coincided with expected warm weather. This

factor was important in getting the system installed and having the cameras fully adjusted before facing freezing conditions.

10. *Expand the program.*

The City of Anywhere has not planned future expansion of its automated enforcement system at this time. Because the system has only been operational for approximately a year, program organizers and city officials want to allow more time in order to develop an accident database and to gather statistics about the success and costs of the program. The City has also become very interested in the potential of using Digital technology to limit the need for film handling and data processing. Based on the success of its current automated enforcement system and the results of field tests using digital technology, the City will decide when and what type of technology to use for future expansion.

CONCLUSIONS

Drivers committing red light violations are a very serious problem that is increasing in frequency. Traditional methods used by police departments to enforce red light violations are dangerous to the enforcing officer, other motorists, and pedestrians and bicyclists in the area. Enforcement methods, such as team enforcement, that involve the use of many officers at one intersection, are resource intensive and the high cost associated with the procedure does not allow for enforcement to be performed with the frequency necessary to significantly affect driver behavior. Although violations that are enforced by police officers are often upheld in court, the large number of violations that are not enforced requires that new methods to enforce red light violations be researched.

Several court decisions have established the precedence that the use of automated enforcement technology does not violate the Constitution and is not an infringement on an individual's right to privacy. Previous experience using automated enforcement technology has also shown that the photographs produced by automated enforcement systems can be used as valid evidence in court. In the case of using automated enforcement for red light violations, the police must usually establish that the photograph taken, the position of the vehicle in the intersection while the traffic signal was red, and the time shown were provided by an instrument which has been proven to accurately identify, photo, and synchronize these events. If the violation is going to be treated as a moving violation, the identity of the driver must also be clearly shown.

The use of automated enforcement technology for red light violations has been shown to reduce the number of red light violations occurring at intersections. The implementation and continued operation of automated enforcement programs for red light violations in Australia (since 1979) and New York City (since 1993) has proven that the overall benefits of an automated enforcement program are acceptable to local governments, law enforcement agencies, and contracted vendors who support the costs of implementing, operating, and maintaining such programs. More recent programs such as Howard County and San Francisco also show that the use of automated enforcement for red light violations is becoming a publicly accepted method to address the problem of red light violations at intersections.

A major decision that must be made when enabling legislation allowing for the use of automated enforcement technology is whether the violation will be treated as a moving violation or a nonmoving violation. Treating the violation as a moving violation will require the use of frontal photography in order to positively identify the driver and the penalty will usually be a monetary fine and the addition of points to the driver's license. If the violation is going to be enforced as a nonmoving violation with the usual penalty of only a monetary fine, the legislation must contain a provision holding the registered owner of the vehicle responsible for the violation.

Several applications of automated enforcement for red light violation systems in the United States and abroad have shown that many issues should be considered when creating and implementing an automated enforcement program for red light violations. These essential elements

include if a public awareness program will accompany the use of automated enforcement systems, how violations will be processed and tracked, and whether the violation will be a moving violation or a non-moving violation. By following the strategies presented that are based on previous programs using automated enforcement technology, agencies will be able to implement a program that may improve the safety of intersections and that is acceptable to law enforcement agencies, supporting governments, and the general public.

Further research into the capabilities, requirements, and limitations of digital cameras is still needed. Court precedence should be examined to ensure that the use of digitally produced photographs will be admissible as evidence. Research should also be performed to determine if the extra cost currently associated with digital cameras is offset by the potential benefits of a digital system. The possibility of continuing to reduce the manpower associated with enforcing red light violations while improving the quality of photographs produced by automated enforcement systems warrants further research into digital camera use.

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APPENDIX

The following table provides a listing of companies that manufacture automated enforcement systems for red light violations.

Table 5. Manufacturers of Automated Enforcement Systems for Red Light Violations

Company Name	Address of Company Headquarters
35-mm Camera Systems	
American Traffic Systems (ATS)	4141 N. Scottsdale Road Suite 335, Scottsdale, AZ 85251
Gatsometer B.V.	Tetterdeweg 10, 2050 AA Overveen, Holland
Multanova AG	Seestrasse 110, CH 8612 Uster 2, Switzerland
Traffipax - Vertrieb	4000 Dusseldorf 13, Hildener Str. 57
Truvelo	PO Box 92, Teddington, Middlesex, TW 11 9 BP, England
Video Camera Systems	
A.W.A. Traffic Systems	P.O. Box 161, Elizabeth South Australia 5112
Cohu, Inc./Electronics Division	5755 Kearny Villa Rd. San Diego, CA 92123
Econolite	3360 E. La Palma, Anaheim, CA 92806
Hughes	Bldg. M30, MS R10, P.O. Box 11337 Tucson, AZ 85734-1337
Peek Traffic Systems, Inc.	3000 Commonwealth Blvd., Tallahassee, FL 32303-3157
Syntonic, ATS Systems Division	1616 Broadway Kansas City, Missouri 64108-1208
Digital Cameras	
Eastman Kodak Company	11633 Sorrento Valley Road San Diego, California 92121