Synthesis and Evaluation of Red Light Running Automated Enforcement Programs in the United States

U.S. Department of Transportation
Federal Highway Administration

Office of Highway Safety Infrastructure
400 7th Street, S.W.
Washington, D.C., 20590

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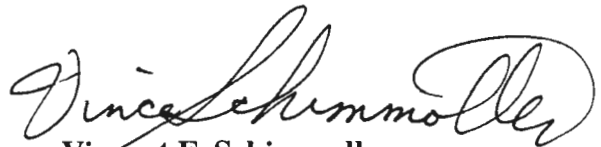

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FOREWORD

The Federal Highway Administration has identified red light running equipment as a potential safety countermeasure, and therefore, funded technology demonstration and evaluation programs in several municipalities. This report presents the information from those demonstrations as well as information on two other locations where red light running programs have been implemented. Information is provided on changes in red light violations and crashes, costs, public acceptance and institutional barriers. This report will be of interest to state and local agencies who are considering implementation of a red light running program within their jurisdiction.

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16. Abstract

The incidence of motorists violating the red phase of a traffic signal has been on the rise and is a contributing factor to intersection crashes. Technology has become available that automatically detects a motorist running the red light and records photographically the occurrence, which in turn is used for violation citations. The FHWA funded the demonstrations and evaluations of this technology at five municipalities. The results from those demonstrations plus red light running (RLR) programs implemented at two additional cities is synthesized in this report. Information on the effectiveness of the program and the equipment includes data on changes in red light violations, changes in intersection crashes, costs, public acceptance, and institutional barriers. Descriptions of the equipment and its deployment is provided.

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Intersection crashes, red light running, technology, video camera, evaluation. | | **18. Distribution Statement**

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INTRODUCTION

The high percentage of crashes that occur at intersections has led the Federal Highway Administration (FHWA) to identify red light running equipment as a countermeasure to be considered when addressing intersection crashes. This equipment is a form of automated enforcement, which involves the use of image capture technology to monitor and enforce traffic control laws, regulations or restrictions. [1] It can detect and cite motorists who enter a signalized intersection in violation of the red phase and has the potential to reduce fatalities, injuries and crashes by enhancing respect for traffic control devices such as traffic signals.

In order to increase public awareness about red light running (RLR), FHWA began a program in 1992 aimed at changing motorist attitudes and increasing compliance with traffic signals. FHWA has funded technology evaluation programs in several municipalities to test the efficacy of RLR programs. Five jurisdictions (Los Angeles County, California; Polk County Florida; Howard County, Maryland; Charleston, South Carolina, and Washington, D.C.) received grants to implement red light running cameras for test and evaluation in red light running enforcement. Due to the fact that the Washington, D.C. and Charleston programs are new and evaluation data is not available, syntheses were not conducted for these programs. Syntheses for the RLR automated enforcement programs in San Francisco and New York City were added to the report in place of those programs. New York's program was not subsidized by federal funds, but valuable data are available for this summary.

The primary objective of this document is to synthesize the results of the demonstrations for the following locations:

- Los Angeles County.

- City and County of San Francisco.

- New York City.

- Polk County.

- Howard County.

The primary focus of this synthesis is to establish how well the systems achieve their principal objective, which is to reduce crashes at signalized intersections, at least at those locations with frequent violations. There are several other measures of effectiveness that will be used to evaluate the systems' efficacy, including:

- Reduction in red light violations.

- Cost savings over manual enforcement (including maintenance and operations costs).

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- Public acceptance.

- Institutional barriers.

The camera technology used is documented, but the evaluation of specific vendors is not included. This report is organized in the following format:

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

- Provide background information on electronic enforcement of RLR.

- Describe electronic enforcement technologies.

- Synthesize the results of the evaluations for the RLR automated enforcement programs referenced earlier in this report.

- Identify an implementation strategy for an automated enforcement of RLR program.

LITERATURE REVIEW-SCOPE OF THE RLR PROBLEM

According to the Fatality Analysis Reporting System (FARS), and the General Estimate System (GES) for the year 1997, approximately 800,000 motor vehicle collisions occurred at signalized intersections resulting in over one-half million injuries and several thousand fatalities. [2,3] Over the past five years, the number of crashes at traffic signals has increased.

RLR Statistics

One study, conducted using a sample of 4,526 police reports on public roads in four urban areas, showed that 22 percent of these crashes were caused by the driver running a traffic control device. This study also showed that motorists are more likely to be injured in crashes involving RLR than in other types of crashes (45 percent of RLR crashes caused injuries, compared to 30 percent for other crash types).[4]

Another study was conducted between 1994 and 1995 obtaining data on RLR for two intersections in Arlington, Virginia. The study yielded 8,121 RLR violations over a period of 2,694 hours of data collection, an average of 3.0 RLR violations per hour.[4]

To obtain a profile of RLR violators, a study was conducted that included 1,373 observations, 462 RLR violators and 911 compliers.[4] On the average, deliberate violators were younger, less likely to use safety belts, had poorer driving records and drove smaller and older vehicles. As a group, the drivers causing RLR crashes were identified to be younger than 30, male, have prior moving violations and convictions for driving under the influence, and have consumed alcohol prior to the crash.

How to address RLR?

There are a number of countermeasures available to address the RLR problem. These measures include:

- Removal of unwarranted traffic signals — remove signals from low traffic volume locations.

- Signal Timing — provide adequate clearance or change intervals.

- Enforcement — use new technologies to aid in enforcement, given that current resources to enforce traffic laws are inadequate in relation to the number of vehicles on the road.

This research focuses on new technologies for enforcement of RLR violations.

ELECTRONIC ENFORCEMENT TECHNOLOGY

Usually, a photo detection system is comprised of electromagnetic loops buried in the pavement, a terminal block that houses a microprocessor, and an industrial 35-mm camera atop a 15± foot (4.6 m) pole. Cables connect the terminal block to the loops and the signal. The loops are buried six to eight feet past the stop line in each lane.[7] When the signal turns red, the system becomes active and the camera takes pictures when cars entering the intersection disturb the electromagnetic field over the loops.[7] Photographs are then taken of the vehicle and the camera records the date, time of day, time elapsed since beginning of red signal, and the speed of the vehicle. Upon review of the photograph, and depending on state law requirements, tickets are issued by mail to either vehicle owners or to the drivers at the time of the offense.[6]

Photo detection systems are increasingly being used to help communities enforce traffic laws by automatically photographing vehicles whose drivers deliberately run red lights.[6] Electronic enforcement systems must be capable of detecting and recording violations under a variety of field conditions, and must produce clear images that are easily retrieved and stored. The following ten requirements for an automated enforcement technology were identified by a vendor as the minimal needs for these programs:

1. The ability to capture, transmit, process, store and recover captured images so that data may be managed in an efficient manner;

2. 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);

3. The capability to prevent the spreading of overexposed portions of an image (anti-blooming) that may result from vehicle headlights or sunlight from reflective surfaces;

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4. Adequate differentiation of light to dark areas within an image to provide necessary details (also referred to as contrast latitude);

5. The ability to provide clear images of moving vehicles;

6. The ability to detect violators at varying levels of light;

7. Image enhancement circuitry to eliminate major sensor defects such as bright or dark columns which detract from the visible presentation of the image;

8. Continuous read-out of images to support monitoring along with single frame capture capability for recognizing several successive vehicles committing a violation;

9. The ability to be moved to different locations or to be mounted into a permanent position; and

10. Components that are environmentally friendly.[8]

There are three types of cameras available for use with automated enforcement of red light violations. 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 equipped with automated enforcement technologies is usually equipped with one camera to record red light violations. However, sometimes two cameras are necessary to photograph the front and rear of a violating vehicle. The higher cost of two-camera systems has limited the implementation of such applications.[8]

There are many different accessories 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 the system.[8] The decision to use these flash units is based on site specific requirements including cost, angle of the sun on the intersection, and reflectivity of the license plates.

The following sections provide a general description of the three types of cameras and necessary equipment used for automated enforcement programs.

35-mm Cameras

Thirty-five millimeter cameras are the most common cameras used for automated enforcement of red light violation systems. Automated enforcement systems equipped with 35-mm cameras produce both black and white and color photographs. Although black and white photographs are less expensive, color photographs can be used to identify vehicle color and eliminate any doubt as to whether the traffic signal was in the red phase.

The camera system is typically connected to both the traffic signal system controller and to loops or piezo sensors.[8] The loops or 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 weather or vandalism and placed atop poles. Figure 1 illustrates a red light automated enforcement configuration deployed in New York City.

When the traffic signal switches to the red phase, the camera used by the automated enforcement system becomes active. Vehicles traveling over the detectors while the camera is active signals the system to photograph the vehicle. A "grace" period of about 0.3 seconds after the signal turns red is common in these systems. A minimum speed of about 19 miles per hour (30 kph) is needed to activate the system.

Upon activation of the system, at least two pictures are taken by the camera. The first picture shows the vehicle as it approaches the intersection during the red phase, the pavement marking defining the intersection, and the traffic signal showing the red phase. In some systems the first picture shows the front of the vehicle, while for others it shows the rear of the vehicle. The second picture then shows the vehicle in the intersection a short time later (about 1 second). Systems are available to show the second photograph at a preset distance from the first photograph. If driver identification is necessary, a third picture of the driver may be taken.

Two pictures taken by the automated enforcement system in Howard County, Maryland are shown in Figures 2 and 3. For both pictures, the first line of the "data bar" are the headings for the numbers displayed on the second line. In figure 2, it can be seen that the vehicle was at the approach at 18:15:29 (6:15 and 29 seconds, p.m.) on 7-30-98. The code is an intersection number. The amber phase is 4.02 seconds in length and the red phase was on for 0.65 seconds.

Figure 3 is the second picture taken by the automated enforcement system, 0.56 seconds after the first picture, showing the vehicle in the intersection while the traffic signal is red. The first column shows the speed of the vehicle (45 mph [76 kph]). The next three columns are identical to figure 2. Under the red column it shows 001.21, which is the time that the red signal has been on; the difference between this number and the same number for figure 2 is 0.56 seconds. The other additional information displayed is the speed limit for the road.

The use of 35-mm camera units has 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, — a so called "false installation." By having many housing units at different intersections, more areas per camera can be covered and drivers do not know which unit has a camera and which does not (known subsequently in this report as "false installations"). [8]
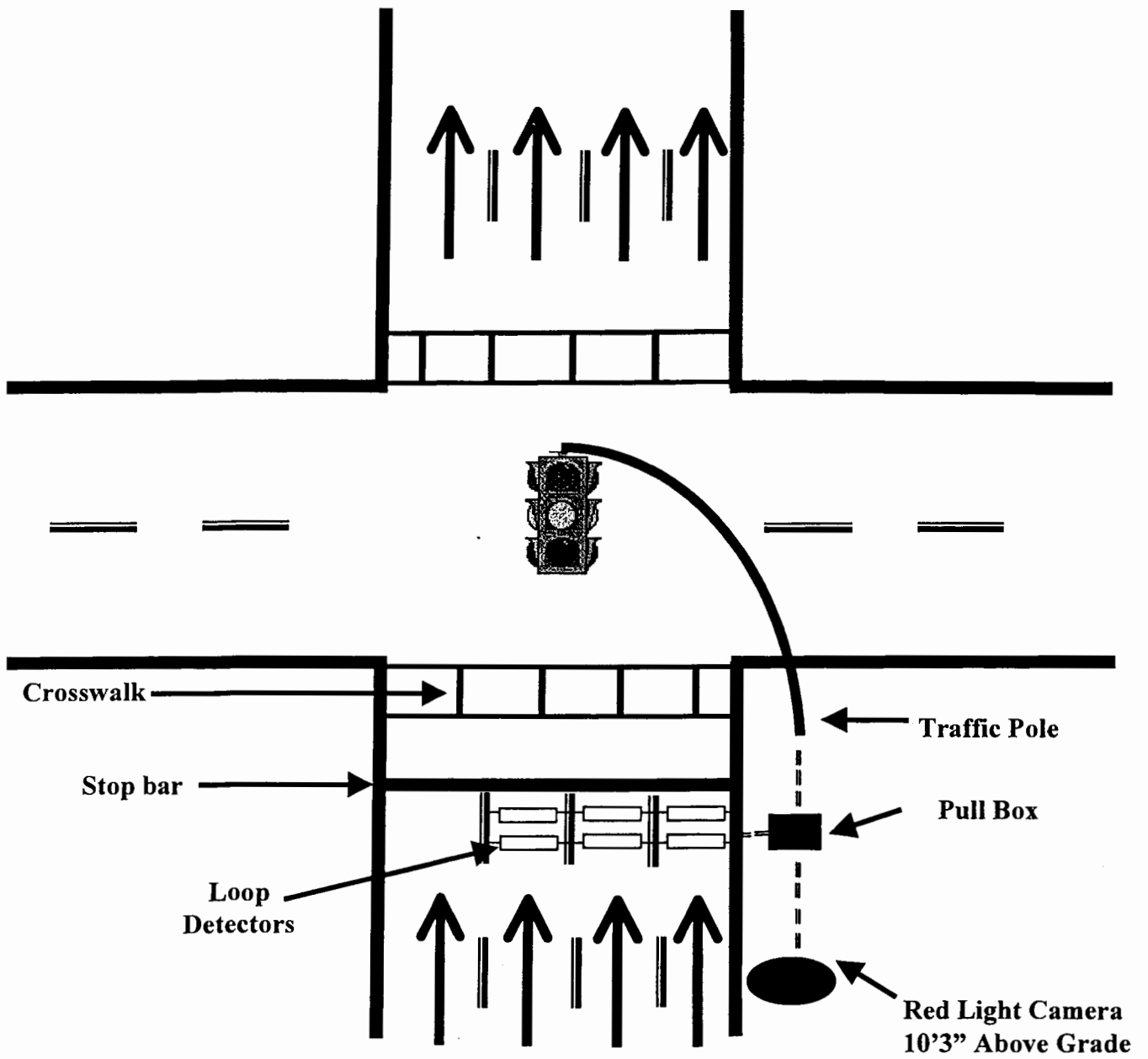
Figure 1. Automated Enforcement Configuration Used in New York City. [8]

Crosswalk

Stop bar

Loop Detectors

Traffic Pole

Pull Box

Red Light Camera 10'3" Above Grade

SPc---- Time   Date   Code   Amb1 Red1   Foto   Limit   09
----mPh 18:15:23 07.30.98 6090019 4.02 000.65 0188   - - - mPh 2-
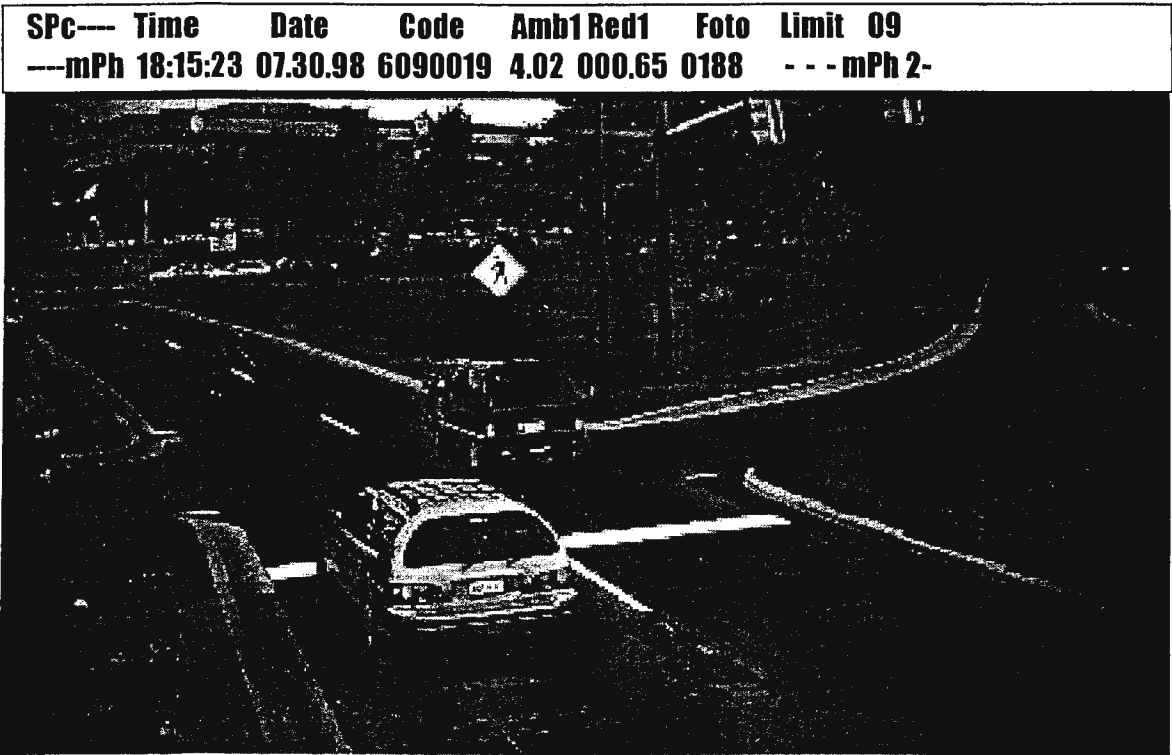
Figure 2. First Picture Taken By Automated Enforcement System
(Source: Howard County Police Department)

Spc 2500 Time   Date   Code   Amb1 Red1   Foto   Limit   f6
045 mPh 18:15:29 07.30.98 6090019 4.02 001.21 0189   035 mPh -2
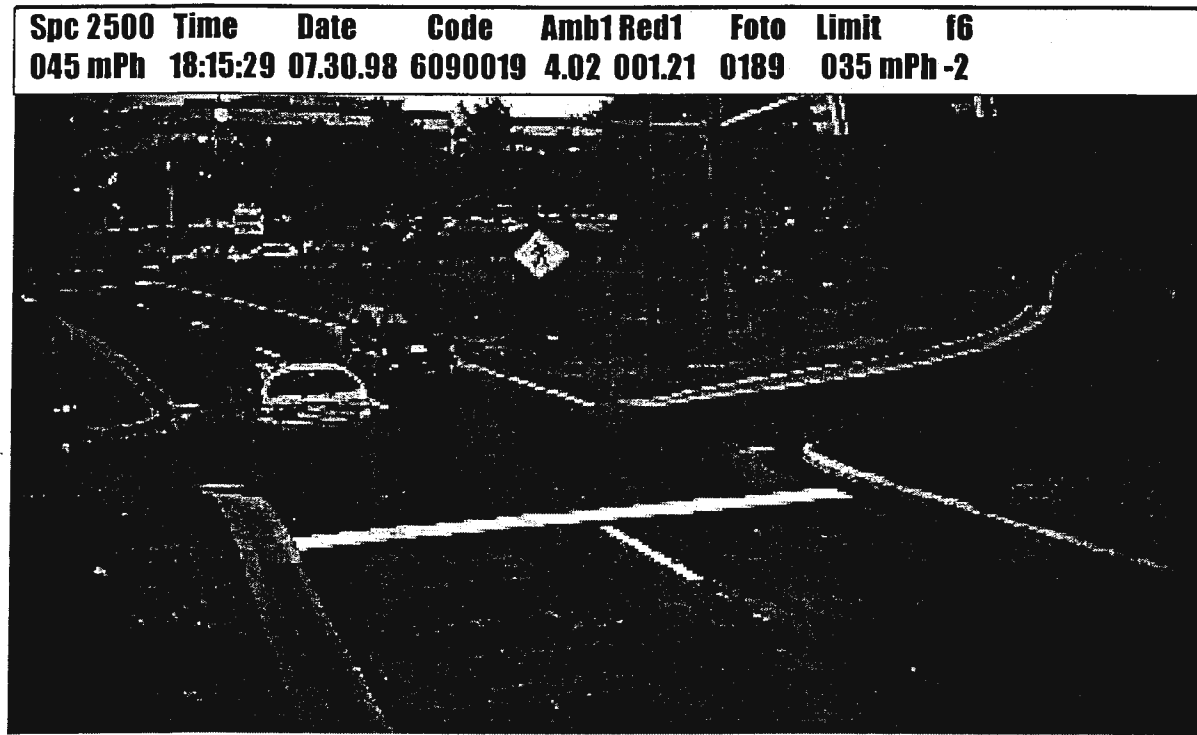
Figure 3. Second Picture Taken By Automated Enforcement System
(Source: Howard County Police Department)

Video Cameras

Because legislation and court precedence in many states do not support the use of video recordings as evidence, video technology has not been used as frequently as 35-mm cameras for automated enforcement of red light violations programs. However, intersections can be equipped with traffic surveillance video cameras which record the intersection when the signal changes to red.

The use of video cameras is 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. By recording an intersection and viewing a large number of violations, evidence about the severity of red light running can be gathered and used to justify the need for the implementation of programs which address red light running.

However, one video system currently available has the capability of recording red light violations and identifying vehicles that are at risk for entering the intersection after the red light phase has been initiated. The onset of the green phase for cross traffic is then delayed until the violating vehicle has cleared the intersection.

Digital Cameras

The use of digital cameras is relatively new to the area of automated enforcement of red light violation systems. The digital camera/system requirements for an automated enforcement program should be capable of the following:

- Data management — facilitate the ability to capture, transmit, process, store and recover captured data.

- Resolution — sufficient to meet all intended uses (license reading, vehicle identification).

- Anti-blooming — prevention of the spreading of overexposed portions of the image.

- Contrast latitude — adequate differentiation of light to dark.

- Stopping power — clear images of moving vehicles.

- Sensitivity — ability to detect violators at low light levels.

- Image enhancement circuitry — camera electronics to eliminate major sensor defects such as bright or dark columns.

- Frame rate — continuous read out of images to support monitoring along with single frame capture capability.

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- Installation flexibility — ability to mount into permanent or mobile settings. [11]

Digital cameras have the capability to produce higher resolution, more sharply detailed images of vehicles, and are equipped to prevent image smears and reflections from headlights. Photographs produced by digital cameras may be in black and white or color. Systems are usually activated by inductive loop detectors or by machine vision vehicle tracking technology with visual data stored in a storage drive. [11]

Along with producing better vehicle images, the major expected benefit of digital cameras is the improvement in the processing and distribution of notices or violations.[8] Digital cameras have the capability of being 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 plate with records of vehicle registration databases.[8] Once the license plate numbers are successfully matched with vehicle owners, tickets can be automatically processed and mailed to the address of the registered vehicle owner.

Several jurisdictions are testing photo enforcement systems that replace the standard photographic wet film process with a digital system that stores the violation images on a CD-ROM within the housing unit. The digitized images can then be downloaded to a police department server at the end of each day for verification and processing. George Frangos, Howard County Traffic Engineer, believes that digital systems offer significant benefits over wet film cameras and soon will replace wet film cameras in automated enforcement.

RLR PROJECT SYNTHESIS

The literature review did not provide the most recent or site specific data available regarding RLR programs in the United States. Therefore, additional research was conducted to obtain this information for the following RLR electronic enforcement programs:

- Los Angeles County.

- City and County of San Francisco.

- New York City.

- Polk County.

- Howard County.

Due to the fact that the Washington, D.C. and Charleston, South Carolina programs are new and evaluation data is not available, they were not included in this report. The RLR automated enforcement programs in San Francisco and New York City were added to the report in place of those programs. Data were collected for these syntheses and are organized into the following topics:

- Project description.

- Public involvement.

- Legislation enacted.

- Technology.

- Data processing.

- Operational problems.

- Program results.

Los Angeles County, California

The Long Beach Blue Line, opened in mid-1990, is a light rail transit line which runs over 22 miles (35.4 km) between downtown Los Angeles and downtown Long Beach. In mid-1993, the Board of Directors of the Los Angeles County Metropolitan Transportation Authority (LACMTA) authorized funding for the Long Beach Blue Line Grade Crossing Safety Improvement Program. The safety improvement program consisted of 17 separate projects, designed to enhance public safety at the 100 at-grade crossings on the line.[12]

Starting in late 1992, the LACMTA project team carried out five demonstration projects involving the use of photo enforcement cameras at grade crossings. Citations were issued as a part of three demonstration projects. For these projects, large reductions in the number of grade crossing violations were measured after photo enforcement equipment was installed and citations issued. Between September 1995 and December 1997, 3,000 citations were issued for grade crossing violations where photo enforcement cameras were placed. [12] At the Compton Boulevard crossing, the rate of violations dropped from about one violation every hour to one violation every 12 hours. [12]

Public Involvement

In August 1994, the LACMTA completed telephone interviews with 400 persons who live along the Metro Blue Line cab signal route segment and who use Metro Blue Line grade crossings at least one time per week. Survey respondents identified the following areas as the most important for affecting safety at the grade crossings, and state their views on the placement of photo enforcement cameras at these locations:

- Drivers and pedestrians do not understand that Blue Line trains get to the intersection in a hurry after lights start flashing (80 percent of those surveyed believe this as a problem).

- Drivers trying to "beat the train" by driving around lowered crossing gates (76 percent).

- Union Pacific freight trains are long and slow (70 percent).

- Drivers and pedestrians don't understand that two, and sometimes three trains can go through the intersection at the same time (70 percent).

- Not enough barriers to keep pedestrians off the tracks (68 percent).

- Cameras will cut down on accidents at grade crossing (71 percent).

- Support the use of automated cameras for enforcement of traffic laws (83 percent).

- Support the use of public transportation funds for traffic enforcement by automated cameras (75 percent).[12]

These results supported the implementation of the Metro Blue Line Grade Crossing Enforcement Initiative program. Upon beginning the program, warning signs were placed at sites equipped with photo enforcement technologies.

Legislation Enacted

Based on the positive demonstration project results, the LACMTA elected to proceed with the installation of photo enforcement at 17 crossings. The LACMTA also initiated modifications to the California Vehicle Code, under State Senate Bill 1802, which makes citations for violations recorded by photo enforcement equipment subject to the same procedures as citations written by police officers for other moving violations. The provisions enacted under Senate Bill 1802 have since been extended for red light running violations at signalized intersections. [12]

Technology

The five demonstration projects that were conducted between 1992 and 1994 used each of the three camera types described in the Automated Enforcement Technology section of this report. 35-mm, video and digital cameras were used in the demonstration projects.

Four of the five pilot installations involved the use of high resolution 35-mm film cameras mounted in cabinets on a 10 foot (3.1 m) high pole, activated by vehicles running under or around railroad crossing gates, or making left turns against red left turn arrows across the Metro Blue Line tracks. Two photographs of the vehicle license plate and the driver's face were taken as the basis for issuing a citation.

Video loops were also installed at one of the pilot test sites. A digital photo enforcement camera was installed to record left turn violations at the Los Angeles street intersection. Images of the recorded violators were stored and transmitted by a cellular telephone link at night, doing away with the need to change and develop film.

The LACMTA required that 35-mm camera systems be used for the project in order to obtain maximum resolution photographs. In 1994, the digital technology was not as advanced as it is in 1998, therefore 35-mm cameras were recommended. In the long run, LACMTA believes that digital camera systems will be used for photo enforcement, eliminating the need for film retrieval and handling.

Data Processing

Film is retrieved from the camera units daily, Monday through Friday. At each location as the film is retrieved, the camera unit is checked to verify that it is functioning correctly, and data concerning verification is logged for possible use at a later date if contested in court. The rolls of film are delivered to a processing center where the film is developed and viewed. Data concerning each violation, including the vehicle license plate, is taken from photographs and processed to obtain registered owner data from the California department of motor vehicles. When this data has been obtained and verified, the citations are prepared, printed for review and signed by the Transit Police Department. The California Vehicle Code (CVC) requires that citations be mailed out within 15 days from the date of violation.

Operational Problems

The day to day operation of photo enforcement systems using 35-mm film is labor intensive, and requires operating personnel to pay considerable attention to details in order to maintain the chain of custody of the photographic evidence. There were some difficulties in setting up the detection zones to minimize the number of bad triggers for the video camera pilot test.

Program Results

Violations were recorded when a motorist drove under the railroad crossing gates after the flashers had been activated; the gates had clearly begun to lower, or when a motorist drives around lowered crossing gates. This definition of a violation provides a grace period for motorists of at least three seconds after the gates begin to lower.

Since the opening of the Metro Blue Line in July 1990 through the end of June 1997, there have been 353 collisions between light rail trains and motorists resulting in 33 fatalities and numerous injuries at the 100 at-grade crossings. Photo enforcement cameras were highly effective in reducing the number of traffic violations and the number of train/vehicle collisions at grade crossings. Between 1993 and 1998, there were no train/vehicle collisions at any crossing where photo enforcement took place.[10] The LACMTA conducted pilot installations at three crossings to evaluate the effectiveness of photo cameras in reducing grade crossing violations. The pilot study was done in as a controlled a manner as possible in order to measure accurately the number of violations "before" and "after" the introduction of the photo enforcement cameras. At the three intersections, there were reductions in the number of violations by 92, 78 and 34 percent respectively.

San Francisco, California

According to the city and county of San Francisco, California estimates that red light violations cause approximately 785 reported injury accidents annually which account for about 25 percent of all reported accidents where an injury occurs. A conservative estimated cost to the local economy annually for the accidents that result from red light violations is $40 million. In enforcing red light violations, the San Francisco Police Department issues 15,000 to 20,000 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 other two vendors participated in the program.[8]

Public Involvement

A large scale public education program, sponsored by the Federal Highway Administration, was performed 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.

Television and newspapers provided positive coverage during the initiation of the automated enforcement program. To test the system and make drivers aware of the program, warning notices showing drivers committing a violation were initially mailed. Street signs placed at intersections or city entrances are also required in California to let the public know that automated enforcement technology is being used at that specific intersection.

Legislation Enacted

The California Legislature amended the CVC in 1996 to permit the use of automated enforcement of red light violations, as mentioned previously in the Los Angeles County synthesis. The seriousness of the RLR problem and political atmosphere resulting from recent fatalities caused the Legislature to decide that automated enforcement of red light violations be judged as moving violations so that fines could be issued as well as points added to a driver's record.[8]

Enforcing RLR as a moving violation requires positive identification of the driver of the vehicle. Frontal photography was used to identify drivers, and once the driver was identified, the police department signs the violation and it is mailed to the registered owner. The violation must be mailed within 15 days of the violation date.

Beginning in 1998, fines were increased from $104 to $271. The revenue received from the automated enforcement program is distributed in a balanced manner between State, County, and City. A sum of approximately $80 per violation was set aside for the purpose of furthering the automated enforcement program.

Technology

Gatsometer manufactures the 35-mm cameras used in San Francisco. The sensor configuration and location is similar to the configuration illustrated in Figure 1. There are two loops per lane in the pavement, a three tenths of a second (0.3 sec.) buffer was allowed and the minimum speed criterion of 15 miles (24 kph) per hour for vehicles to be photographed was included in the system.

Data Processing

Identification of the driver makes the task of data processing very important and labor intensive. Drivers license photographs are used to identify drivers and vehicle license plates must be matched against DMV records. A software package was developed that aids in this process. No additional staff were required for the demonstration project, but future expansion will require supplemental staffing.

Several factors have limited the effectiveness of the photographs taken by the automated enforcement cameras. Approximately 15 percent of the photographed violations could not be matched with vehicle records because the vehicles did not have frontal license plates.

The requirement of frontal photography for driver identification also causes problems such as driver glare, dark interiors and image clarity of the driver.

Program Results

Six months into the pilot, the number of vehicles photographed running red lights dropped by more than 40 percent. Approximately 40 percent of all violations that are photographed by the automated enforcement systems are matched with a driver and result in the issuing of a citation. Conviction/adjudication rates match that of police-issued citations.

New York City, New York

New York City has one of the oldest and largest automated enforcement of red light violation programs in the United States. The program began operation in 1993 and as of 1997 has been installed at 18 intersections. The Chief of the Red Light Running Camera Program for New York City, Rudolph E. Popolizio, has 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 1980's in an attempt to learn about the programs being used in Europe and Australia.[8]

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 does not interfere with any existing vehicle summonsing or tracking procedure.[8] This guideline was viewed as essential because of the need to track each notice of liability and the resulting revenue. 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. The total cost for the three and a half year contract came to $13,900,000. Of the total cost, $5,460,000 of the total amount was used for operations and maintenance.

Public Involvement

The city made no efforts to educate or inform the public about the effects of red light violations on accidents. The city also did not publicize the use of automated enforcement for red light violations and did not require advance notice signs at intersections using automated enforcement technology.

Legislation Enacted

Before the Request for Proposal (RFP) could be advertised, a state law had to be enacted allowing 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.[8] 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 over one million to implement and operate a demonstration project limited to 50 intersections using automated enforcement technology for traffic control violations.[8] 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 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 Robot 35-mm camera was used for the system. Two loops per lane were placed in the pavement, a three-tenths of a second buffer was allowed, and the minimum speed criterion of 15 miles per hour (24 kph) for vehicles to be photographed was included in the system. Figure 1 illustrates a typical site setup for the New York City system.

Although cameras have shown some wear, the replacement of gears, bushing rings and flash units on all the cameras has solved this problem.[8] Climate appeared to have no effect on the cameras during 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, personnel were hired to form a photograph viewing staff and an 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 violations to be sent. The adjudicating staff deals with the public and handles problems or appeals. Because of budget constraints, only one help center (as of 1997), located in Manhattan, is open exclusively for the automated enforcement program. When the program expands, it is expected that more centers will open throughout the city.

Operational Problems

The presence of parking lanes affected the ability of cameras to provide a clear picture of intersections. Double parked trucks also blocked the view of intersections. To combat this problem, the cameras were placed on large "mast arm installations" 16 feet (4.9 m) high and extending out about eight feet from the curb. Previously, the standard camera set-up was only ten feet in the air and two feet from the curb.

Glare from the flash of the cameras has also presented 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 38 percent since the program was initiated. Statistics from the program show that 65 percent of the violators pay the fine in response to the first notice that is sent. It is worth noting that the total revenue collected during the three year period was $18.5 million, but the cost of the project over the three year contractual period was only $15.5 million.

The program's success lead to the extension of legislation enabling the use of automated enforcement for red light violations. New York City also planned on expanding the program by 12 cameras in the near future.[8]

Polk County, Florida

In November 1993, the Polk County Community Traffic Safety Team proposed to test and evaluate automated photo traffic enforcement technologies used to deter traffic violations. Polk County, Florida began using automated enforcement technology for red light violations in September of 1994 as a part of a FHWA demonstration project. Systems were placed in Bartow, 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. Three locations were selected by a committee that included the FHWA-designated project director, a representative from the Florida Department of Transportation Traffic Operations Division, the Polk County Community Traffic Safety Team (PCCTST) Chairman, Polk County

and Lakeland traffic engineering personnel and law enforcement representatives. The cameras for these systems were leased or placed on loan from Automated Enforcement Equipment Vendors.[10]

Public Involvement

As part of the automated enforcement campaign, a public education program was initiated. The program was funded by FHWA and followed the suggestions given in the *Red Light Running Program Strategic Planning Guide*.[9] 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 running violations. Legislation has been introduced for five successive sessions of the legislature, but has not been successfully enacted. Warning letters are mailed to drivers who are caught running red lights by automated enforcement systems.

Technology

Three vendors participated in the demonstration project started in 1994. American Traffic Systems (ATS) of Scottsdale, Arizona; U.S. Public Technologies of San Diego, California; and Truvelo of South Africa were assigned intersection locations in the participating cities. Cameras photograph vehicles from the front and rear and record the time, date, speed, lane location, time since the light turned red, and photo identification number.[10]

Data Processing

Data processing was completed by members of the County's automated enforcement program. Information to identify violators was 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.[10] Because Florida has a high volume of tourist and winter resident population, many different license plate colors and configurations from different states were 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 made the process of vehicle identification difficult, those violations that were successfully matched with registration records were sent to vehicle owners. Florida has also experienced some problems with large trucks in the lane closest to the camera blocking the camera's ability to photograph the violators in the adjacent lane.

There were problems keeping the staff (members of PCCTST, law enforcement officers, and transportation officials) active on the project. Staff turnover was a particular problem that reduced the amount of data collected during this demonstration project.

Program Results

The red light running technology proved to be accurate, safe, reliable and cost effective.[10] The vendors products provided photo enforcement cameras that successfully recorded red light running violations on 35-mm film and video tape. However, the success of the program did not convince Florida legislators to pass legislation allowing for the issuance of monetary fines; therefore, only warning notices can be mailed to violators. The project has nonetheless served to heighten awareness among the public about the problems associated with red light running and the increased risk of apprehension at the four intersections.[10]

As a part of the demonstration project, PCCTST implemented several public information and education strategies. Statistics related to the impact of Polk County RLR Campaign were prepared as a part of the final report for Polk County Automated Enforcement Systems. These findings are summarized in the following paragraphs.

Pre-(1994-1995) and Post-(1996) campaign county wide crash data for Polk County are provided in Table 1.

Table 1. Polk County, Florida Crash Data Pre and Post RLR Campaign. [10]

Time of Year	1994 Crash Data Pre RLR Campaign	1995 Crash Data Pre RLR Campaign	1996 Crash Data Post RLR Campaign
January to June	113	133	122
July to December	114	127	119
Totals	227	260	241

Table 2 illustrates Florida statewide crash data for the same three year period.

Table 2. Florida Statewide Crash Data. [10]

Time of Year	1994 Crash Data	1995 Crash Data	1996 Crash Data
January to June	5,294	5,310	5,412
July to December	4,945	4,835	5,230
Totals	10,239	10,145	10,649

The Polk County crash data for 1996 (campaign period) show 122 and 119 crashes; a decrease from the 1995 statistics that show 133 and 127 crashes respectively, but an increase compared to 1994 statistics of 113 and 114, respectively.[10] To ensure that these results were not a part of some change in driver behavior statewide, crash data for Florida from 1994 to 1996 were also obtained. For the one year pre and post campaign (1995 and 1996 respectively), there was a 5 percent increase in crashes statewide during this time period, whereas there was 7.3 percent reduction in crashes in Polk County, which may be attributed to the RLR campaign. However, the authors would like to stress that while these are encouraging results, additional data are needed to validate these findings and quantify the effect of the RLR campaign on traffic crashes.

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.[11] 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.[8] The most frequent citizen complaints received relate to traffic violations. Of those traffic concerns, the top two are speeding in residential areas and red light running vehicles.

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.[11] Although the team enforcement concept was successful, it was also 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.[11] Experience has also shown that only frequently repeated enforcement efforts have a positive impact on reducing the number of observed violations.

Howard County has 71 traffic signals under its control, and 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 FHWA, Howard County field tested two cameras from March of 1996 to March of 1997. Because Howard County

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wanted to know the true capabilities of the system, as well as the maintenance and manpower costs associated with operating an automated enforcement system, the county decided to rent (instead of buy) the cameras and equipment, to handle film loading, unloading and developing, and to issue the warning notices themselves.

Of the 71 traffic signals in Howard County, there are currently 16 county signals and eight state highway signals with cameras. There will be a total of 20 intersections under camera surveillance by mid-year 1999. Howard County is just beginning to use the "false camera" strategy whereby the camera boxes and electrical circuitry and warning signs are installed, but there is no camera. The Howard County Police Department manages the vendors who conduct the red light running detection activities. Formal automated enforcement of red light running began in February of 1998.

Public Involvement

A significant public awareness and education program was conducted as part of the effort to make drivers aware of the dangers of running red lights. Television ads and radio announcements were created by a professional advertising firm. To get the message out to many people, the ads were run during major events; for example, some 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 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 letters were 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 showing them photographs taken by the cameras and informing them they had committed a violation. The warning notices also contained a phone number which people could call with concerns or questions about the program. During the test period, public reaction to the system was positive.

The goal of the public education/awareness was to change peoples' opinions about the enforcement of red light violations. In a questionnaire issued in 1996, Howard County residents were asked the questions: "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 fewer people would receive a citation for the violation. The same questionnaire asked people how often they observed red light violations. The top answers were "everyday" and "2 or 3 times a week." [11]

Legislation Enacted

Maryland attempted 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 bills failed due to the lack of a coordinated effort among counties, some of whom were not even aware that the bills were being considered. [11]

Transportation Act 21.202.1 was eventually enacted and allows for the use of automated enforcement technology for red light violations effective October 1, 1997. The Act 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, and after review by a police agency technician, it is determined a violation has been committed."[8] 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 the red signal indication." Transportation Act 21.202.1 also allows for citations to be mailed to offenders and does not contain a Sunset provision. The Act 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. The Act also defines that the civil penalty may not exceed $100 and that citations must be mailed within two weeks of the alleged violation.[11] In Maryland, the fine has been set at $75 by the Chief Judge of the District Court of Maryland.

Technology

The camera technology being used is manufactured by Robot of Germany, and the specific camera being used is a Robot Industrial High Speed Camera with a 100 foot (30.5 m) film pack. Trafficpax is the representative for Robot in the United States. The sensor configuration and location are similar to that illustrated in Figure 1. Two loops per lane were placed in the pavement, a three tenths of a second buffer was allowed, and the minimum criterion of 19 mph (31 kph) for vehicles to be photographed was included in the system.

Data Processing

The demonstration projects involved installing cameras at two locations, and for this part of the project, 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. Even with the small nature of the project, data quickly accumulated and the need for a formal processing technique became evident. Currently the Howard County Police Department contracts with a company to supply computer processing and digitizing equipment within the Howard County Police Facility. This substantially improved the quality of the images on the citation and speed of the process. At the present time, contractor personnel maintain the cameras as well as exchange and develop film as evidence. Under police supervision, other contract personnel sign out film, create a digital image

from the photograph and review each image for violation criteria. Police personnel then conduct final review and determine if a citation should be issued.

Operational Problems

The major problem with the use of the automated enforcement system involved glare from the highly reflective Maryland registration plates which affected the quality of the photographs taken by the camera. Glare presented the most significant problems at night and in the winter time when the sun hits the plates at lower angles. Glare also affected many photographs because the equipment being used, during the test, in Howard County to identify vehicle license plates magnified them for clarity, but made them less readable. Technology exists to use equipment that can change the contrast of the photograph to make the license plate more legible.

Servicing the cameras also presented a significant problem. Being responsible for the operation and maintenance of the cameras and for the loading, unloading and processing of the camera film was manpower intensive. Employees spent many work hours matching violations and preparing and mailing notices of violation. The two-week turnaround time defined in the legislation allowed little time to develop film, identify alleged violators and mail out the violation.

Program Results

Warning notices were issued up until February 1998. However, the issuance of warnings led to a significant decrease in the number of violations at intersections equipped with automated enforcement technology. 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 per day and the other intersection experiencing approximately 24 violations per day. The combination of mailing warning notices to violators and engaging the public in an 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 at each intersection. Overall, the program achieved a 23 percent reduction in the number of violations.[11]

These two intersections began to issue citations to alleged violators in 1998. Crash data were compiled and analyzed comparing the crash rates for 1997 (before citations were issued) and 1998 (citations issued). Tables 3 and 4 illustrate the crash data for each of the two intersections for 1997 and 1998.

Table 3. Crash Data for Broken Land Parkway and Stevens Forest Road Intersection
Source: Howard County Traffic Engineering Department

Intersection #1- Broken Land Pkwy. and Stevens Forest Road				
1998 ADT exceeds 40,000, Peak Hour Volume exceeds 2000, and Growth Rate ('93-'97)=5.2% per year				
	Crash Type			
Year	Rear End	Angle	Other	Total
Before, 1997	14	3	3	20
After, 1998	10	6	2	18

Table 4. Crash Data for Little Patuxent Parkway and Columbia Road
Source: Howard County Traffic Engineering Department

Intersection #2- Little Patuxent Pkwy. and Columbia Road				
1998 ADT exceeds 40,000, Peak Hour Volume exceeds 2000, and Growth Rate ('93-'97)=2.4 % per year				
	Crash Type			
Year	Rear End	Angle	Other	Total
Before, 1997	5	5	5	15
After, 1998	6	2	0	8

The crash data for two intersections in Howard County provided in Tables 3 and 4 show a decrease in total crashes at each site from 1997 to 1998. At intersection #1 there was a decrease in total , "rear end," and "other" accidents, but "angle" accidents doubled from 3 to 6. At intersection #2 there was a decrease in total, "angle" and "other" accidents, however, there was an increase in rear end accidents from 5 in 1997 to 6 in 1998. "Other" accidents were classified as those not labeled as rear end or angle in the police report. The first year of after data may not capture the success of the program because the first year data may include biases with respect to users becoming familiar with the program. Additional data are needed to quantify the effect of the RLR campaign in Howard County.

ELECTRONIC ENFORCEMENT IMPLEMENTATION

Based on a review of automated enforcement programs worldwide, the following elements are necessary for a successful program: public education and awareness, involvement of local judiciary and passage of enabling legislation.[1]

Favorable public opinion and public acceptance have been identified most as the critical issue for implementation of an automated enforcement program.[1] This issue can be successfully dealt with by developing public safety campaigns that explain the need for the program and stress the advantages of the program. Local government should also be involved for a successful program. In many cases the legislative issues are more challenging than the technological and procedural ones. Legislative issues can add months or years to the deployment process.[7] Specifically, state legislation must be enacted permitting electronic equipment to generate admissible citations to violators (traditional laws require police officers to issue tickets at the scene).[7]

Other institutional issues related to the use of automated enforcement include privacy, distribution of ticket revenue, and ticketing procedures. Legal experts have concluded that automated enforcement does not violate a citizen's legal right to privacy.[1] Most people believe that they are giving up some personal privacy if they are driving in an area with automated enforcement in place.[1] To overcome this, it is recommended that the public be aware and constantly reminded of the benefits of the program.

It is important to determine in the design stage where the revenue generated by automated enforcement will be allocated. Two potential uses for this revenue are to put it into the city general fund or a special fund that is used solely for transportation safety improvement measures.[1]

It is also important for implementors to decide early on the criteria used to issue a ticket, and the penalty for the ticket. If tickets issued by automated enforcement systems are not moving violations, then the task of identifying the driver of the vehicle is eliminated because no points are assessed for non-moving violations.[1]

Passetti defined ten strategies for successful implementation of an Automated Enforcement program.[8] These strategies are enumerated below:

1. Demonstrate a need for the program.

2. Establish institutional arrangements.

3. Review applications and technology vendors 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.

These strategies were developed to assist jurisdictions in the creation and implementation of programs for the automated enforcement of red light violations. In order for an automated enforcement of red light violations program to be successful, many political, economic and social issues must be addressed.

SUMMARY AND CONCLUSIONS

The objectives of this report were to:

- Summarize the scope of the RLR problem.

- Provide an overview of automated enforcement of RLR.

- Synthesize and evaluate five automated enforcement programs in the United States.

- Develop an implementation strategy for a successful automated enforcement of RLR program.

The measures of effectiveness that were examined for this synthesis were as follows:

- Reduction in red light violations.

- Reduction in crashes.

- Cost savings over manual enforcement (including maintenance and operations).

- Public acceptance.

- Institutional barriers.

The major conclusions regarding these measures that are drawn from this synthesis are identified in the following section.

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Reduction in Red Light Violations

- Implementation of an automated enforcement program for red light running should translate into at least 20 and as much as a 60 percent reduction in violations.

Reduction in Crashes

- There was a reduction in crashes in Howard County and Polk County when comparing crash data one year before and one year after the RLR campaigns were implemented. However, these simple comparisons are not statistically rigorous to conclude that the RLR program will result in crash reduction immediately or in the long run.

- Additional crash data are needed to validate and quantify the RLR automated enforcement programs implication on crashes.

Cost Savings over Manual Enforcement

- Howard County estimated that automated enforcement of one intersection could produce 2,000 citations in one month. For two police officers it would take about two years to issue 2,000 citations.

- Manual enforcement of red light violators can be dangerous to police, motorists, pedestrians and bicyclists.

Public Acceptance

- Before a jurisdiction implements a RLR automated enforcement program, it should make sure that there is a need (high accident/violation rates related to RLR) for the program. Videos of intersections with high violation rates is a useful way to convince the public of the need.

- The public will accept this type of program if statistics of lives saved, number of accidents saved, or money saved are available.

- Public acceptance may impact the success of a RLR automated enforcement program. San Francisco, Howard County, Polk County and Los Angeles County informed the public early in the program which translated to quicker acceptance.

Institutional Barriers

- Legal and Social institutional barriers significantly affect RLR automated enforcement programs.

    - Initially some groups felt RLR programs infringed on motorist's rights, however, Supreme Court decisions have led to the belief that the use of automated enforcement technology does not violate an individual's right to privacy.

    - Legislation should be established that allows for the use of automated enforcement technology. Registered owner liability is the preferred legislation.

    - Public awareness campaigns that provide detailed information should accompany RLR automated enforcement programs.

The technology for these programs are constantly changing and research should be performed to identify the appropriate system and vendor for the needs of the potential user.

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