Automated Speed Enforcement in the U.S.: A Review of the Literature on Benefits and Barriers to Implementation

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ABSTRACT

Excessive speed is considered to be a major contributing factor to motor vehicle crashes and is thus an important focus of highway enforcement efforts. Automated speed enforcement programs have been widely applied outside of the U.S. to effectively address speeding-related safety problems. In the U.S., automated speed enforcement programs are currently operated in only 11 states and in Washington D.C., most of which are located on residential streets and not highways. Moreover, a number of automated speed enforcement programs have been discontinued since 1990**.** This literature review explores the potential benefits and barriers to implementing automated speed enforcement programs in the U.S. by examining the large body of literature on automated enforcement programs, including red-light and speed programs. It begins with background on the implementation of automated speed enforcement and includes a discussion of research on the potential safety and financial effects of these programs. Next, the legal restrictions to the implementation of automated speed enforcement in the U.S. are outlined. This is followed by a discussion of stakeholder support including potential concerns of citizens, special interest groups, elected officials, and governmental agencies. Then, an evaluation of key program design choices is provided, encompassing issues related to owner or driver liability, manned or unmanned systems, mobile or fixed systems, visibility, location, enforcement thresholds, program management, and revenue distribution. The study concludes with a discussion of major findings.

Key Words: automated speed enforcement, legal and institutional barriers, ITS

Word Count: 7,500

INTRODUCTION

Excessive speed is considered to be a major contributing factor to motor vehicle crashes and is thus an important focus of highway enforcement efforts. In the U.S., the National Highway Traffic Safety Administration (NHTSA) reports that in 2003 speeding contributed to 30 percent of all fatal traffic crashes, in which 13,113 lives were lost (*1*). Moreover, the economic cost of these is estimated to be over 40 billion dollars per year (*1*).

Automated speed enforcement is one tool that can be used to reduce roadway speeds and crashes. These programs combine radar and image capturing technologies to detect speeding and collect photographic evidence of violations (i.e., including a picture of a driver and/or license plate) that can be used to issue a citation. In the U.S., automated speed enforcement programs are currently operated in only 11 states and in Washington D.C., most of which are located on residential streets and not highways**.** Automated speed enforcement programs have been more widely applied in many countries outside the U.S. to effectively address speeding-related safety problems.

This study explores the potential benefits and barriers to implementing automated speed enforcement programs in the U.S. by reviewing the relatively large body of literature on automated enforcement programs, including red-light and speed programs, in the U.S. and abroad. The core of the literature review is drawn from general overviews and case studies of automated enforcement programs published in academic journals, by governmental agencies, and by professional associations. When necessary, this information is supplemented with newspaper articles and reports by non-profit interest groups.

The study begins with background on the implementation of automated speed enforcement inside and outside the U.S. and includes a discussion of research on the potential safety and financial effects of these programs. Next, the legal restrictions to the implementation of automated speed enforcement in the U.S. are outlined. This is followed by a discussion of stakeholder support including potential concerns of citizen, special interest groups, elected officials, and governmental agencies. Then, an evaluation of key program design choices is provided, encompassing issues related to owner or driver liability, manned or unmanned systems, mobile or fixed systems, visibility, location, enforcement thresholds, program management, and revenue distribution. The study concludes with a discussion of major findings from the literature review.

It is hoped that the results of this study may provide some helpful insights to those considering implementation of automated speed enforcement programs in the U.S. by outlining (1) necessary conditions for automated speed enforcement program implementation; (2) design elements to help meet program goals under differing levels of stakeholder and legal support; and (3) critical trade-offs between the feasibility of implementation and program effectiveness.

BACKGROUND

History

By some accounts, automated speed enforcement was originally applied in the U.S. in 1910 (*2*). However, it was not until the 1970s that photo-radar technology was more widely applied for automated speed enforcement in Europe (*3*). In the U.S., an automated speed enforcement was tested in Texas in the 1970s (*4*), but it was not until 1987 that photo-radar was applied for law enforcement purposes in Paradise Valley, Arizona (5). Red-light camera automated enforcement programs, which now far outnumber photo-radar programs, did not appear in the U.S. until the 1990s (*6*). According to the Insurance Institute of Highway Safety (IIHS), as of May 2007, 23 states and the District of Columbia have red-light programs in more than 200 communities in the U.S. and only 11 states and the District of Columbia have automated speed enforcement programs in about 30 communities (*7*). The states with automated speed enforcement include Arizona, Colorado, Iowa, Massachusetts, New Mexico, North Carolina, Ohio, Oregon, Tennessee, Texas, and Washington (*7*).

A long-running residential automated speed enforcement program in San Jose, California was recently halted over concerns about the legality of issuing tickets and fines (see more detailed discussion below, California currently does not have enabling legislation) and may become a warning program in the future.

Automated speed enforcement programs in the U.S. largely target speeding on surface streets with speeds from 30 to 50 miles per hour, and many, such as those in Portland (Oregon), and Denver (Colorado), are restricted to residential streets. Washington, D.C. has one of the few programs that operate without roadway classification restriction; photo-radar is used there on some high-speed urban arterials and highways (*8*).

An automated speed enforcement demonstration project was recently implemented on Arizona State Route 101 from January 2006 to October 2006 in the City of Scottsdale (*9*). The demonstration included six fixed-speed enforcement cameras (three in each direction) over a 6.5 mile segment of the route (*9*). After a preliminary study of the demonstration project indicated positive safety benefits of the program, the City of Scottsdale reactivated the program in February 2007. It appears that the program may be expanded to other cities in the state.

Outside of the U.S., automated speed enforcement is used more extensively (*5*). Australia, Germany, and the U.K. appear to make the most use of speed cameras, but 14 other countries including Korea, Taiwan, and the United Arab Emirates have active automated speed enforcement programs as well (*5*).

Safety Effects

An important motivating goal of many automated speed enforcement programs is the reduction of speeding-related crashes and resulting injuries and fatalities. A number of studies that evaluate the safety effects of automated speed enforcement programs were examined for this review. In general, these studies indicate an approximately two to 15 percent reduction in speed and a nine to 50 percent reduction in crashes. Many studies also find that the speed cameras were most effective at reducing more serious crashes involving injury and death. The location, roadway and camera type, method of analysis, and key results of these studies are summarized in Table 1. The quality of the evaluation in these studies varies, and when possible, this information is detailed in

Table 1. Some studies employ naïve before and after analysis without controlling for changes in traffic trends during the study period, regression to the mean, and spillover effects. Studies that do not control for traffic trends between the before and after time frame, for example, by collecting data from comparable sites with and without speed enforcement, may overestimate or underestimate safety effects. Studies that do not account for regression to the mean effects may overestimate safety benefits from the program because many speed cameras are employed at locations with a high rate of crashes. Studies that focus on the intersection level effects underestimate safety benefits because of behavioral changes induced by the cameras typically "spillover" to a larger area. In addition, some studies have a small sample size and thus there is greater uncertainty in the significance of their findings.

TABLE 1 Summary of Studies Evaluating the Safety Effects of Automated Speed Enforcement Programs.

Location	Roadway	Camera	Method of Analysis	Results
Scottsdale, AZ, US (*9*)	Highway	Fixed	Before & after; with comparison group; Bayes' analysis (6 sites)	9.5 mph decline in mean speed; all crashes except rear-end decline
France (*10*)	Streets & highways	Mobile & fixed	Before & after (3 years)	5 km/h decline in mean speed; 30% decline in fatal crashes
Netherlands *(11*)	Streets	Mobile	Before & after with control (28 sites)	3.5 km/h decline in mean speed; 21% decline in accidents and casualties
Cambridgeshire, UK (*12*)	Streets	Fixed	Before & after control for trend, seasonality, and regression to the mean effects (49 sites & 12 year data set)	45.7% decline in injury crashes
West London, UK (*13*)	Highways	Fixed	Before & after (36 months) with controls (10 sites)	8.9% decline in crashes; 12.1% decline in fatal & serious crashes; 55.7% decline in fatal crashes
Washington DC, US (*8*)	Streets	Mobile	Before (1 year) & after (6 months) with control (7 sites)	14% decline in mean speed; 82% decline in speeding vehicles
South Wales, UK (*14*)	Highways & streets	Mobile	Before (38 months) & after (17 months) with control (101 sites)	51% decline in injury crashes
San Jose, CA, US (*15*)	Streets	Mobile	Before & after	15% decline in proportion of speeding 10 mph over limit
British Columbia, CA (*16*)	Highways & streets	Mobile	Before & after; time-series cross sectional; interrupted time series	25% decline in speed related crashes; 17% decline in crash fatalities (daytime)
New Zealand (*17*)	Not noted	Hidden fixed	Before & after with interrupted time-series design with control	0.7 km/h decline in speed, 11% decline in crash rate; 19% decline in casualty rate
Paradise Valley, AZ, US (*5*)	Streets	Mobile	Before & after	40% reduction in crashes
National City, CA, US (*18*	Streets	Mobile	Before & after (6-years)	10% decline in traffic speeds; 51% decline in crashes
Beaverton & Portland, OR, US (*19*)	Streets	Mobile	Before & after with control	2% decline in mean speed; 30% decline in speeding vehicles
Norway (*20*)	Streets	Fixed	Before & after controlling for general trends & regression to the mean (64 sites)	20% decline in injury accidents
Victoria, Australia (*21*)	Note noted	Mobile	Before & after	Reduced percent of speeding vehicles from 23% to 2.9%; 22% decline in total crashes; 38% decline in injury crashes
New South Wales, Australia (*21*)	Streets & Highways	Mobile	Before & after	22% decline in serious crashes
Germany (*22*)	Highway	Fixed	Before & after	Reduced percent of speeding vehicles from 95% and 80% to 7% and 3%, respectively; accident rated reduced by a ratio of 18 to 1; fatalities reduced from

				7 to 8 a year to 1.

Financial Effects

While the goal of automated enforcement programs is to reduce speeding and save lives, questions are often raised about the financial effects of such programs. Our review of the literature indicates that few existing programs in the U.S. actually generate revenue (Washington D.C. and Scottsdale) and many are either revenue-neutral or require a subsidy. Of the seven red-light automated enforcement programs in California, only San Diego and Oxnard generate significant net revenues (*23*). In addition, six of the seven automated speed enforcement programs implemented in California over the past 15 years cited program costs as a contributing factor leading to their discontinuation (*24*).

A number of factors can contribute to the financial effects of automated speed enforcement programs including the capital, operation, and maintenance costs of the equipment; administrative costs to courts, police, and departments of motor vehicles resulting from the increased volume of traffic tickets; and state laws limiting ticket revenues to local implementing jurisdictions (*24*).

In theory, all automated speed enforcement programs should incur relatively consistent equipment costs. What can vary from jurisdiction to jurisdiction, however, is the degree to which governing laws restrict revenues and increase administrative costs. For example, during the life of the six defunct programs in California, state law imposed significant restrictions on "the amount of revenues that cities could receive from traffic fines" (*24*, p. 24). In addition, California law did not (and still does not) have enabling legislation for direct legal service of photo-radar speed citations through the mail. Cities can only issue a "notice of speed violation" to the registered vehicle owner, beginning the process of legal service for an eventual citation. If this notice is ignored, then the administrative cost to follow up with alleged violators is significantly increased (*24*). In the Pasadena program, initially only 16 percent of tickets were ignored; however, by the end of the program approximately 40 percent were ignored as violators increasingly realized that compliance was voluntary (*24*). It may be that the longevity of the automated speed enforcement program in San Jose, California, which was recently halted over legal concerns (see discussion below), was related to relatively rare instances of ignored citations, perhaps, resulting from strong community involvement including resident nomination and approval procedures for locations eligible for automated speed enforcement.

Because automated speed enforcement may have benefits related to avoided injuries and deaths, many communities choose to subsidize these programs. Such benefits may be significant. For example, one study of British Columbia's automated speed enforcement program examined the avoided costs of speeding-related fatalities and injuries and concluded that it produced an annual savings of over 38 million Canadian dollars (*25*.

LEGAL RESTRICTIONS

In this section, legal restrictions on the implementation of automated speed enforcement programs are reviewed, including possible constitutional restrictions, enabling legislation, and evidentiary requirements.

Constitutionality

> If there is one constant in enforcement, it is that drivers will contest speeding citations. Because constitutional attacks are easily fashioned to assert nearly any position, it can be expected that implementation of photo-radar in a state will generate constitutional challenges. (*26*, p.10)

Automated enforcement programs in the U.S. have the potential to be challenged on the grounds that they may violate constitutional rights and protections, including the right to privacy and freedom of association under the First Amendment; protection against illegal search and seizures under the Fourth Amendment; the right to due process under the Fifth and Fourteenth Amendments; the equal protection doctrine in the Fourteenth Amendment; and the taking clause of the Fifth Amendment (*5, 24, 26, 27*). Legal scholars, however, appear to agree, based on the body of established case law--both specific and not specific to automated enforcement--that these programs do not violate these constitutional rights (*5, 24, 26, 27*).

Enabling Legislation

The implementation of automated enforcement programs usually requires enabling legislation or code amendments. Typically, if the state is operating the automated speed enforcement program, then state legislation is passed (*5*). However, if the local agencies are operating the program, then both local and state legislation amendments may be needed (*5*). Specific elements of the state and local enabling legislation are usually determined in cooperation with the courts, enforcement agencies, state transportation departments, motor vehicle departments, and any other agency whose operations may be affected by the program (*5*).

According to the IIHS (*7*), the following states have some sort of local or statewide enabling legislation for automated speed enforcement: Arizona, Arkansas (school zones); Colorado (school zones, residential areas or adjacent to park); Illinois (construction zones or toll authority roads); Maryland (school zones and residential districts); Utah (school zones or where speed limit is less than 30 mph with officer present and local ordinance); and Washington D.C. (no restrictions). In Oregon, photo radar is authorized by a provision that is separate from the state level red-light legislation (four hours per day section 810.438) (*7*). Many more states have statewide legislation authorizing red-light programs (*28*).

State enabling legislation may include the following elements:

- definition of acceptable automated enforcement devices;
- any restrictive uses (e.g., manned, unmanned);
- description of acceptable photographic evidence;
- description of the admissibility of such evidence;
- a registered owner liability section including provisions for rebuttable presumptions;
- description of any required corroborating testimony (e.g., civil or criminal);
- provisions for summons by mail; and
- penalty provisions. (*5*, p. 21)

Local enabling legislation may include more specifics on program implementation:

- specific automated enforcement devices, operating criteria, and data to be collected for that jurisdiction;
- the specific agency (e.g., police, traffic department) empowered to operate the program;
- restrictive uses particular to that jurisdiction (e.g., expressways, local streets, schools);
- requirements for advanced notification (e.g., signs);
- requirements of expert witness and/or operator testimony in court;
- any sunset and/or review clauses regarding the life of the program; and
- any criteria that must be satisfied before automated enforcement can be used at a particular location or area. (*5*, p. 21)

Automated speed enforcement programs have been implemented in communities without state level enabling legislation. However, the history of automated enforcement in the U.S. suggests that without enabling legislations, these programs are more vulnerable to legal challenges that may contribute to their demise (*24*). In California, the law authorizes the use of enforcement cameras for red-light and at grade-railroad crossing violations. While the use of photo-radar is not prohibited, the state's photo-enforcement enabling legislation explicitly states that its provisions do not apply to photo-radar (California Vehicle Code sections §§ 210, 21455.5, 21455.6, 40518-40521). Despite this, seven communities in California have, but no longer, operated automated speed enforcement programs by issuing a "notice of speed violation" to the registered vehicle owner, to begin the process of legal service for an eventual citation: Campbell (1990 to 1996); Danville (1990 to 1993); Folsom (1990 to 1993); National City (1991 to 1997); Pasadena (1998 to 1992); Roseville (1990 to 1992); and San Jose (1996 to 2007). The long-running residential automated speed enforcement program in San Jose, California was recently halted over concerns about the legality of issuing tickets and fines. In this program, the owner was given the option of signing and returning the notice of speed violation, or making an appointment to view the photograph. Until the owner signed the notice, the locality did not have jurisdiction over the alleged violator or the authority to issue a speeding ticket. However, once the alleged violator signed and returned the notice of a speeding violation, the city would typically issue a formal complaint that was filed with the court.

A state legislator from Los Angeles introduced Senate Bill 466 in February 2005, which would have authorized photo-radar for use on residential streets only. The bill is currently active. However, there are no hearings scheduled at this time. The author and supporters of the bill are currently reviewing its feasibility and impact before proceeding any further.

Evidentiary and Procedural Issues

Automated enforcement programs have raised questions about the admissibility of photo evidence. Two theories that support the admissibility of photographs generated by automated enforcement devices as evidence are pictorial testimony and silent witness (*24, 26)*. Under the first theory, the admissibility of automated enforcement generated photographs is dependent on the statement of a witness who testifies that the picture is an accurate description of what they personally observed, which would require the automated enforcement device to be manned (*24*). For unmanned automated enforcement devices, the silent witness theory can support the

photograph as a substitute for oral testimony as long as the photograph includes images that provide evidence of its authenticity, such as the driver, driver's license plate, make, model, and color of vehicle (*24*). To safeguard against false depictions, defendants can be given the option to argue that the photograph was unclear or had some defect (*24*).

To insure that photographs taken at photo-radar camera sites are admissible in court, a clear chain of custody must be established (*26*). To protect against potential evidentiary challenges, Lynn et al. (*26*) recommends that jurisdictions establish the following: time frames for mailing citations to violators, procedures for loading and unloading film, and standards for laboratory processing and storage of photo evidence.

STAKEHOLDER SUPPORT

Many of the case studies and general overviews reviewed as part of this evaluation stress the importance of stakeholder support and interagency cooperation in the development and implementation of an automated speed enforcement program. In this section, key automated speed enforcement stakeholders are identified, their potential concerns are described, and recommendations are made to address these concerns.

Citizens

The public support for automated speed enforcement is examined by reviewing the results of public opinion surveys conducted in the U.S. and making recommendations to improve public support based on past program evaluations.

Public Opinion Surveys

Since the early 1990s, a number of national and regional public opinion surveys have explored the public's response to automated enforcement. In general, the results of these surveys indicate that a majority of respondents support automated enforcement. However, the margins of support vary widely, from a low of 51 percent in Washington, D.C. (*29*) to a high of 77 percent in Scottsdale, Arizona (*30*).

In a national survey sponsored by NHTSA in 2002 (*31*), 68 percent of the respondents indicated that the use of automated speed enforcement systems was a good idea for those "going 20 mph or move over the posted speed limit" and 78 percent for speeding in a school zone (p. 68). In addition, 56 percent of drivers favored photos taken of the driver from the front of the vehicles and matched to the driver's license, and 32 percent were in favor of taking photos of the rear license plate only.

In an earlier 1998 national survey sponsored by NHTSA (*32*), 71 percent of the respondents indicated that they favored the use of automated devices for speed enforcement. The results of this survey indicated that females are more likely than males to endorse automated speed enforcement (by 15 percentage points) (*32*). The survey also found that 76 percent of drivers believed that the use of automated speed devices would reduce speeding-related accidents (*32*).

The 1998 NHTSA survey (*32*) also explored the reasons for respondents' support or lack of support of automated enforcement programs in general. They found that 69 percent thought it

was a good idea, 15 percent disliked the idea, and 16 percent had mixed feelings. The leading reasons provided by those who liked the idea were the following:

- photo evidence proves a violation (20 percent),
- increased driver awareness (19 percent),
- fewer police needed for traffic enforcement (19 percent),
- drivers would obey traffic laws and regulations (18 percent),
- freeing up police for other types of enforcement (9 percent),
- Deterring speeding (7 percent), and
- Reducing accidents (9 percent). (*32*, Table 3-1)

The leading reasons provided by those who disliked the idea were the following:

- invasion of privacy, violation of rights, or government infringement (26 percent),
- preference for in-person contact with an officer (18 percent),
- licensee must pay ticket no matter who was driving (14 percent),
- camera failures including error, malfunction, and other (13 percent),
- machines should not do police work (12 percent), and
- could be ineffective or unenforceable (11 percent). (*32*, Table 3-2)

In August 2002, approximately nine months after speed cameras were installed in Washington D.C., a telephone survey was conducted to gauge the public's opinion of the program (*29*). The survey results indicated that overall, 51 percent of respondents favored and 36 percent opposed the use of the speed cameras. Thirteen percent of respondents reported having no opinion. In addition, the results suggested that "support for camera enforcement was higher among middle-aged and older drivers, among drivers who had not received a speeding ticket in the mail and did not know anyone who had, and among drivers who said speeding was a problem" (*29*, p. 100).

In 2004, a survey of Scottsdale (Arizona) residents was conducted to explore opinions about the automated enforcement programs in the city (*30*). Seventy-seven percent supported the programs, 17 percent opposed, and 6 percent were unsure. Female respondents were more likely to support the program than men (by 10 percentage points). Seventy-four percent of respondents supported the expansion of current automated enforcement programs. Forty-five percent indicated that they were more careful about observing speed limits after the implementation of photo radar. About 25 percent of respondents indicated that the programs had "done a great deal" to "improve traffic safety in Scottsdale" (*30*, p. 10).

In 1989, telephone surveys were conducted in and around a number of cities in the U.S. that had recently initiated automated speed enforcement programs: Paradise Valley, Phoenix, and Scottsdale, Arizona and in Pasadena, Glendale, Burbank, South Pasadena, Alhambra, San Gabriel, Temple City, Arcadia, El Monte, Monrovia, Altadena, San Marino, La Canada, La Crescenta, Sierra Madre, and Duarte, California (*33*). Participants were read a description of photo-radar and those who had not already mentioned photo-radar were asked if they had known about its use (*33*). The results indicated that a majority of survey respondents were aware of the use of automated speed enforcement systems and supported its use. In addition, 58 percent of the survey respondents approved or strongly approved of the use of automated speed enforcement devices, 37 percent disapproved or strongly disapproved, and 5 percent were unsure. Sixty-seven

percent of those who approved thought that the use of these systems should be increased or expanded. In addition, 47 percent indicated that they drove more slowly as a result of the automated speed enforcement program in their respective cities. Those who disapproved most frequently cited these reasons: "wrong person can get ticket and errors will be made," "gives policy and unfair advantage" or "sneaky," and "violates rights to privacy" (*33*, p. 63).

Public Outreach and Involvement

Many experts assert that public acceptance of automated speed enforcement programs may hinge on the public's recognition of speeding as an important community problem. Retting (*29*), in his analysis of the Washington D.C. automated enforcement public opinion survey found that support for the program was higher among those who thought speeding was a problem. Many automated enforcement programs in the U.S. were also initiated in response to a strong public outcry over a sharp upward trend in crashes or several high-profile crashes. For example, in San Francisco, a serious crash caused by a driver running a red light "led then Supervisor Susan Leal to wage a campaign to use red-light phone enforcement in San Francisco" (*6,* p. 46).

Public involvement appears to increase the odds of program success. In Hawaii, the lack of public involvement in the development of their automated speed enforcement program may have contributed to the public backlash that eventually led the Hawaiian legislature to shut the program down (*34*). In the longest running automated speed enforcement program in California, the San Jose program, at least 51 percent of the households fronting the street where the photo radar would be implemented were required to sign and application requesting its application. The guidelines, developed by NHTSA (*1*) for red-light camera program implementation, provide outreach strategies and identify the following public information objectives as necessary for red-light camera implementation:

- make citizens more aware of the safety consequences of the violation,
- explain program objectives and results, and
- provide advanced warning that there will be increased enforcement.

The type and extent of public outreach necessary to build public support for automated speed enforcement varies. It can include traditional public education and outreach methods, such as public service announcements, press releases, and posters, at the very beginning of the program. Other programs use the Internet and media to maintain a dialogue with citizens about the benefits of the program. Washington, D.C., for example, provides extensive monthly summaries of violation rates on their website and issues regular press releases at program milestones. Most programs publish some version, on the Internet or in print, of 'Frequently Asked Questions' or 'Myths and Facts' to address specific concerns. Some also sponsor a telephone hotline to answer questions and register complaints.

Special Interest Groups

Motorist associations, such as state and regional Automobile Association of American (AAA) clubs, the IIHS, health and safety advocates, and local and state transportation organizations are among the special interest groups who may weigh in publicly, with varying degrees of influence, on automated enforcement programs. Some AAA clubs have actively opposed automated speed enforcement, but many have also supported it because of their strong safety mission. For

example, one AAA club representative, in a 2005 interview about the Washington D.C. program, stated that:

> When automated enforcement is done for safety, we support it. When it's a gotcha game for greenbacks, we oppose it. (*35*)

Elected Officials

Elected officials play a crucial role in many automated enforcement programs. In some cases, they have acted as strong champions by sponsoring enabling legislation or amendments to continue or strengthen the original legislation, as was the case for San Francisco's red-light program. In other instances, elected officials have either shut programs down or preemptively prevented the technology from being used. In Hawaii, the legislature first passed its automated speed enforcement legislation in 2000, but it was repealed in 2002, after its introduction prompted a wave of complaints. In response to the proposed expansion of the Scottsdale program on a highway, the state legislature introduced a bill to ban the use of photo-radar on state highways. This bill, however, was ultimately unsuccessful.

Governmental Agencies

Governmental agencies, such as motor vehicle, law enforcement, courts, and transportation, may have several important concerns surrounding the automated enforcement programs, in particular implementation and enforcement costs and adoption by law enforcement personnel. As discussed previously, automated speed enforcement programs are designed to improve enforcement efforts and, as a result, they increase the volume of citations that must be processed by the police, courts, and the departments of motor vehicles. In addition, agencies may incur significant capital, operation, and maintenance costs, either in-house or through a vendor, for the automated enforcement equipment.

Early involvement of legal experts can help minimize the impact of the program on the courts. Local judiciaries who will be hearing automated speed enforcement defenses and appeals should be involved early in the program design phase because without judicial support it may be difficult to enforce citations (*5*).

The agency that initiates and manages automated speed enforcement programs is often, but not always, a police department. For example, the San Jose and New York programs are managed by transportation agencies. Regardless of which agency is responsible for the administrative duties associated with operating an automated speed enforcement program, police officers almost always play a key role in the success of any program. A number of automated speed enforcement programs have, in fact, been initiated or supported by police to reduce speeding-related accidents, increasing the cost-effectiveness of enforcement, and addressing the difficulties and hazards associated with stopping speeders in/at high speed facilities (*5, 24*). On the other hand, other studies (*5*) document a number of significant concerns about automated enforcement among law enforcement personnel, such as:

- reducing felony arrests,
- perpetuating a negative image of officers as sneaky,
- depriving motorists of officer discretion, and

- opposition by unions because of image and job security concerns. (p. 32)

Concerns of law enforcement personnel may be addressed by soliciting their involvement early in the process and by outreach campaigns to inform them about the program and its benefits (*5*).

PROGRAM DESIGN CONSIDERATIONS

In this section, key choices about program design features that hold significant potential to improve stakeholder support, reduce the operating costs of the program, and enhance the safety benefits are outlined. Unlike the legal and stakeholder concerns discussed above, this section describes the program design features over which policymakers may have more direct control.

Owner or Driver Liability

A key element of automated enforcement enabling legislation is the provision that assigns liability. Many automated enforcement programs assign liability to the registered-owner as a civil infraction similar to a parking ticket. Registered-owner liability is the legal principle behind parking tickets and the penalty is only a civil fine. The tickets issued are not moving violations, which are criminal acts requiring a decision of guilty or not guilty. Instead, they are non-criminal civil infractions for which fines are assessed but no demerit points are assigned. Unlike parking tickets, however, many automated enforcement programs will dismiss a citation if the vehicle owner can provide proof that they were not driving at the time of the infraction. These programs require that a photograph be taken of the driver, in addition to the license plate. For example, owners who were not driving at the time of a photo-radar violation in Portland, Oregon can sign and return a 'certificate of innocence,' along with a photocopy of their drivers' license to have the citation dismissed.

Automated enforcement programs in the states of Colorado, Washington, Arizona, and California assign responsibility only to the driver. When identification is positively established, the violation can be treated like a moving violation, which is a criminal infraction, allowing the program to impose stiffer penalties including higher fines, demerit points, and possible license suspension. Driver-liability typically requires that the issuing agency manually establish a positive match between the driver in the automated enforcement photo and the driver's license photo on record. This requires a clear frontal photograph of the driver, which can be difficult to obtain. As a result, driver-liability programs appear to have lower citation rates than registered owner-liability programs. For example, of all the violations recorded by red-light cameras in San Francisco, only 25 percent of violations result in a citation, and the issuance would more than double if only a clear license plate number were needed (*6*).

It is thought that registered-owner liability may improve the deterrent effect of automated enforcement by increasing the likelihood of being cited. The legislation promoted by the National Committee on Uniform Traffic laws and Ordinances (2001) promotes registered-owner liability. Registered owner liability may be especially critical in a highway environment, where photographic quality is impacted by the speed of the vehicle (*26*). However, some argue that only drivers should be liable because it is unfair to hold owners responsible for the actions committed by others with their vehicle. Others assert that it is unfair to have two different penalties for violating speed limits, and that the lesser penalty may make speeding violations

seem less serious. Driver-liability appears to be preferred when stakeholders want to maintain the stricter penalties for violators.

Manned/Mobile or Unmanned/Fixed Operation

Another key decision, which may need to be codified, is whether the automated speed enforcement equipment will operate with or without an officer present. As described above, under the legal principle known as the pictorial testimony theory, automated enforcement equipment must be attended by an officer who can testify that the photograph is an accurate depiction of the event. Under the silent witness theory, the photograph itself can stand as evidence. In all cases, the equipment must be certified as regularly calibrated and properly maintained. Most courts in the U.S. admit photographic evidence under the silent witness theory. All red-light camera programs operate unmanned, at fixed locations. However, most photo-radar programs in the U.S. are operated by a trained technician or police officer out of a stationary police car or a van that moves along predetermined locations.

Photo-radar does not necessarily need to be operated from a vehicle. In fact, both Scottsdale and Washington D.C. operate fixed, unmanned speed cameras, along with mobile cameras. From a safety perspective, fixed cameras, which are enforced 24 hours a day, appear to be more effective than mobile cameras that are usually not operated 24 hours a day. A study conducted for the U.K. Department for Transportation found that, on average, individuals killed or seriously injured due to speeding-related car accidents fell by 65 percent at fixed sites and by 28 percent at mobile sites (*36*). In addition, because fixed cameras are relatively small, they can be used in locations where a mobile van cannot be used. Fixed cameras are also less expensive to operate because they require less equipment and personnel time.

Mobile units appear to be more popular in U.S. automated speed enforcement programs for several reasons. Their mobility allows cities to expand the reach of photo-radar by rotating their cameras frequently among a large number of locations. For example, San Jose rotated its three camera vans among 170 streets and Scottsdale deploys its mobile units around its residential streets, but uses its fixed cameras in the city's most crash-prone intersections. There is also a sense that mobile, manned cameras are somehow "fairer" because they require the presence of an officer or technician. This may be particularly important when a state vehicle code (as is the case in California) treats speeding as a "prima facie" or "at first sight" violation, which can be mitigated by the presentation of additional evidence such as traffic conditions, weather, and visibility; while red light running is a per se violation that is not open to interpretation, it does not require further evidence.

Visibility

The degree to which automated enforcement programs notify the public about their cameras can have an effect on the program's acceptance and safety benefits. Some enabling legislation in the U.S. requires each camera to have a sign, and others require only that signs be posted at entrances to the city. The U.K. requires camera housings to be yellow, but exceptions are considered, such as for areas of outstanding national beauty. In Australia, signs are posted in zones in New South Wales where radar is enforced, but motorists in Victoria are not notified of the location of the speed cameras so that "the optimum effect of both general and specific deterrence to speeding is obtained" (*21*, p. 36). A study of programs in New Zealand suggests

that there is a more specific effect at the signed cameras, but that the overall deterrent effect is greater when the cameras are hidden (*17*). However, reviews of U.S. automated speed enforcement programs suggest that, when there are public concerns that these programs are essentially speed traps, it may be useful to make the camera clearly visible (*5*).

Location

In the U.S., there is currently only one automated speed enforcement program on high-speed, high-volume roadways, in Washington D.C. In both Colorado and Hawaii, the use of photo-radar on state highways was abandoned after a short period. A 1992 study established the feasibility of operating photo-radar on the Capital Beltway, though neither Maryland nor Virginia chose to follow through with implementation. As discussed above, a one-year pilot study of photo-radar on a dangerous stretch of freeway was implemented in Scottsdale and plans are in place to expand the program in the state. Photo-radar, however, has been more widely used on highways in Canada, Australia, Germany, France, and the U.K. In the U.S., the placement of automated enforcement equipment on highways may make it more vulnerable to attacks because high-volume facilities will generate more tickets and revenues relative to lower volume facilities. In addition, such programs may be less likely to garner strong local advocates because its safety benefits may be more diffuse relative to neighborhood programs.

In practice, it appears that the location of automated enforcement equipment is typically left to the agency managing the program. The ITE (*5*) recommends that agencies clearly define and follow location selection criteria to avoid charges that the programs are being operated simply to generate revenue. In addition, locations should also be chosen to enhance stakeholder support by addressing their concerns and involving them in decision making.

Enforcement Thresholds

Some have suggested that the controversy over automated speed enforcement has been driven, in part, by the concern that the technology may not measure speeds accurately (*5*). To avoid this charge, many programs establish a threshold below which they do not issue tickets. On the other hand, establishing thresholds may raise concerns that the speed limit has somehow been artificially raised. Such thresholds have not typically included enabling legislation in the U.S. In Europe and Australia, the threshold is often expressed as a percent of the posted speed limit. For example, at the start of the program in Victoria, the speed threshold was set at 23 percent above the limit; however it has since reduced that to 2.9 percent (*5*). Alternatively, enforcement thresholds can be determined by the officers operating equipment based on time of day, posted speed, weather, and normal speed patterns, as is the case in Portland (*19*).

Program Management

A number of red-light automated enforcement programs have encountered legal problems due to a lack of program oversight. In the interest of efficiency, most governmental agencies choose not only to rent the photo enforcement equipment from a vendor, but also to contract the system equipment and services necessary to operate the program. Larger cities, such as New York, have assigned a full-time manager to oversee operations, manage the vendor contract, and respond to

public concerns. However, in a number of cities, the programs are just one of many responsibilities of a commanding officer.

A number of well-publicized lawsuits in San Diego and San Francisco illustrate the types of contracting and program management problems that can arise. The San Francisco program was upheld, but the court ruled for the dismissal of 250 tickets in San Diego. In 2001, a State Superior Court judge found that evidence from San Diego's red-light cameras was inadmissible because the city had given the vendor too much control over the program (*23*). A critical piece of evidence illustrating this was that "the vendor had moved detection loops for the camera system at three intersections without the city's knowledge or approval" (*23*, p. 15). Furthermore, "because the vendor was essentially operating the program and being paid on a contingency basis, the court found a potential conflict, which further undermined the trustworthiness of evidence used to prosecute red-light violations" (*23*, p. 15).

The San Diego case prompted the California legislature to pass legislation in 2003 specifically prohibiting the contractors from being paid by the ticket, selecting the locations, changing the signal timing, or reviewing or approving tickets (California Assembly Bill 1022, 2005). Until this rule, it was customary for automated enforcement contracts in California to be structured so that the vendor received a payment for each successful ticket, and those contracts will remain valid until their expiration date (*24*).

In 2002, the California State Auditor released a comprehensive audit of the implementation procedures and effectiveness of red-light camera programs in seven California jurisdictions. The report found that all had weaknesses that made them vulnerable to legal challenges similar to those faced by San Diego and San Francisco. The report recommended more rigorous supervision of vendors. Specifically, the report suggested that more of the programs establish and enforce basic business rules such as rules for screening violations, how long records will be kept, and how often maintenance will be performed. In addition, the report recommended periodic site visits to the vendor's operations to ensure that the vendor's procedures comply with state law and the contract terms (*23*).

Revenue Distribution

> To gain public trust, camera programs must be operated in ways above any suspicion of a profit motive (*23*).

A common concern raised in regard to automated enforcement is that revenue generation is the primary motivation for its use. However, as described above, most photo enforcement programs in the U.S. either operate at a loss or generate very little extra money for the cities. But in case a program does generate revenue, Turner and Polk (*37*) advise deciding what to do with any extra money during the program's design phase and specifically recommend placing it in a safety improvement fund.

SUMMARY OF KEY FINDINGS

Automated speed enforcement programs in the U.S. primarily target speeding on surface streets with speeds from 30 to 50 miles per hour, and many, such as those in Portland (Oregon) and Denver (Colorado), are restricted to residential streets. However, Washington, D.C. uses a program that operates on some high-speed urban arterials and highways (*8*) and, after a

successful automated speed enforcement freeway pilot in Scottsdale, Arizona, there are now plans in place to expand the program to other freeways in the state of Arizona. Outside of the U.S., automated speed enforcement is used much more extensively (*5*).

An important motivating goal of many automated speed enforcement programs is the reduction of speeding-related crashes and resulting injuries and fatalities. A number of studies that evaluate the safety effects of automated speed enforcement programs were examined indicating approximately a two to 15 percent reduction in speed and a nine to 50 percent reduction in crashes. Many studies also find that the speed cameras were most effective at reducing more serious crashes involving injury and death.

While the goal of automated enforcement programs is reducing speeding and saving lives, questions are often raised about the financial effects of such programs. Our review of the literature indicates that few existing program actually generate revenue and many are either revenue neutral or require a subsidy.

The legal restrictions to the implementation of automated speed enforcement in the U.S. include constitutional, legislation, and evidentiary issues. Automated enforcement programs in the U.S. have the potential to be challenged on the grounds that they may violate constitutional rights and protections, including the right to privacy and freedom of association under the First Amendment; protection against illegal search and seizure under the Fourth Amendment; the right to due process under the Fifth and Fourteenth Amendments; the equal protection doctrine in the Fourteenth Amendment; and the taking clause of the Fifth Amendment (*5, 24, 26, 27*). Legal scholars, however, appear to agree, based on the body of established case law - both specific and not specific to automated enforcement - that these programs do not violate these constitutional rights (*5, 24, 26, 27*). On the other hand, enabling legislation is typically necessary to establish a number of important legal conditions necessary for the effective operation of automated enforcement, including responsibility for the citation, admissibility of evidence, and acceptability of serving citations through the mail. Two theories that support the admissibility of photographs generated by automated enforcement devices as evidence are pictorial testimony and silent witness (*24, 26*). To safeguard against false depictions, defendants can be given the option to argue that the photograph was unclear or had some defect (*24*). In order to ensure that photographs taken at photo-radar camera sites are admissible in court, a clear chain of custody must be established, including time frames for mailing citations to violators, procedures for loading and unloading film, and standards for laboratory processing and storage of photo evidence (*26*).

A number of national and regional public opinion surveys have explored the public's response to automated enforcement. In general, the results of these surveys indicate that a majority of respondents support automated enforcement; however, the margins of support vary widely, from a low of 51 percent in Washington, D.C. (*29*) to a high of 77 percent in Scottsdale, Arizona (*30*). Common reasons for opposing automated speed enforcement include privacy concerns, preference of officer contact, as well as concerns about effectiveness, enforceability, and inaccuracy.

Almost all of the case studies and general overviews reviewed as part of this evaluation stress the importance of engaging stakeholders, such as citizens, special interest groups, elected officials and governmental agencies, in the development and implementation of automated speed enforcement programs. Public information and outreach should make citizens more aware of the safety consequences of the violation, explain program objectives and results, and provide advanced warning that there will be increased enforcement (*38*).

Elected officials can play a crucial role in many automated speed enforcement programs. In some cases, they have acted as strong champions by sponsoring enabling legislation. Governmental agencies, such as motor vehicle, law enforcement, courts, and transportation, may have several important concerns that need to be addressed in the program design including implementation costs, enforcement, and adoption by law enforcement personnel.

Key choices about program design features that hold significant potential to improve stakeholder support, reduce the operating costs of the program, and enhance the safety benefits are outlined include: owner or driver liability, manned or unmanned systems, mobile or fixed systems, visibility, location, enforcement thresholds, program management, and revenue distribution. Careful consideration of these key choices in the program design may allow a program to help meet its goals under differing levels of stakeholder and legal support.

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