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63

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**Abstract**

Because of increasing difficulties in enforcing posted speed limits on the Capital Beltway around Washington, D.C., local officials proposed that experiments be conducted with photo-radar to determine if that method of automated speed enforcement (widely used in Europe for about 30 years and very recently employed in the western United States) could help reduce average speed and speed variance.

A project task force led by the Virginia Department of State Police, with assistance from the Maryland Department of State Police and the Virginia and Maryland Departments of Transportation and with technical assistance from the Virginia Transportation Research Council, conducted site visits to cities in Europe and the United States where photo-radar is being used. The task force also invited six manufacturers of photo-radar equipment to staff and demonstrate their equipment. Five of the manufacturers conducted a 2-week series of tests on sections of interstate highways with varying volumes of traffic and different traffic characteristics. The tests, which were conducted from June through September 1990, were designed to provide the evaluators with data on the accuracy, reliability, and efficiency of each unit (in terms of the number of speeding cases that could potentially be generated by the use of photo-radar on the Beltway) and help the study team determine if photo-radar could be successfully deployed on the Capital Beltway as an enforcement tool. In addition, the project included an analysis of legal and constitutional issues associated with photo-radar use as well as an evaluation of public sentiment concerning the use of photo-radar on the Capital Beltway. The evaluators concluded that photo-radar use was feasible on high-speed, high-volume roads such as the Capital Beltway and, therefore, recommended efforts to pass state enabling statutes and test further the efficacy of photo-radar in actual traffic enforcement conditions. Although the results of the study indicate that it is feasible to use photo-radar on high-speed multilane roadways, further study is required to determine its effect on travel speed and safety.

There are also important operational issues that must be considered when using this device. Some items of consideration are identification and selection of operational sites and times to deal with identified traffic safety and enforcement problems; provision of equipment-specific training programs for police officers to ensure the equipment is properly operated; provision for the availability of properly trained technical support personnel to ensure the continuing accuracy of the equipment; setting of speed thresholds that are realistically determined and target the excessive speeder; number of lanes on the roadway; visual obstructions on the roadway; and customizing of photo-radar applications to fit the highway safety problem area.



**FINAL REPORT****AUTOMATED SPEED ENFORCEMENT PILOT PROJECT  
FOR THE CAPITAL BELTWAY: FEASIBILITY OF PHOTO-RADAR**

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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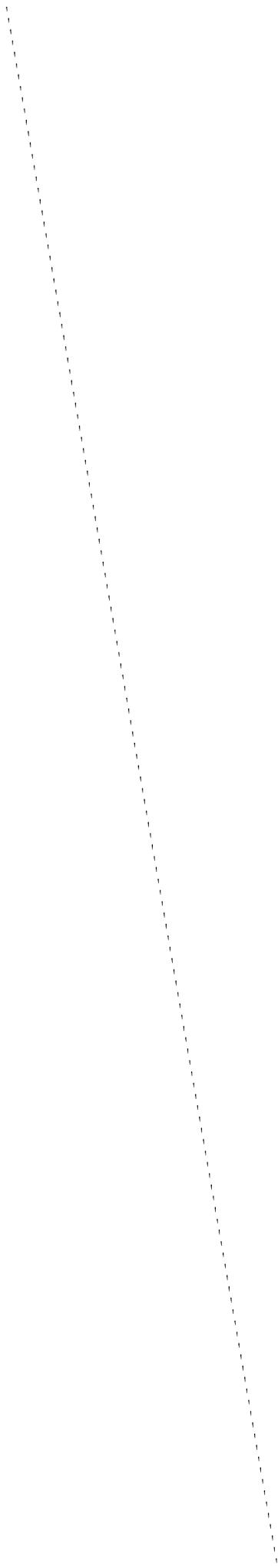
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62



## TABLE OF CONTENTS

LIST OF TABLES .....	vii
LIST OF FIGURES .....	ix
ABSTRACT .....	xi
INTRODUCTION .....	1
Description of the Beltway .....	2
Operating Speeds on the Beltway .....	4
PURPOSE AND SCOPE .....	4
BACKGROUND .....	5
History of Speed Enforcement Technology .....	6
Time-Distance Method .....	6
Pacing .....	7
Tachograph .....	7
Radar .....	7
History of Photo-Radar Technology .....	8
LEGAL ISSUES .....	10
Constitutional Issues .....	10
Evidentiary Issues .....	14
Virginia .....	14
Maryland .....	16
Requirements for Legal Service .....	17
Virginia .....	18
Maryland .....	18
Statutory Amendments .....	18
Film/Photograph Handling Issues .....	19
Chain of Custody Concerns .....	19
Privacy Concerns .....	22
Recommended Procedures .....	25
FCC Policy on Photo-Radar .....	26
METHODS .....	27
Site Visits and Manufacturers' Nonempirical Demonstrations .....	27
Field Demonstrations .....	30
Site Selection .....	31
Site Description .....	32
Photographic Quality and Utility .....	32
Accuracy of Recorded Speeds .....	35
Effect of Vehicle Clustering on Accuracy of Speed Measurements ...	36
Percentage of Usable Photographs of Vehicles Exceeding Threshold	
Speed .....	36
Misalignment Flexibility (Cosine Effect) .....	37

620

**TABLE OF CONTENTS (cont.)**

Ease of Detection by Radar Detectors .....	37
Effect of Photo-Radar on Speed Characteristics .....	38
Public Acceptance .....	38
RESULTS .....	39
Site Visits .....	39
Paradise Valley, Arizona .....	40
Pasadena, California .....	41
Europe .....	42
Field Demonstrations .....	44
Photographic Results for Each Manufacturer .....	44
Comparisons Among Manufacturers on Photographic Quality .....	49
Accuracy of Recorded Speeds .....	59
Effect of Vehicle Clustering on Accuracy of Speeds/Measurement ...	63
Percentage of Usable Photographs of Vehicles Exceeding Threshold Speed .....	63
Misalignment Flexibility (Cosine Effect) .....	67
Ease of Detection by Radar Detectors .....	67
Effect of Photo-Radar on Speed Characteristics .....	68
Public Acceptance Survey .....	69
SUMMARY OF FINDINGS .....	70
Background .....	70
Photographic Quality .....	71
Accuracy of Recorded Speeds .....	71
Efficiency of Photo-Radar .....	72
Misalignment Flexibility (Cosine Effect) .....	72
Radar Detection .....	72
Public Acceptance .....	72
CONCLUSIONS AND RECOMMENDATIONS .....	72
LESSONS LEARNED .....	73
NOTES .....	75
APPENDIX A: Standard Criterion Photographs .....	83
APPENDIX B: Public Acceptance Poll Questionnaire .....	95
APPENDIX C: Description of Photo-Radar Equipment .....	101
APPENDIX D: Conditions Under Which Manufacturers' Photographs Were of Highest Quality .....	117
APPENDIX E: Calculations of Public Acceptance Poll Sample Accuracy .....	127
APPENDIX F: Model Photo-Radar Statutes for Maryland and Virginia .....	131

**LIST OF TABLES**

Table 1: Trip Itineraries and Persons Interviewed During Site Visits in the United States and Europe ..... 28

Table 2: List of Study Sites ..... 33

Table 3: Number of Photographs Taken for Analysis by Each Manufacturer ..... 45

Table 4: Locations of Photographs Taken ..... 49

Table 5: Weather Conditions Under Which Photographs Were Taken ..... 50

Table 6: Vehicle Location in Photographic Frame ..... 50

Table 7: Direction of Operation of Photographs Taken ..... 51

Table 8: Mode of Operation When Photographs Were Taken ..... 51

Table 9: Format of Photographs Taken ..... 52

Table 10: Number of Vehicles in Photograph ..... 52

Table 11: Type of Vehicle in Photograph ..... 53

Table 12: Lane in Which Photographed Vehicles Were Traveling ..... 53

Table 13: Photographic Performance Measures: Receding Traffic ..... 54

Table 14: Photographic Performance Measures: Oncoming Traffic ..... 54

Table 15: Reasons License Plates in Photographs Could Not Be Read ..... 56

Table 16: Reasons Driver's Face in Photographs Could Not Be Identified ..... 57

Table 17: Effect of Highway and Environmental Characteristics on Photographic Quality for Receding Traffic ..... 58

Table 18: Effect of Highway and Environmental Characteristics on Photographic Quality for Oncoming Traffic ..... 58

Table 19: Differences Between Loop and Photo-Radar Speed Readings ..... 63

Table 20: Hit Rate for Oncoming Traffic ..... 64

Table 21: Hit Rate for Receding Traffic ..... 65

Table 22: Lane Distribution of Usable Photographs ..... 66

Table 23: Hit Rates by Distribution of Speeds of Speeding Vehicles Photographed ..... 66

**LIST OF TABLES (cont.)**

Table 24: Maximum Error in Recorded Speed for Misalignments Up to 8 Degrees (Cosine Effect) .....	67
Table 25: Radar Detection Distance for Each Piece of Equipment .....	67
Table 26: Comparison of Speed Characteristics at Study Sites .....	68
Table 27: Opinions Concerning Potential Use of Photo-Radar on Beltway .....	70
Table 28: Opinions on Photo-Radar Use by Demographic Characteristics .....	70

**LIST OF FIGURES**

Figure 1: Map of Capital Beltway in Virginia and Maryland ..... 3  
Figure 2: Allowable Differences Between Photo-Radar and Loop Readings ... 62



## ABSTRACT

Because of increasing difficulties in enforcing posted speed limits on the Capital Beltway around Washington, D.C., local officials proposed that experiments be conducted with photo-radar to determine if that method of automated speed enforcement (widely used in Europe for about 30 years and very recently employed in the western United States) could help reduce average speed and speed variance.

A project task force led by the Virginia Department of State Police, with assistance from the Maryland Department of State Police and the Virginia and Maryland Departments of Transportation and with technical assistance from the Virginia Transportation Research Council, conducted site visits to cities in Europe and the United States where photo-radar is being used. The task force also invited six manufacturers of photo-radar equipment to staff and demonstrate their equipment. Five of the manufacturers conducted a 2-week series of tests on sections of interstate highways with varying volumes of traffic and different traffic characteristics. The tests, which were conducted from June through September 1990, were designed to provide the evaluators with data on the accuracy, reliability, and efficiency of each unit (in terms of the number of speeding cases that could potentially be generated by the use of photo-radar on the Beltway) and help the study team determine if photo-radar could be successfully deployed on the Capital Beltway as an enforcement tool. In addition, the project included an analysis of legal and constitutional issues associated with photo-radar use as well as an evaluation of public sentiment concerning the use of photo-radar on the Capital Beltway. The evaluators concluded that photo-radar use was feasible on high-speed, high-volume roads such as the Capital Beltway and, therefore, recommended efforts to pass state enabling statutes and test further the efficacy of photo-radar in actual traffic enforcement conditions. Although the results of the study indicate that it is feasible to use photo-radar on high-speed multilane roadways, further study is required to determine its effect on travel speed and safety.

There are also important operational issues that must be considered when using this device. Some items of consideration are identification and selection of operational sites and times to deal with identified traffic safety and enforcement problems; provision of equipment-specific training programs for police officers to ensure the equipment is properly operated; provision for the availability of properly trained technical support personnel to ensure the continuing accuracy of the equipment; setting of speed thresholds that are realistically determined and target the excessive speeder; number of lanes on the roadway; visual obstructions on the roadway; and customizing of photo-radar applications to fit the highway safety problem area.

601

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**INTRODUCTION**

In response to a growing public concern about incidents, crashes, congestion, and delay occurring on the Capital Beltway around Washington, D.C. (hereinafter called the Beltway), the Secretaries of Transportation in Maryland and Virginia, in cooperation with the senior leadership of the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA), created an interstate task force in 1988 to study the problems associated with the Beltway and recommend, test, and implement measures for remediation.

Since one of the concerns of the task force was controlling speeds on the Beltway, one of their proposals was a demonstration project to evaluate automated photographic speed enforcement (APSE). A device with APSE technology, which is capable of identifying all vehicles being driven above a selected speed using either radar or some other detector equipment, photographs the vehicle's license plate and the

driver's face and records the speed of the vehicle and the time of the photograph. Photo-radar is a form of APSE with radar being used for detecting a speeding vehicle. The task force was aware of the limited use of photo-radar in speed enforcement in Pasadena, California, and Paradise Valley, Arizona, as well as its long-term use in Western Europe, Scandinavia, South Africa, and Australia. It was not clear, however, whether photo-radar technology had been successfully employed on roadways with characteristics similar to those of the Beltway.

In order to determine the feasibility of using photo-radar equipment on the Beltway, a study group was formed consisting of personnel from the Virginia and Maryland Departments of State Police and Departments of Transportation. The Virginia Transportation Research Council (VTRC) was selected to staff the study group and perform the evaluation (Lynn, C., Ferguson, W., and Garber, N., 1990, *Photo-Radar Automated Speed Enforcement: An Experimental Application on the Capital Beltway Around Washington, D.C.* VTRC Report No. 90-WP20. Charlottesville: Virginia Transportation Research Council).

### **Description of the Beltway**

The Beltway is a 64-mile-long limited-access highway encircling Washington, D.C. The majority of the Beltway, 41.6 miles, is in Maryland; a section of approximately one-tenth mile on the Woodrow Wilson Memorial Bridge is in Washington, D.C.; and the remaining 22.1 miles is in Virginia (see Figure 1).

The Beltway was constructed in the late 1950s and early 1960s as a four- and six-lane facility to carry an estimated annual average daily traffic (AADT) of 40,000. In the 1960s and 1970s, most of the Beltway was widened to eight lanes because traffic growth was higher than originally assumed; however, there are still some six-lane sections. Increasing the number of lanes resulted in a significant reduction in shoulder width, mainly because of the limited right of way, thus making safe enforcement by mobile police patrols difficult and hazardous because traffic stops are made in close proximity to the high-volume travel lanes.

There is a diverse mix of trip purposes, vehicle types, and traffic patterns associated with the Beltway. Although the Beltway was originally conceived as a bypass around Washington, expansion of the metropolitan area and extensive development along the Beltway and intersecting highway corridors have placed the roadway within the metropolitan area, rather than around it.

It is estimated that nearly two-thirds of all trips and one-half of all vehicle miles of travel (VMT) in the Washington metropolitan area in 1989 were made on the Beltway. Further, in 1989, the traffic volume was estimated at 120,000 vehicles per day; however, the volume on some sections exceeded 150,000 vehicles per day.

In 1989, there were approximately 3,034 reported crashes on the Beltway, an average of 8.3 per day. The estimated cost to society of these crashes, using NHTSA criteria for cost per accident, was \$69.7 million. The accident rate for the Beltway in 1989 was estimated as 86 accidents per 100 million VMT.



## Operating Speeds on the Beltway

Speed data collected in 1990 for the Maryland and Virginia sections of the Beltway indicated that average nonpeak speeds ranged from approximately 58 mph to approximately 64 mph, depending on the location. About 80 percent of the vehicles exceeded the 55 mph maximum speed limit, and about 40 percent exceeded 65 mph. The monitoring of 65,850 vehicles traveling in one direction during a 24-hour period in 1988 indicated that the average speed on the Beltway in Virginia was 64.6 mph. These Virginia data include speeds for rush-hour traffic, when traveling faster than the posted limit is generally not possible. Even so, during this 24-hour period, more than 43 percent of the vehicles exceeded 65 mph. The number of speed violations on the Beltway for one 24-hour period (28,503) almost matched the total number of traffic citations for the entire year of 1988 reported for the metropolitan area by the Virginia Department of State Police.

In Maryland, speed surveys were conducted at four sites on the Beltway. These data show a similar but slightly lower rate of speeding. The Maryland surveys were conducted for traffic traveling in both directions on the Beltway and indicated the following fourth quarter results:

I-495 @ River Road	74,733 vehicles
	18,928 exceeding 65 mph (25.3%)
I-95 @ Md. Rt. 214	71,239 vehicles
	22,792 exceeding 65 mph (32.0%)
I-95 @ Temple Hills Road	19,823 vehicles
	8,474 exceeding 65 mph (42.7%)
I-495 @ Md. Rt. 650	42,846 vehicles
	7,031 exceeding 65 mph (16.4%)

These data indicate a high rate of violations of the 55 mph speed limit and a significant percentage of traffic exceeding 65 mph. Because the shoulders on the Beltway are narrow and because pulling over vehicles traveling on the inside lanes is dangerous, speed enforcement capabilities on the Beltway are extremely limited. Clearly, given the physical limitations on speed enforcement and the volume of speeding vehicles on the Beltway, there is a need for innovative methods of speed enforcement.

### PURPOSE AND SCOPE

The purpose of this study was to evaluate the feasibility of using photo-radar technology on high-volume, high-speed expressways, such as the Beltway. A

secondary objective was to compare and contrast the performance of several brands of photo-radar devices to determine whether they meet the minimum levels of accuracy, reliability, and efficiency required for use on the Beltway in accordance with the U.S. legal system. In addition, the impact of traffic characteristics on accuracy and reliability was examined. A final objective was to make recommendations concerning the use of photo-radar on types of highways other than urban expressways should photo-radar use on interstate highways prove infeasible.

Information concerning the various brands of photo-radar equipment and their capabilities was obtained from manufacturers' sales literature and was corroborated by the results of several site visits. However, the most important information concerning the performance of the various devices came from actual demonstrations on the Beltway and other high-speed interstate highways in Virginia and Maryland. Thus, the feasibility of using photo-radar was largely determined by the results of performance testing on site, rather than by manufacturers' claims or nonempirical demonstrations in Europe and the United States.

The scope of this project was rather limited. The researchers assessed the technical and operational feasibility of the different types of equipment but did not evaluate the effectiveness of the use of photo-radar in reducing travel speed or the number of speed-related crashes since it was not possible to give citations during the demonstration period. In order to avoid creating a hazardous environment for the manufacturers and the study team, and to avoid disrupting the traffic flow at the study sites, no special signing was used. In addition, media coverage was limited to a press conference on the second Tuesday of each demonstration period. Thus, no fully coordinated media campaign was employed. A further limitation on the scope of the study was that Multanova, one of the major manufacturers, declined to participate in the demonstrations in Virginia and Maryland. Therefore, there are insufficient data from which to draw conclusions concerning the accuracy, reliability, and efficiency of Multanova's equipment.

### BACKGROUND

Many people approach the use and evaluation of photo-radar as if it were a new and uniquely invasive technology. In fact, photo-radar equipment is simply the combination of several pieces of previously existing equipment—camera, radar, and electronic controls—all of which have been used either together or separately in enforcement and the prosecution of offenses for many years. The validity and reliability of these older forms of speed enforcement technology had to be proved to both the police and the courts prior to general acceptance. Thus, it is important to consider the use of photo-radar in the context of (1) the history of speed enforcement technology, and (2) the history of photo-radar technology.

## History of Speed Enforcement Technology

In the past, the introduction of a new and innovative speed enforcement technology often generated a negative reaction. The public's distrust of the use of high technology by enforcement officials is often evidenced by claims that the technology is simply another attempt by "Big Brother" to invade their lives. When radar was first introduced in the 1950s, *Time Magazine* ran an article headlined "Big Brother Is Driving," the text of which characterized radar as being "as invisible as the Thought Police in Orwell's chiller [1984]."<sup>1</sup> The use of radar was also challenged as being unconstitutional.<sup>2</sup> The history of speed enforcement is replete with examples of new enforcement techniques; subsequent negative public reaction and resistance; and finally, assuming survival through legal challenges, ultimate acceptance.

### Time-Distance Method

The use of the first known method of speed enforcement dates back to 1902 in Westchester County, New York. This system was composed of three dummy tree trunks set up on the roadside at 1-mile intervals. A police officer with a stopwatch and a telephone was concealed in each trunk. As a speeding vehicle passed the first trunk, the hidden police officer telephoned the time to the second police officer, who recorded the time at which the vehicle passed him and then computed its speed for the mile. If the vehicle was exceeding the speed limit, the officer telephoned the third police officer, who proceeded to stop the vehicle by lowering a pole across the road.<sup>3</sup> The "tree trunk" method was subject to hearsay objections in court because officers had to testify regarding the time statements of other officers since there was no way to observe the vehicle over the entire distance.<sup>4</sup>

This is an early example of the time-distance method of speed enforcement. Time-distance measurements are computed by measuring the time taken to traverse a distance of known length.<sup>5</sup> Several methods of speed enforcement employ the time-distance principle. Pavement markings or mirror boxes that are observed by police officers with a stopwatch have replaced dummy tree trunks, and two-way radios between patrol cars or aircraft have replaced the telephone system, but the technique remains much the same.<sup>6</sup>

The speedwatch, also referred to as the Prather speed device, was one of the first "electric timers" to employ the time-distance principle.<sup>7</sup> This device consisted of two rubber tubes that were stretched across a street at a known distance apart. The tubes were connected to two switches, which were in turn connected to a control panel containing a stopwatch, a switch, and a reset button. A police officer was positioned so as to observe both tubes, and when a vehicle approached, he flipped the switch to activate the first tube. On contact with the tires of the vehicle, the switch in the first tube started the stopwatch, which was stopped when the vehicle hit the second tube. The stopwatch was scaled to reflect the speed of the vehicle.<sup>8</sup> The speedwatch is believed to have been accurate to within 2 mph, and the officer's testimony as to his observation of the speeding vehicle and the accuracy of the instrument was admissible in most courts.<sup>9</sup>

The most recent technique employing time-distance measurements is the visual average speed computer and recorder (VASCAR). VASCAR is a computerized system that mechanically computes the speed of a car by measuring the distance between two fixed markers and the time traveled, thereby giving the observing police officer a quick, easily readable speed determination.<sup>10</sup>

In 1947, only 1 state used a time-distance device,<sup>11</sup> but by 1970, 34 states were employing at least one—the majority using VASCAR or aerial surveillance.<sup>12</sup> Because time-distance devices have been categorized as “speed traps,” their use has been prohibited in at least 2 states: California and Washington.<sup>13</sup>

## **Pacing**

Another widely used method of speed enforcement in the 1940s was “pacing.”<sup>14</sup> Police officers paced a speeding vehicle by following it for a specified distance and observing the speedometer of the police vehicle to calculate the average speed of the paced vehicle over the distance. In 1947, 20 percent of the states required pacing before apprehension of a speeding driver.<sup>15</sup> A large percentage of states used unmarked cars, identifiable only by decals, and/or motorcycles as pacing vehicles.<sup>16</sup> Because pacing depends on the accuracy of the pacing vehicle’s speedometer, many states adopted the use of calibrated speedometers and regulations defining the frequency at which speedometers must be calibrated.<sup>17</sup>

## **Tachograph**

The tachograph, also referred to as a tactograph or tachometer, was a speed enforcement method used by trucking companies to control the speed of truck drivers. The tachograph contained a clock with a paper dial attached to the driveshaft or transmission of the truck. The dial recorded the speed of the truck at any given time.<sup>18</sup> The chart produced by this device was used to corroborate the testimony of the arresting officer;<sup>19</sup> ironically, however, it was often admitted into evidence to prove the innocence of the implicated driver.<sup>20</sup>

## **Radar**

Police radar was introduced in the late 1940s and early 1950s. Although generally referred to as “radar,” police radar is not technically radar. True radar has the ability to measure an object’s distance, direction, and size as well as its speed, but police radar measures only speed. Police radar operates according to the scientific principle known as the Doppler effect: the frequency of sound waves (or microwaves) being emitted by or reflected off of an object will vary in direct relation to the speed of the object itself. The Doppler effect is noticeable in everyday life in the rising and falling of a car horn’s pitch as the car approaches and passes. Police radar transmits microwaves at a set frequency. When the microwaves are reflected off of a vehicle, the frequency of the returning microwaves shifts because the vehicle is in motion. This shift in the original frequency, the Doppler shift, is measured by the radar device, which converts the signal into a measurement of the vehicle’s speed.

An early hurdle encountered by police radar (hereinafter called "radar") was evidentiary in nature. Before judicial notice was taken of the underlying principle involved, courts required that an expert witness testify as to radar's accuracy and reliability.<sup>21</sup> The Virginia Supreme Court was among the first courts to take judicial notice of radar's underlying principle, thereby eliminating the need for expert testimony.<sup>22</sup> However, testimony as to the accuracy of the particular machine used to detect the violation is still required.

Constitutional questions have also arisen in radar cases, as they invariably do whenever a new scientific technique becomes useful in enforcement.<sup>23</sup> The Virginia statute providing that radar evidence constitutes *prima facie* evidence of speeding was found to be constitutional under the Fourteenth Amendment of the U.S. Constitution.<sup>24</sup> The defendant in the case argued that the provision was tantamount to his being presumed guilty.<sup>25</sup> However, the court held that the defendant was still presumed innocent under such a standard.<sup>26</sup> A Pennsylvania due process claim based on the alleged instantaneousness of the machine's determination and the potential for error was likewise denied.<sup>27</sup> In denying the claim, the court noted the complete absence of cases holding the use of radar for speed measurement to be unconstitutional.<sup>28</sup> Cases raising the issue of a citizen's constitutional right against self-incrimination have likewise been unsuccessful.<sup>29</sup>

### History of Photo-Radar Technology

Law enforcement's latest innovative technology for the enforcement of speed laws is photo-radar. Photo-radar equipment combines a camera and radar with electronic controls to detect and photograph a speeding vehicle. The unit can photograph the driver's face and the front license plate if deployed to photograph oncoming traffic or the rear license plate if deployed to photograph receding traffic. The license number of the speeding vehicle is extracted from the picture, and a citation is sent to the registered owner of the vehicle. The radar used in photo-radar equipment operates on the same Doppler principle as the radar used by the police.

Although photo-radar is a relatively new technology in the United States, it is not the first speed detection device to use a camera. In 1910, a device known as a photo speed recorder was used in Massachusetts.<sup>30</sup> The photo speed recorder consisted of a camera, synchronized with a stopwatch, that took pictures of a speeding vehicle at measured time intervals. The speed of the vehicle was determined by a mathematical calculation based on the reduction in size of the vehicle in the photograph as it moved farther away from the camera. This photographic evidence was held admissible by the Supreme Judicial Court of Massachusetts, and the scientific approach was judged more reliable than eyewitness testimony because it did not rely on the "fluctuations of human agencies."<sup>31</sup>

However, in 1955, the unattended use of the photo-traffic camera (Foto-Patrol) was prohibited in New York because of the difficulty in identifying the driver of the vehicle.<sup>32</sup> The Foto-Patrol device, a camera mounted on the side of the road

activated by an electronic impulse when passed by a vehicle traveling in excess of a predetermined speed, took a picture of the rear license plate only, making it impossible to identify the driver. The court was unwilling to adopt the presumption that the driver was the registered owner of the vehicle, absent any corroborating evidence, and prohibited the use of Foto-Patrol unless it was staffed by an attending officer available to stop and identify the driver on the spot.<sup>33</sup>

The problem of driver identification was resolved by the Orbis III (Orbis) system introduced in the late 1960s.<sup>34</sup> Orbis operated much like an advanced Prather speed device that employed a camera.<sup>35</sup> The contacts the vehicle ran over were 72 inches apart and connected to a computer that triggered the camera, which was set up to capture the vehicle's front license plate and the driver's face if the vehicle's speed exceeded a preset limit.<sup>36</sup> When Orbis was introduced, it encountered a unique form of resistance.<sup>37</sup> To avoid being recognized, people would speed by the Orbis machine wearing a Halloween mask.<sup>38</sup> Such a tactic would be illegal in Virginia, but not in Maryland, because of a statute that prohibits those over 16 years of age from wearing a mask in public.<sup>39</sup> Orbis was abandoned for administrative reasons.<sup>40</sup> Research did not identify any cases that successfully challenged Orbis on legal grounds, and a study prepared for the U.S. Department of Transportation indicated that the device was probably constitutional.<sup>41</sup>

It is uncertain whether photo-radar will be accepted by the public. Previous speed enforcement techniques usually gained acceptance if the technology proved accurate and if they survived the initial constitutional and evidentiary challenges. However, even after a technology gains acceptance, drivers have often undertaken efforts to thwart the technology's effectiveness. One example of a popular form of resistance to speed detection technology is the use of a radar detector. Radar detectors, which are illegal in Virginia,<sup>42</sup> sound a warning to the driver when they detect the microwave signal emitted by the radar unit. Drivers have also tried using other methods to avoid being caught speeding by radar.<sup>43</sup> These methods included using transmitters designed to disrupt the radar signal, putting nuts and bolts in the hub-caps, painting the fan blades with aluminum paint, and attaching hanging chains to the undercarriage of the car.<sup>44</sup> There is even a 160-page book entitled *Beating the Radar Rap*.<sup>45</sup> Photo-radar will no doubt encounter many, if not all, of these methods of resistance. However, if photo-radar is proven to be accurate, and if it is able to withstand the initial legal challenges, then it should gain acceptance as an effective tool in speed enforcement.

There is evidence that the public may support photo-radar use in residential settings. In Pasadena, California, and Paradise Valley, Arizona, where photo-radar has been used in residential settings on local, noninterstate roadways, a majority of respondents in public opinion polls have been in favor of photo-radar use. However, one must interpret these findings in light of the fact that more than 90 percent of those cited for speeding in these two locations are nonresidents. This will not likely be the case in Virginia and Maryland, especially if photo-radar is used on the Beltway.

## LEGAL ISSUES

### Constitutional Issues

If there is one constant in speed 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 to its use. However, although constitutional attacks are easily levied, they are not necessarily successful. Current jurisprudence supports the constitutionality of photo-radar despite potential challenges to its use.

Although an attack might be leveled against photo-radar on the grounds that photographs produced by photo-radar violate the automobile operator's zone of privacy,<sup>46</sup> such an assertion does not reflect the scope of the zone of privacy. The first explicit discussion of a right to privacy by the U.S. Supreme Court appeared in *Griswold v. Connecticut*,<sup>47</sup> in which the appellants challenged a Connecticut statute prohibiting the distribution of birth control information to married persons.<sup>48</sup> The Court held that the Connecticut statute was unconstitutional, concluding that the marital relationship was such that it belonged within a class of fundamental rights deserving of special protection and that the Connecticut statute unnecessarily intruded into the relationship.<sup>49</sup>

But the zone of privacy is narrowly construed. The rights falling under the zone of privacy are "limited to those which are 'fundamental' or 'implicit in the concept of ordered liberty.'"<sup>50</sup> The activities found by the Supreme Court to fall within the zone of privacy include "matters relating to marriage, procreation, contraception, family relationships, and child rearing and education."<sup>51</sup> Placing a right within the zone of privacy limits the state's regulatory power over the activity.<sup>52</sup> The operation of an automobile simply does not fall within the category of fundamental rights protected by the zone of privacy. To the contrary, the Supreme Court considers a person's expectation of privacy in an automobile to be quite limited, and automobile operation is properly subject to significant state regulation.<sup>53</sup>

Another possible attack against photo-radar could be made under the Fourth Amendment right to be free from unreasonable searches<sup>54</sup> on the grounds that photo-radar photographs constitute a Fourth Amendment search. Therefore, photo-radar use is subject to the Fourth Amendment's probable cause and warrant requirements. Under the Fourth Amendment, a person has a constitutional right to freedom from unreasonable search and seizure in circumstances where the person has a reasonable expectation of privacy.<sup>55</sup> This constitutional right is protected through the requirement that a police officer have probable cause and a warrant in order to engage in certain types of searches.<sup>56</sup>

Unless a person exhibits a reasonable expectation of privacy under the circumstances, the Fourth Amendment warrant and probable cause requirements are not triggered.<sup>57</sup> However, a person has a lowered expectation of privacy in an automobile.<sup>58</sup> Moreover, "what a person knowingly exposes to the public" receives no

“Fourth Amendment protection.”<sup>59</sup> For this reason, in *United States v. Knotts*, the Supreme Court upheld the warrantless placement by law enforcement officers of a beeper in an automobile to monitor the vehicle’s movements.<sup>60</sup> According to the Supreme Court, a person traveling in an automobile on public roads has no reasonable expectation of privacy in his or her movements since this information is knowingly exposed to all who care to look.<sup>61</sup> Likewise, photo-radar merely photographs that which a person knowingly exposes to the public while driving—the person’s likeness. Because of this, the use of photo-radar violates no reasonable expectation of privacy and, therefore, is not subject to the Fourth Amendment warrant and probable cause requirements.

A further claim that might be raised against photo-radar is that its use chills the freedom of association found by the Supreme Court to be implied by the First Amendment.<sup>62</sup> Such a claim asserts that both drivers and passengers might avoid traveling in vehicles with individuals with whom they would normally associate in order to avoid being officially observed and photographed by photo-radar.<sup>63</sup> This argument misconstrues the scope of associational rights. The Supreme Court has delineated two types of associational rights: (1) freedom of expressive association, and (2) freedom of intimate association.<sup>64</sup> The freedom of expressive association protects organization within groups for the exercise of First Amendment rights, such as freedom of speech and religion.<sup>65</sup> The freedom of intimate association is an outgrowth of the privacy doctrine and protects an individual’s right to engage in intimate relationships without threat from excessive governmental regulation.<sup>66</sup>

Speed enforcement through photo-radar technology does not compromise freedom of expressive association for two reasons. First, a claim that photo-radar use might prevent certain individuals from traveling with persons with whom they would normally associate will not support a claim for infringement of freedom of expressive association. A showing “of specific present objective harm or a threat of specific future harm” to associational rights and First Amendment rights is necessary to support a freedom of expressive association claim when government regulations will only indirectly affect the exercise of First Amendment rights.<sup>67</sup> In *Laird v. Tatum*<sup>68</sup> and *Donohoe v. Duling*,<sup>69</sup> the activities of the plaintiffs’ lawful political groups were under surveillance. The *Laird* plaintiffs argued that surveillance by U.S. Army observers of the activities of the political groups had a chilling effect on their First Amendment right to free speech and freedom of association.<sup>70</sup> The plaintiffs in *Donohoe* claimed that the taking of pictures by uniformed police officers of persons involved in demonstrations violated the demonstrators’ First Amendment rights.<sup>71</sup> The Supreme Court in *Laird* held that a claim of a hypothetical chilling effect on First Amendment and associational rights would not support a freedom of expressive association claim if the government regulation did not directly prohibit First Amendment activity.<sup>72</sup> Thus, the *Laird* and *Donohoe* courts held that, where government activity prevents exercise of First Amendment rights indirectly, a freedom of expressive association claim requires a specific showing of an objective present harm or threatened future harm.<sup>73</sup>

Second, the freedom of expressive association claim against photo-radar is far weaker than the claims presented in *Laird* and *Donohoe* since photo-radar speed

enforcement is not solely directed at groups organized for the purpose of exercising First Amendment rights. Freedom of expressive association protects association only for the purpose of exercising First Amendment rights.<sup>74</sup> Successful freedom of association claims involve government regulations targeting the activities of particular groups organized specifically to exercise First Amendment rights.<sup>75</sup> The only group targeted by photo-radar would be speeding drivers, who certainly do not represent an organized group, much less a group organized for First Amendment purposes.

Moreover, photo-radar use will not provide a basis for a freedom of intimate association claim. Although the boundaries of intimate association remain largely undefined, as an outgrowth of the zone of privacy, it has been used to strike down regulations that interfere with certain marital and familial relationships.<sup>76</sup> Successful freedom of intimate association claims involve statutes that directly interfere with marital and familial relationships.<sup>77</sup> The connection between photo-radar use and association through intimate relationships is attenuated at best. Photo-radar clearly does not prevent individuals from engaging in intimate relationships with family members, or any other person for that matter, and, therefore, does not implicate the freedom of intimate association.

An equal protection claim based on the fact that not all speeders would be detected by photo-radar and cited for speeding<sup>78</sup> would also most likely fail. Because a photo-radar unit requires 1 second to reset itself after photographing a violator, not all speeding drivers passing through the photo-radar field would be detected. Thus, not all those violating the speed laws receive the same treatment.

However, to launch a successful equal protection claim, the plaintiff must prove that the standard used to select the claimant for enforcement "was deliberately based on an unjustifiable criterion such as race, religion, or other arbitrary classification."<sup>79</sup> The inability to prosecute all violators will not provide the basis for an equal protection claim.<sup>80</sup> Since the determination of who is missed by photo-radar and who is caught is based on the technical abilities of the system and not on an intentional decision to discriminate based on a suspect classification, an equal protection challenge to the use of photo-radar would almost certainly fail.

Finally, because a citation for a speeding violation detected by photo-radar must pass through a development process and is issued through certified mail, there is a delay between the time of the violation and the issuance of a citation that could undercut efforts by a violator to prepare a legal defense. For this reason, a ticketed driver could assert that photo-radar use constitutes a denial of due process of law. Currently, the cities of Paradise Valley, Arizona, and Pasadena, California, which employ photo-radar, have circumvented due process claims by issuing citations within a given time period following the offense and by deploying signs providing considerable warning of approaching photo-radar units. Still, photo-radar is subject to a due process claim on the grounds that the element of delay hampers the ability to gather witnesses and evidence and thus to prepare a proper defense.

However, the delay involved in citing an alleged violator using the photo-radar process is relatively short, reducing the possibility that a defendant will lose

access to witnesses or evidence. Access to evidence with photo-radar may, in fact, be better than with a conventional stop since photo-radar creates a photographic record of the scene where the speeding violation occurred. Further, in *United States v. Delario*,<sup>81</sup> the defendant argued that a preindictment delay of more than 1 year constituted a denial of due process. The Court found that the argument lacked merit and held that the defendant would have to show that the delay was a deliberate attempt by the government to gain a tactical advantage and had resulted in actual and substantial prejudice.<sup>82</sup> Because the delay involved in issuing photo-radar citations cannot reasonably be viewed as an attempt by the government to gain a tactical advantage, case law suggests that a due process claim against photo-radar is also likely to fail.

If constitutional attacks against photo-radar are unsuccessful, a ticketed driver might pursue civil liability against the state under the common law right of privacy. The common law right of privacy is a tort action created by state courts permitting recovery of damages for an invasion of privacy as defined by state law.<sup>83</sup> A state law action for invasion of privacy might be brought against the use of photo-radar on the basis that the unauthorized taking of a person's photograph constitutes an invasion of privacy.<sup>84</sup> A common law right of privacy claim against a local government for the use of photo-radar is likely to fail in Virginia and Maryland for several reasons.

First, courts have repeatedly held that an individual's privacy must yield to the reasonable exercise of a state's police power.<sup>85</sup> Included within the state's police power is the authority to photograph persons charged with a crime.<sup>86</sup> Thus, in *Downs v. Swann*, the Maryland Court of Appeals rejected a claim for invasion of privacy against the Baltimore Police Department on the grounds that photographing and fingerprinting a suspect charged with a crime did not violate the suspect's right of privacy.<sup>87</sup> As long as the police department neither published the pictures nor gave the pictures of suspects not yet convicted to a rogue's gallery, the police department was not subject to the common law right of privacy.<sup>88</sup> Second, state courts outside Virginia and Maryland have indicated that there is no invasion of privacy under the common law right of privacy if the photographing of an individual by a law enforcement agency does not violate a reasonable expectation of privacy under the Fourth Amendment.<sup>89</sup> These opinions suggest that a law enforcement agency may photograph whatever a person knowingly exposes to the public without violating the common law right of privacy.

Finally, although no Virginia state court has spoken on the issue, the U.S. Court of Appeals for the Fourth Circuit has stated that no common law right of privacy exists in Virginia.<sup>90</sup> The Fourth Circuit construes Virginia law as providing merely a statutory right of privacy, preventing the use of photographs for commercial purposes only.<sup>91</sup> Under the federal court's interpretation, Virginia law does not countenance a damages action against a law enforcement agency for the use of photo-radar photographs in speed enforcement. For these reasons, Virginia and Maryland courts would most likely permit use of photographs produced by photo-radar in legitimate speed enforcement efforts without threat of civil liability under the common law right of privacy.

## Evidentiary Issues

Photo-radar devices detect speeders by radar and then photograph the front or rear license plate of the vehicle and, in most cases, the driver. In Pasadena and Paradise Valley, police officers are always present when the devices are in operation. If the registered owner of the vehicle challenges the citation, the attending officer testifies in the court proceeding as to the accuracy of the background scene depicted in the photograph and compares the likeness of the driver in the photograph to the registered owner. No appellate challenges regarding evidentiary issues have occurred in either locality.

A photograph is usually admitted into evidence under the pictorial testimony theory. Under this theory, photographic evidence is "admissible only when a witness has testified that it is a correct and accurate representation of relevant facts personally observed by the witness."<sup>92</sup> However, it is not necessary that the witness be the actual photographer.<sup>93</sup> The witness is required to know only about "the facts represented or the scene or objects photographed, and once this knowledge is shown he can say whether the photograph correctly and accurately portrays these facts."<sup>94</sup> Prosecutors in Pasadena and Paradise Valley have proceeded under the pictorial testimony theory when introducing photo-radar photographs into evidence. Because their photo-radar devices are attended by police officers, the officers can testify in court that the photographs are accurate representations.

For any proposed system for use on the Beltway, it is likely that the device will be attended by a police officer. However, if unattended use is anticipated, a different theory must be used in order to admit the photographs into evidence. This newer theory of admission is referred to as the "silent witness" theory.<sup>95</sup> Under this doctrine, photographs constitute "'substantive evidence' in the sense that photographic evidence alone can support a finding by the trier [of fact]."<sup>96</sup> Thus, under the silent witness doctrine, "photographic evidence may draw its verification, not from any witness who has actually viewed the scene portrayed on the film, but from the reliability of the process by which the representation was produced."<sup>97</sup> The silent witness theory, however, is not accepted in all jurisdictions.<sup>98</sup>

### Virginia

In Virginia, photographic evidence is admissible under both the pictorial testimony theory and the silent witness theory.<sup>99</sup> The pictorial testimony theory remained the sole theoretical basis for the admission of photographic evidence until the 1972 Virginia Supreme Court ruling in *Ferguson v. Commonwealth*.<sup>100</sup> The sole issue in that case was whether photographs could be admitted under the silent witness theory.<sup>101</sup>

In *Ferguson*, the defendant was convicted of forgery for cashing a forged check at a drugstore equipped with a Regiscope camera.<sup>102</sup> The Regiscope camera photographed each check-cashing transaction, with the photograph including the person presenting the check, the identification presented by the person, and the check itself.

This process was accomplished by the person placing the check and the identification at the base of the camera while standing at the cashier's window where the camera was installed. Each transaction was assigned a number that was stamped on the check prior to the time the photograph was taken. The check and the transaction number were used to identify the transaction when a photograph was requested from the Regiscope Company.

In the *Ferguson* case, the store manager who had loaded the film also removed the film and sent it to the Regiscope Company to be developed. Regiscope then delivered the photograph of the defendant to an employee of the drugstore, who in turn delivered it to the police. During the ensuing trial, "no witness testified that the photograph depicted a scene or event as witnessed by him."<sup>103</sup> The Virginia Supreme Court determined that "the evidence was sufficient to provide an adequate foundation assuring the accuracy of the process" and thus that the photograph was properly admitted into evidence under the silent witness theory.<sup>104</sup>

The Code of Virginia expressly provides for the admissibility of photographs in particular kinds of cases under the silent witness theory. For example, in larceny prosecutions, photographs of the goods allegedly stolen may be introduced as evidence, rather than the goods themselves. In *Saunders v. Commonwealth*,<sup>105</sup> the Virginia Court of Appeals examined in detail this codification of the silent witness theory. The court concluded that each of the statutory requirements must be met in order for the photograph to be admissible. Since the statute required the arresting officer to sign the photograph, his failure to do so resulted in the court finding that the photograph could not stand as substantive evidence under the silent witness theory.<sup>106</sup> However, the court ruled that the photograph was admissible under the pictorial testimony theory because the arresting officer testified that the photograph accurately represented what he observed and photographed.<sup>107</sup>

Under *Ferguson* and *Saunders*, it appears that the silent witness theory provides an acceptable basis for the admission of photographic evidence in Virginia in certain contexts. In *Ferguson*, the Virginia Supreme Court carefully examined the Regiscope process before determining that it presented an "adequate foundation assuring the adequacy of the process."<sup>108</sup> Although the silent witness theory has been codified for limited circumstances, *Saunders* demonstrated that such statutes are to be narrowly construed. Under both holdings, the procedures used in obtaining and bringing the photographs to trial are crucial in determining their admissibility as evidence.

To determine whether photographs taken by an unattended photo-radar system would be admissible under the silent witness theory, the test that must be applied is "whether the evidence is sufficient to provide an adequate foundation assuring the accuracy of the process producing it."<sup>109</sup> It is useful to compare the photo-radar process to the Regiscope process to speculate whether photo-radar photographs would meet this test. If the two processes are sufficiently similar, it is likely that photo-radar photographs would be admissible as evidence under the silent witness theory.

The photo-radar process appears to be substantially similar to the Regiscope process. A police officer will load the film. When the radar device detects a speeding vehicle, the camera will photograph the vehicle, thereby recording the front license plate and the face of the driver, or the rear license plate only. The police officer will unload the film and send it either to the photo-radar company or to a police photo-processing laboratory. A citation will then be issued to the registered owner(s) of the vehicle. As with the Regiscope system, if the photograph is required for evidence in a trial, the photo-processing laboratory can develop the film and send the police the photograph that will be identified by the license plate number.

The Regiscope system and photo-radar system differ in that the Regiscope appears to be manually operated, with the cashier controlling the camera, and the photo-radar camera is automatically activated when the radar detects a speeding vehicle. It is possible that photo-radar equipment would be staffed in some cases. Whether operated automatically or by police officers, evidence of the technical accuracy of the activation device would have to be presented to the court in order for a photo-radar photograph to be admissible.

Another difference between the two systems that may bear on the accuracy of the process is that the Regiscope system is set up inside a store that presumably is constantly monitored by employees. The photo-radar system would be set up outdoors, and tampering with the system would be possible in unmonitored locations. This difficulty could be remedied by producing evidence that tampering does not affect the accuracy of the system or that tampering did not occur in the situation in question.

One other accuracy problem may arise in connection with the use of the photo-radar system. In some instances, more than one vehicle may be shown in the same photograph, thereby creating difficulty in determining which of the drivers was speeding. Charles Ollinger, Town Attorney for Paradise Valley, explained that this difficulty is easily resolved. Older photo-radar cameras have a 29-degree field angle; the newer models have a 22-degree field angle. The radar equipment has a 5-degree field angle. On the photograph taken by the photo-radar device, the portion of the photograph containing the radar field can be distinguished. Thus, the car in that portion of the photograph is the speeding vehicle detected by the radar system. Some photo-radar systems use a template, which is placed over the picture, to identify the speeding vehicle when there is more than one vehicle in a photograph.

Although the Virginia courts and the Virginia legislature have not specifically addressed the admissibility of photo-radar photographs under the silent witness theory, it appears that the photo-radar process can meet the accuracy test laid down in *Ferguson*. Thus, it is likely that photo-radar photographs may be admissible even if no attending police officer can testify as to the accuracy of the background scene.

## **Maryland**

The acceptability of the silent witness theory in Maryland is not so clear as in Virginia. In *Sisk v. State*,<sup>110</sup> the defendant appealed the admission of Regiscope pho-

tographs in the retrial of his forgery case. In the first hearing, the reviewing court determined that the Regiscope photograph had not been sufficiently authenticated under either theory of admission for photographic evidence.<sup>111</sup> During the retrial, two types of authentication evidence were admitted: (1) testimony regarding the accuracy of the Regiscope system, and (2) testimony by a store employee identifying the background scene.<sup>112</sup> In its review of the retrial, the Maryland Supreme Court stated that "this seems to be the first time that we have been called upon to consider, specifically, the [silent witness] rule."<sup>113</sup> Although the court ruled that the Regiscope photograph had been sufficiently authenticated, it discussed both theories and did not explicitly state under which theory the photograph had been admitted.<sup>114</sup>

It is possible that this case stands for the proposition that the silent witness theory may be used for the admission of photographic evidence in Maryland courts. *Sisk* differs from *Ferguson*, however, in that no witness was required to testify as to the accuracy of the photograph in the Virginia case. It is possible that the Maryland court was fashioning a modified silent witness theory, which imposes the additional requirement that a witness testify as to the accuracy of the photograph. Under the facts of *Sisk*, it appears that it is not necessary that the witness be present at the time the photograph is taken in order to testify as to its authenticity if other evidence ensuring the accuracy of the process of identifying speeding vehicles and photographing them is also admitted. In the case of photo-radar, this would mean that the police officer who loaded the film would testify as to the accuracy of the background scene. There have been many technological advances in photography and radar in the 26 years since *Sisk* was decided. It is possible that courts would now be less skeptical of the accuracy of the process and therefore less likely to require a witness to testify regarding its accuracy.

No other Maryland case addresses the acceptability of the silent witness theory. Although the Maryland Supreme Court discussed the silent witness theory in favorable terms and stated that the issue before the court was admissible under the silent witness theory, the holding in *Sisk* does not clearly state that the theory is acceptable in Maryland. Given the lack of precedent for this theory and the lack of clarity in the one case addressing the issue, the acceptability of the silent witness theory in Maryland is uncertain.

### **Requirements for Legal Service**

Some of the photo-radar systems under consideration for installation on the Beltway use a procedure whereby the company providing the photo-radar service mails the speeding citation to the residence of the alleged offender. This procedure would present difficulties in both Maryland and Virginia because both mandate personal service for the issuance of traffic citations. It is clear that the method of service presently employed by photo-radar providers is inconsistent with the statutory service requirements of Maryland and is likely to be inconsistent with the statutory service requirements of Virginia.

## Virginia

“Personal service of a traffic citation” involves several actions by the arresting officer. When a driver is detained by a police officer for any violation of Title 46.2 that is “punishable as a misdemeanor,” Virginia law requires the driver to give a written promise to appear for a hearing.<sup>115</sup> This requirement is normally fulfilled by the signature of the driver at the time of the issuance of the traffic citation. Because speeding is a violation punishable as a misdemeanor,<sup>116</sup> the offense is subject to the requirements of Section 46.2-936, requiring a written promise to appear from a driver detained by a police officer for a speeding violation.

It is questionable whether the written promise requirement would apply to the photo-radar method because the prerequisite to the requirement is the detention or custody of the driver.<sup>117</sup> When a driver is not detained, a written promise may not be necessary. This would be the case where a citation is mailed to the residence: no interaction between the driver and the police officer would be involved. It is not possible to determine in advance whether Virginia courts would accept this narrow construction of the statute.

## Maryland

Maryland state law requires that a driver charged with a traffic violation acknowledge receipt of the citation by signing it at the time of issuance.<sup>118</sup> An Attorney General’s opinion issued in 1979 confirmed this requirement.<sup>119</sup> That opinion stated that the signature requirements of Section 26-203 of the Transportation Code also applied to Section 26-201(a) of the same article.<sup>120</sup> Section 26-201(a) contains a list of statutes for which police officers are given authority to charge violators.<sup>121</sup> Included in the list are all Maryland vehicle laws.<sup>122</sup> Speeding offenses, codified at Section 21.801 *et seq.* of the Transportation Code, are a part of Maryland’s vehicle law and therefore are subject to the signature requirements of Section 26-203.

It is clear that under Maryland law the mailing of citations to the residence of the alleged offender would violate the service requirements incorporated in the Maryland Transportation Code, Section 26-203. Section 26-203 specifically requires at the time of issuance the driver’s signature as acknowledgment of receipt of a traffic citation. Therefore, using photo-radar in Maryland would require either statutory revision or personal issuance of the citations by police officers.

## Statutory Amendments

Legislative action in both Virginia and Maryland would assist in the implementation of photo-radar as a viable speed detection system. Specifically, the adoption of statutes that provide for service of traffic citations by mail would facilitate implementation, as would codification of the silent witness theory of admissibility for photo-radar photographs. In Virginia, violation of the provisions for use of high-occupancy vehicle (HOV) lanes does not require personal service of the citation. However, in Virginia, although the HOV violation is a type of traffic infraction, it is not a misdemeanor and is treated much as a parking ticket. Thus, the HOV prece-

dent does not apply to the several requirements for the misdemeanor speeding violation.

### **Film/Photograph Handling Issues**

Both manned and unmanned photo-radar sites will require manual camera loading and unloading, laboratory photo processing, and storage of the resulting negatives and prints. In developing operational procedures to carry out these functions, two additional issues arise. The first involves how the film and photographs are physically stored between the time of an alleged speeding violation and the admission of the photo-radar photograph into evidence. The procedures instituted for handling and developing the film must ensure that the "chain of custody" provides reasonable certainty that physical tampering or alteration does not occur to either the film or the photograph. The second issue involves individual privacy rights. The privacy of individuals in Virginia and Maryland is protected under both common law and statutory enactments. Thus, it is necessary to ensure that the photographic handling and storage procedures do not interfere with these privacy entitlements. The following subsections examine Virginia and Maryland law with regard to chain of custody requirements and individual privacy rights and recommend operational film/photograph handling procedures that conform to the provisions of the law in both jurisdictions.

#### **Chain of Custody Concerns**

Due to the ease with which film and pictures can be altered, photographs offered under the silent witness theory must be authenticated. Thus, the film/photograph handling procedures must ensure that photographs used in cases involving a contested speeding ticket are genuine. Authentication is accomplished by establishing the chain of custody of photographs prior to their introduction into evidence. This chain of custody is usually established by eliciting testimony from each successive custodian of the film/photograph to show that the original film was delivered to the laboratory and developed without any tampering and that the photograph introduced in court was reproduced from the original film. In addition, chain of custody authentication typically requires that the evidence be secure when not in use and that it is made available only to those individuals directly involved in its processing.

In Virginia, the general chain of custody rule (as stated in *Reedy v. Commonwealth of Virginia*) is that "evidence of the physical properties of an item . . . requires proof of the chain of custody to establish with reasonable certainty that the material was not altered, substituted, or contaminated."<sup>123</sup> Only one decision, however, has discussed the operational procedures required with respect to the handling and processing of film and photographs. In *Ferguson v. Commonwealth*,<sup>124</sup> a store used a Regiscope camera to photograph every check-cashing transaction that took place. The film was sent to the Regiscope Corporation for processing and storing. Upon learning that a check had been forged, the store owner requested a

photograph of a particular transaction from Regiscope. Regiscope then sent a print from the negative to one of the store's employees, who in turn took it to the police. The *Ferguson* court held that evidence which established the reported sequence of events was "sufficient to provide an adequate foundation assuring the accuracy of the process producing [the picture]" and thus admitted the photograph into evidence.

Another chain of custody decision, *Robertson v. Commonwealth of Virginia*,<sup>125</sup> is also applicable to the photo-radar film handling procedures. In *Robertson*, the court held that the mailing of a sealed package containing evidence did not upset the chain of custody since, in the absence of any evidence of tampering or mishandling, it will be presumed that the U.S. Postal Service has properly discharged its duties.

In developing operational procedures that conform to the *Reedy-Ferguson-Robertson* chain of custody rules, it is helpful to examine (1) the procedures the Virginia State Police use to ensure the admissibility of photographic evidence in court, and (2) the film-handling procedures required in other jurisdictions. According to Lt. Col. C. M. Robinson, the Virginia State Police use the following procedures for the handling and processing of photographs admitted into court. The police officer who took the picture delivers the film to the police photo laboratory, with a request specifying the number and size of the prints required. The laboratory logs in the film, develops it, makes prints, and returns copies of the prints in a sealed package to the officer in charge of the case by U.S. mail. The negatives are retained at the laboratory. During this process, the film/photographs are stored in limited access areas to prevent tampering prior to trial.

As to other jurisdictions, in *State v. Young*,<sup>126</sup> a Maine appellate court ruled that the following was sufficient to establish the authenticity of photographs from a bank surveillance camera: (1) testimony of the bank manager as to the installation and field of view of the camera; (2) testimony of an employee of the company that installed the camera as to the camera's operation and periodic testing; (3) testimony of the person who removed the exposed film; (4) testimony of each of the law enforcement officers who had custody of the film from the time it was taken from the camera until the time of the trial; and (5) testimony of the bank teller as to the activation of the camera during the robbery. Similarly, in *Groves v. Indiana*,<sup>127</sup> the Supreme Court of Indiana held that "in cases involving automatic cameras . . . there should be evidence as to how and when the camera was loaded, how frequently the camera was activated, when the photographs were taken, and the processing and chain of custody of the film after its removal from the camera."<sup>128</sup>

Furthermore, some courts have approved even less stringent chain of custody procedures when photographs are admitted into evidence under the silent witness theory. For example, in *Molina v. State*,<sup>129</sup> an Alabama appellate court held that "As long as satisfactory evidence of the integrity of a film or videotape is presented, stringent foundational requirements, such as proof of a continuous chain of custody, are now almost universally rejected as unnecessary."<sup>130</sup> The court then further noted that "[a]n example of a film or tape for which chain of custody might be one

appropriate way of establishing authenticity would be a film or tape made with an automatic camera that recorded an event when no human beings were present. But even in this situation, rather than resorting to proof of chain of custody, it usually should be possible to authenticate the film or tape in some other way, such as by the testimony of a photographic expert who has determined that it has not been altered in any way and was not built up or faked."<sup>131</sup> Similarly, in *Stark v. State of Indiana*,<sup>132</sup> the Indiana Supreme Court held that the admission into evidence of a photograph taken by a Regiscope camera was proper even though the "state provided neither evidence about the manner in which the photograph was processed nor a complete chain of custody."<sup>133</sup>

In Maryland, the common law chain of custody rule requires that there be a "reasonable probability . . . that no tampering occurred while the evidence was in the state's possession and that it is the same evidence linked to the defendant."<sup>134</sup> Thus, the general rule in Maryland is essentially identical with the standard used in Virginia. Unfortunately, however, Maryland appellate courts have yet to address chain of custody procedures specifically with regard to photographic evidence or the related subject of chain of custody requirements with regard to the transmittal of evidence through the U.S. mail.

Although Maryland case law provides only limited guidance as to the required film/photograph handling procedures, additional insight is provided by a Maryland statute that establishes specific chain of custody rules for controlled dangerous substances.<sup>135</sup> Under these rules, the following procedures are followed to establish that physical evidence constitutes a particular controlled dangerous substance:

- A report signed by the chemist performing the test is submitted in court that (1) confirms that the chemist is certified as qualified to analyze controlled dangerous substances, (2) states that he or she made the analysis under the procedures approved by the department, and (3) states that in his or her opinion the substance is or contains the particular controlled dangerous substance specified.
- A statement containing a sufficient description of the material or its container to identify the material is signed by each successive person in the chain of custody (defined as the seizing officer, the packaging officer, the chemist, and any other person who actually touched the substance when it was not contained in a sealed package) stating that the person delivered it to the other person indicated, on or about the date indicated.
- The report and these statements serve as *prima facie* evidence that the material delivered to the chemist was properly tested under the approved procedures, that these procedures are legally reliable, that the material was delivered to him or her by the person stated in the report, that the material was or contained the substance therein reported, and that each person had custody and made delivery as stated.
- The chemist and the successive custodians need not appear in court to create these *prima facie* presumptions.

- Finally, the prosecution can demand (in writing, at least 5 days in advance) the presence of the chemist or any person in the chain of custody as a prosecution witness at trial.

The statutory rules established for handling controlled dangerous substances are helpful in determining the film/photograph handling chain of custody rules since Maryland courts are likely to follow them, at least to the extent that they agree with the general common law rule. Thus, for example, it is likely that chain of custody testimony will not be required by couriers<sup>136</sup> and that signed statements will suffice (without a court appearance) for creating a *prima facie* presumption that the evidence is genuine.

Additional insight is provided by examining the chain of custody procedures Maryland police officers use to comply with these rules. In *Thompson v. State of Maryland*,<sup>137</sup> the procedures used by the City of Baltimore Police Department are given as follows. The police officers immediately transport seized controlled dangerous substances to the evidence control section at police headquarters. The transporting officer executes a chain of custody evidence submission form and a property slip detailing the items submitted for analysis. A technician photographs the evidence in the presence of the transporting officer, places the items in a sealed container, and deposits the container in a depository safe pending chemical analysis. The chemist analyzing the material records the date he or she received the material, the results of the analysis, and the date the material is returned to the property control section.<sup>138</sup>

One final indicator of the chain of custody requirements Maryland courts are likely to impose is the procedure used by the Maryland Department of State Police for the handling and processing of photographs admitted into court. According to Lt. Vernon Betkey, when a state trooper takes a photograph, he or she fills out a slip that lists the date, time, and location at which the picture was taken and identifies the photographer. This slip and the film are then sent to the crime laboratory for processing. The pictures are returned to the police officer who had them taken and are put in the case file. Thus, normal chain of custody procedures (such as evidence bags and custody sheets) are not employed with photographs (although they are with videotapes) in Maryland.

### **Privacy Concerns**

The film/photograph handling procedures must also ensure that the privacy rights of individuals photographed while speeding are not violated. In general, an individual's right to privacy originates from three distinct sources: the U.S. Constitution, state statutory enactments, and state common law court decisions. As discussed earlier, however, the constitutional right to privacy applies only to fundamental rights that involve the family sphere, such as marriage, procreation, and contraception use; it does not encompass the use of photographs taken on public roads. Thus, any privacy protection that affects photo-radar operational procedures must originate from state statutes or case law.

In Virginia, the only statutory protection available to individuals against governmental privacy invasion are the restrictions imposed by the Privacy Protection

Act of 1976.<sup>139</sup> Under this act, agencies and political subdivisions of the Commonwealth that collect personal information must adhere to the following guidelines<sup>140</sup> to ensure that individual privacy is safeguarded:

1. The existence of the information system cannot be secret.
2. The need for the information must be clearly established in advance.
3. The information must be relevant to the purpose for which it is collected.
4. The information cannot be collected by fraudulent or unfair means.
5. Information can be collected only as explicitly or implicitly authorized by law.
6. The information's reliability must be assured, and its misuse prevented.
7. Clearly prescribed procedures must be in place to ensure that the information is used only for the purpose for which it was collected.

For the most part, these guidelines will have little impact on photo-radar use or on the operational procedures developed for film/photograph handling.

Examining each of these guidelines in turn, it is apparent that, with the exception of guidelines 6 and 7, photo-radar use should not be affected since:

1. The existence of photo-radar photograph files will not be secret.
2. The need to retain photographs is clearly required given the potential for court challenges of speeding citations.
3. The retention of photographs clearly meets the purpose of defending speeding citation challenges in court.
4. Fraudulent or unfair means will not be used to obtain the photographs.
5. Collection of the information is implicitly authorized by Va. Code Ann. Section 15.1-138, which authorizes police enforcement of Virginia's traffic laws, and would be explicitly authorized by legislation necessary to establish the photo-radar speed enforcement program.

Guidelines 6 and 7, however, will affect photo-radar film/photograph handling procedures. Specifically, they will require that (1) the chain of custody procedures ensure the accuracy and reliability of the photographs and prevent their misuse, and (2) that the procedures clearly enjoin use of the photographs for any purposes other than identifying violators and defending ticket challenges.

Additional statutory privacy constraints are provided by Va. Code Ann. Section 2.1-380. This section establishes strict requirements on agencies maintaining information systems containing personal information (such as photographs) to ensure that the information is kept confidential. These requirements state that:

1. Only personal information permitted or required by law can be collected, maintained, used, or disseminated.
2. Personal information is maintained consistent with confidentiality requirements.
3. Information is not disseminated to other information systems without the sender specifying requirements for security and usage thereof and without receiving reasonable reassurances that those requirements will be met.
4. A list is maintained of all persons and organizations having regular access to the information in the system.
5. A complete record including the identity and purpose of every access to any personal information in the system (excluding accesses by personnel of the agency that inputs the data) is maintained for a period of 3 years or until such time as the personal information is purged, whichever is shorter.
6. Appropriate safeguards are established to secure the system from any reasonably foreseeable threat to its security.

Thus the procedures established for the handling of photo-radar film and photographs must also ensure that these constraints are met.

Privacy constraints arising through Virginia common law court decisions must also be examined. A review of Virginia case law, however, reveals that common law privacy rights are unlikely to affect photo-radar film/photograph handling procedures. Although Virginia courts have never specifically addressed the privacy issues involved with governmental photographing of automobile occupants on public roadways, they have established that (1) a police officer has the right to look into the interior of an automobile from any number of angles without compromising any expectations of privacy that the driver could reasonably have (since a private citizen could readily make the same observations),<sup>141</sup> and (2) a passenger in a stolen rental vehicle has no reasonable expectation of privacy in the vehicle.<sup>142</sup> Although neither of these decisions is directly on point, they do indicate a reluctance to find privacy rights with regard to automobile contents that are in plain view. In addition, although no Virginia state court has addressed the issue, the Fourth U.S. Circuit Court of Appeals has held that no common law right of privacy exists in Virginia, only the statutory right of privacy discussed previously.<sup>143</sup> Finally, state courts in other jurisdictions that have addressed the automobile occupant privacy issue, as well as the U.S. Supreme Court, have been unanimous in holding that no reasonable expectation of privacy exists when the automobile is exposed to the public.<sup>144</sup> Given this, it is highly unlikely that Virginia courts will find that privacy concerns require special treatment of the film and photographs beyond that required by statute.

In Maryland, even fewer privacy concerns will affect the film/photograph handling procedures. The only Maryland statute affording privacy protection is

Md. State Govt. Code Ann. Section 10-618(f), which allows custodians of public records to deny public inspection of records of investigations compiled for any law enforcement, judicial, correctional, or prosecution purpose. Such a denial, however, can be only to the extent that the inspection would (1) interfere with a valid law enforcement proceeding, (2) deprive another person of his or her right to a fair trial, (3) constitute an unwarranted invasion of personal privacy, or (6) prejudice an investigation. It is at least conceivable that a Maryland court could find disclosure of photo-radar photographs to be an invasion of personal privacy, and thus Maryland officials should not disclose them to the public unless required to do so by a court order. However, this section does not in any way restrict the state from taking such photographs. Thus, as in Virginia, Maryland statutory law will not require any significant privacy-induced constraints on the photo-radar procedures.

Maryland common law privacy rights are also unlikely to pose any constraints on the film handling procedures. Although Maryland courts have never specifically addressed the privacy issues involved with governmental photographing of automobile occupants on public highways, several decisions come fairly close to addressing this issue and make clear the common law rule in Maryland. In *Fowler v. State of Maryland*,<sup>145</sup> a Maryland appellate court held that "society does not consider the interior of an automobile parked in a public place to be a place where a person has a reasonable expectation of privacy."<sup>146</sup> Similarly, in *Dept. of Transportation, Motor Vehicle Administration v. Armacost*,<sup>147</sup> another Maryland appellate court held in an automobile context (involving emission inspections) that "an individual has no expectation of privacy in items that he knowingly exposes to the public."<sup>148</sup> These decisions clearly indicate that Maryland courts are opposed to finding privacy rights with the regard to automobile contents that are in plain view.

### **Recommended Procedures**

The discussion shows that Virginia and Maryland have similar, but not identical, rules concerning chain of custody and privacy. These rules are sufficiently similar so that a single set of procedures is recommended for the handling of film and photographs in both jurisdictions. These recommended procedures should satisfy chain of custody and privacy requirements in both jurisdictions:

- In contracts with the camera providers, there should be a clause ensuring that company representatives will be available to testify at photo-radar trials as to the installation and triggering operation of the camera.
- In the contract with the company that maintains the cameras, there should be a clause that ensures that a company representative will be available to testify at photo-radar trials as to the periodic testing and maintenance of the cameras.
- Photo-radar cameras should be inaccessible to everyone except the maintenance personnel and individuals who remove and replace the film.
- A custody sheet should be initiated with each roll of film at the time the film is placed in the camera. The sheet should record the dates and times

that custody of the film was transferred, as well as the identity and signature of each transferee.

- The film should be either hand delivered or mailed to the processing laboratory. If mailed, the film should be in a sealed package. The laboratory technician should verify that no tampering occurred during mailing.
- After processing, prints developed from the film negatives should be sent in a sealed package to the individuals who process the citations. The individuals should verify that no tampering occurred during mailing.
- All persons who obtain possession of the film or photographs should be available to testify at trial.
- All persons taking possession of the film should sign and date the custody sheet, and the film should be stored in a limited access area when it is not in the physical possession of one of the custodians to ensure there is no possibility of tampering.
- Negatives should be kept on file at the police photo laboratory for 1 year so as to ensure their accessibility if problems develop with the chain of custody of the photographs.
- Use of the film or photographs for any purpose other than identifying violators and defending ticket challenges should be clearly prohibited.
- Negatives and prints should be destroyed periodically after citations are paid and they are no longer required.

### **FCC Policy on Photo-Radar**

The Federal Communications Commission (FCC) promulgates guidelines that manage and control radio-frequency use in the United States. Thus, a potential concern with photo-radar is whether or not its use is consistent with these guidelines. Although the photo-radar emitter is essentially identical with FCC-approved police radar units, concerns regarding photo-radar compliance with FCC regulations have arisen.

In order to determine whether the use of photo-radar complies with existing FCC guidelines, Mr. Eugene Thompson of the FCC's Rules and Regulations Bureau was contacted on May 21, 1992.<sup>149</sup> Mr. Thompson confirmed that the use of photo-radar units by law enforcement agencies (in attended or unattended modes) was consistent with FCC guidelines, and thus, special permission (or policy waivers) would not be required prior to the implementation of photo-radar programs.

## METHODS

Since the use of photo-radar is a complex, multifaceted issue, the feasibility of its use on the Beltway must be judged based on a number of criteria, each involving a different aspect of the technology or its interpretation by the courts. For these reasons, the method used in this evaluation addressed the following issues:

1. the capabilities of the various models of photo-radar equipment as noted by manufacturers' claims and demonstrations at their factory
2. the accuracy of the equipment in determining speeds
3. the reliability of the speed measurements
4. the quality of the photo-radar photographs in terms of the identification of vehicles and drivers according to legal specifications
5. the likelihood of successfully detecting and photographing a speeding vehicle given the obstructions inherent in high-volume traffic and the difficulty in photographing high-speed vehicles
6. the effect of photo-radar as used in this evaluation (without citations) on speed characteristics (i.e., mean speed, 85th percentile speed, and speed variance)
7. the characteristics of a facility that would affect the successful use of photo-radar, such as number of lanes
8. the likelihood of detection by standard radar detectors

### Site Visits and Manufacturers' Nonempirical Demonstrations

In order to collect information on the various manufacturers and their photo-radar devices and peripherals, the study team made two sets of site visits, one in the United States and the other in Europe. The site visits to Pasadena, California, and Paradise Valley, Arizona, took place between February 26 and March 5, 1990. The site visits to Europe were conducted between May 20 and June 2, 1990 (see Table 1). The purposes for these site visits were:

1. *To discuss the equipment on site with the manufacturers.* The individuals who know the most about photo-radar equipment are the individuals who initially developed and now produce the devices—the manufacturers themselves. However, in many cases, the manufacturers, especially those located overseas, contract with agents in the United States to market their products. In many cases, these agents have very little technical training but are, rather, experts in sales and distribution. During the demonstrations, inaccurate information concerning the equipment was often received from agents who represented the manufacturers and may not have had the

Table 1

**TRIP ITINERARIES AND PERSONS INTERVIEWED  
DURING SITE VISITS IN THE UNITED STATES AND EUROPE**

UNITED STATES	
<b>Paradise Valley, Arizona</b>	
Donald Losier	Chief, Paradise Valley Police Department (PVPD)
Sgt. Ronald Warner	PVPD
Karl J. Emberg	Assistant Chief, Field Operations Division, PVPD
Onno M. Prinze	Director, Support Services Division, PVPD
Charles Ollinger	Town Attorney, Paradise Valley
John Baudek	Town Manager, Paradise Valley
Manuel Fuestes	President, Traffic Monitoring Technologies (TMT)
Jim Tuton	President, TMT Southwest
William Gradnik	TMT Southwest
Lt. J. G. Gragg	Peoria Police Department, Peoria, Arizona
<b>Pasadena, California</b>	
Lt. Robert L. Huff	Pasadena Police Department,
Sgt. C. Eugene Gray	Field Services Division
Carroll Gray	Traffic Monitoring Technologies
Robert H. Montoya	
Warren Haas	Commissioner, Municipal Court,
	City of Pasadena
Courtland Crabtree	City Attorney, City of Pasadena
Norman Carter	Deputy Director, Department of Finance
Jack McCool	Department of Finance
John E. Ostrowski	Management Audit Administrator,
	Department of Finance
Donald L. McIntyre	City Manager, City of Pasadena
<b>EUROPE</b>	
<b>Gatsometer BV</b>	
<b>Overveen, Holland</b>	
Gatsometer, BV	
Tetterodeweg 10	
2050 AA Overveen	
The Netherlands	
Thomas Gatsonides	Co-Director, Gatsometer BV
Maurice Gatsonides	Co-Director, Gatsometer BV
H. Smit	Townpolice Wassenaar
A. A. L. van der Vorst	Head of Public Information, SWOV
Hway-liem Oei	Staff Researcher, SWOV
Tapani Makinen	Visiting Researcher, Research Center of Finland

*continues*

Table 1 (cont.)

## EUROPE (cont.)

Multanova  
Uster, Switzerland

Multanova/RPJ, Inc.  
(Multanova AG, Zellweger Uster LTD.)  
Seestrasse 108  
CH-8612 Uster 2/Schweiz  
Switzerland

Martin Schaufelberger  
Kurt N. Baer

Multanova/RPJ, Inc.  
Multanova/RPJ, Inc.

Traffipax  
Benrath, Germany

Traffipax-Vertrieb GMBH  
Hildener Str. 57  
P.O. Box 13 07 26  
D-4000 Dusseldorf 13  
West Germany

Ernst Franz  
Peter Borchert  
Wolfgang Freudenhammer  
Ernst Milatz

Managing Director, Traffipax  
Assistant General Manager, Traffipax  
Export Manager, Traffipax  
Technical Manager, Traffipax

Trafikanalys  
Gavle, Sweden

Trafikanalys AB  
Utmarksvagen 33  
Box 965 S-801 33 Gavle  
Sweden

Lars-Yngve Felth  
Michael Khan  
Stellan Mark  
Kjell Wallin  
Allan Jon

President, Trafikanalys  
Director of Marketing, USA, Trafikanalys  
Head of Engineering, Trafikanalys  
Engineer, Trafikanalys  
Engineer, Trafikanalys

technical expertise or familiarity to be able to provide answers to technical questions. By dealing with manufacturers directly, the study team was able to ascertain the capabilities and idiosyncrasies of the equipment. In addition, they were able to ensure that the manufacturers were fully aware of the Virginia/Maryland demonstrations and the testing criteria for those demonstrations.

2. *To observe the photo-radar equipment in use at locations where the manufacturer felt its use had been successful.* The study team believed that the manufacturer would be the best source of information concerning "successful" use of their products. In addition, by visiting the photo-radar sites, the team was often able to discuss the equipment with the technicians operating it and with police officers who worked the sites.
3. *To evaluate the equipments' design and the manufacturers' claims in relation to photo-radar use on high-density urban expressways.* Most of the locations at which photo-radar has been used successfully are on city streets and in residential areas, both of which are very different from a high-volume, high-speed expressway like the Beltway. During the interviews, the team members made notes of problems that might affect Beltway use, such as "screening." (Screening occurs when a vehicle blocks the radar signal returning from a speeding vehicle or blocks the camera's view of the vehicle. In these cases, photo-radar cannot be successfully used.) The study team made note of this and other problems that might arise on the Beltway so that the U.S. demonstration phase of the project could be designed to test for these problems.

### **Field Demonstrations**

During the summer of 1990, five manufacturers of photo-radar equipment demonstrated their device on interstate highways in Virginia and Maryland for 2 weeks each. A sixth, Multanova, was invited to participate in the demonstrations, but declined. Many steps were taken to ensure a fair and equitable analysis of each company. During each 2-week study period, the manufacturers were given the opportunity to take as many pictures as they wished, using their choice of photographic equipment and film. Manufacturers were also encouraged to take photographs using their equipment in as many ways as possible so that each capability of the equipment could be evaluated. Whenever possible, the film was developed by a local commercial laboratory. However, when local processing was unavailable for unusual film types or unusual canister sizes, other arrangements were made.

All demonstrations were conducted with the manufacturers or their agents operating the equipment under the constant supervision of the research team, who collected the data for all tests. Although the same tests were run for all pieces of equipment, there were some differences in the manufacturers' experience in operating their device. For the most part, these were based on the manufacturers' schedules, their familiarity with the equipment, and whether all of the equipment's functions were working at the time of the demonstrations.

There were, however, some conditions under which all of the manufacturers operated that may have affected the performance of their device, such as the suitability of permanent loop stations (and, thus, the study sites) for taking perfect photographs. In these instances, since all manufacturers operated under the same conditions, no one manufacturer had an advantage over the others.

The performance of each piece of equipment was evaluated after several tests were conducted at the preselected sites. In order to prevent biasing of the desired information, the same types of demonstrations were performed for each type of equipment at the same sites, on the same workdays, and at approximately the same time of day.

**Site Selection**

A major objective of this study was to determine how the prevailing traffic and geometric conditions at a given site affect the accuracy of the speeds recorded and the clarity of the resulting photographs. The ideal location for collecting the information to evaluate this effectiveness would be where accurate volume and speed data could be collected and where light conditions are nearly ideal for photography. The only sites at which speed and volume data could be collected were at sites where loop sensors were permanently installed. Unfortunately, these locations were not necessarily the best for photography. Since the photographs could be taken at the loop sensor locations, and since it would be virtually impossible to collect speeds and volumes accurately at high-volume locations without loops, it was decided that the first criterion for selecting a site would be the availability of loop sensors at the site. The next requirement was that the site provide safe conditions for manufacturers, their agents, and those involved in collecting the data. The final criterion was that the site be a two-, three-, or four-lane interstate highway with suitable vertical and horizontal alignments. Factors taken into consideration in evaluating how safe a particular location was included the availability of adequate site distance and adequate space away from the edge of the pavement for vehicles and equipment.

In addition, the conditions at several of the sites necessitated that equipment be set up in configurations that may not have been ideal for photo-radar operation. In Northern Virginia, for instance, each piece of equipment had to be set rather far back from the roadway in order to ensure the safety of the public and the study team, due to the high volumes and high speeds at these sites. This added an approximate width of one lane to the distance between the equipment and the target vehicles. Also, at the I-495 site in Virginia, there was a significant drop from the roadway to the shoulder that resulted in vehicle-mounted equipment being tilted by up to 5 degrees. Thus, at this site, vehicle-mounted units may in some cases have been projecting the radar beam over compact cars and shooting photographs at an angle. These operational requirements, although not ideal for the use of photo-radar, were equivalent for all manufacturers, thereby giving none an advantage over the others.

The sites selected were therefore not necessarily the most ideal locations for photo-radar equipment with respect to the quality of the photographs taken but were the most suitable if all selection criteria were considered. Thus, it is quite likely that the photographs taken did not represent the best quality that could be obtained by the equipment; however, they served as a good means of comparing the photographic capability between brands of equipment. Because of the safety criterion used for locating the study sites, it was not necessary to use any special traffic control. The traffic pattern was therefore not affected at any of the study sites.

## Site Description

After considerable field evaluation of different sites with loop detectors, six sites were selected based on the enumerated criteria. Table 2 shows the locations of the test sites and the traffic and geometric characteristics at each site. Unfortunately, the ambient lighting conditions were not perfect for photography throughout the day at each site. For example, according to the field notes taken by the supervising technician, because of the angle of the sun, Site 1 was not ideal for photography during the morning hours but seemed to be much better in the afternoon, and the lighting conditions at Site 2 were not perfect for photography in the afternoon. Similarly, the lighting conditions at Sites 4 and 6 seemed better in the morning than in the afternoon, whereas conditions seemed better in the afternoon at Sites 3 and 5. These were, however, subjective judgments made at study sites, rather than empirically based findings.

## Photographic Quality and Utility

In order for a photo-radar program to run successfully, the equipment must be used in such a manner as to produce clear pictures of speeding vehicles and, if necessary, their driver. To determine which manufacturers produce the highest quality and most usable photographs, an analysis of each photograph produced during the 2-week field demonstration period was conducted.

Due to the large number of photographs taken during each test period (more than 7,600 total) and the careful scrutiny given each photograph, the full evaluation of the photographs took about 5 weeks. Detailed information concerning each photograph taken was entered into a computerized data set as the photograph was being viewed. The specific variables used in the evaluation of each photograph were:

1. manufacturer's name
2. roll identification number
3. date the film was exposed
4. time the film was exposed
5. location where the film was exposed
6. conditions under which the film was exposed (i.e., no problems, problems with equipment itself, problems with setup of equipment, problems with equipment itself and setup of equipment, or problems with computer information strip on picture)
7. direction of traffic photographed (oncoming vs. receding)
8. mode (stationary vs. mobile)
9. weather conditions when film was exposed (i.e., bright sun, hazy sun, overcast, nighttime, or raining)

Table 2  
LIST OF STUDY SITES

Site No.	Route	Location	Direction	Rural/ Urban	No. of Lanes	AADT (1989)
1	I-64	Louisa County: 0.02 mile east of mile-post 139	Eastbound	Rural	2	16,060
2	I-81	Rockingham County/ Harrisonburg: 0.58 miles south of mile-post 246	Northbound	Urban	2	28,730
3	I-295	Henrico County: between Nuckols Rd. and Rte. 33	Eastbound	Rural	3	14,835
4	I-495	Fairfax County/ Annandale: 1 mile south of Rte. 236	Northbound	Urban	4	178,640
5	I-95	Fairfax County/ Alexandria: 1 mile north of Van Dorn St.	Northbound	Urban	4	155,200
6	I-95	Prince George's County: 1/2 mile south of Maryland Rte. 214	Southbound	Urban	4	140,000

10. whether prints or negatives were evaluated
11. number of vehicles in the frame
12. type of vehicle (i.e., passenger car, van/small truck, large truck or bus)
13. lane in which the vehicle was traveling
14. location of the vehicle in the picture (i.e., no vehicle in frame, out of range left, in left third of frame, in center of frame, in right third of frame, or out of range right)
15. whether the license plate could be read
16. reason the vehicle's license plate(s) could not be read (i.e., rain, glare, out of frame, too far away, view obstructed, no plate, reflectorization, or poor film exposure)
17. whether the driver was identifiable as compared to a standard photograph
18. reason the driver could not be identified (i.e., rain, glare, out of frame, too far away, view obstructed, receding traffic, or poor film exposure)
19. whether it was possible to determine which vehicle was speeding (In cases where two or more vehicles were photographed, a method was needed to determine which vehicle had triggered the photo-radar photograph. If a method was specified and it identified a vehicle in the photograph, this variable was coded as a "yes.")

Information from each vehicle photographed was then analyzed to determine what percentage of a manufacturer's pictures could be used in court, based on possible criteria for photo-radar cases. These criteria included (1) whether the license plate and the state of issue were readable, (2) whether the driver could be identified, (3) whether the vehicle's speed was clearly stated, and (4) whether the speeding vehicle *could* be identified in multivehicle photographs. In order to determine which vehicle in a multivehicle photograph was speeding, several manufacturers provided a template. This clear plastic overlay outlined where in the photograph the radar beam fell. The vehicle over which the template's radar beam falls is the speeding vehicle. An additional manufacturer stated that each template must be drawn based on the speed data for the particular site. Thus, each site would have its own template. In cases where there were two or more vehicles in the beam, some manufacturers claimed that their unit would not take a picture. Other manufacturers stated that their unit would take a picture but that such a picture would obviously not be used in a prosecution.

The effect of such factors as weather and distance from the camera on photographic quality was also evaluated. In addition, at the start of the evaluation, photographic standards for overall utility of the photographs were set, against which each manufacturer's photographs were compared. These standard photographs appear in Appendix A. Several of the photographs were enlarged to determine whether

higher-quality photographs could be produced for use in court. Two types of film were evaluated: prints and negatives. The prints were viewed without any enhancements except magnification. The negatives were evaluated by use of a viewer capable of changing a negative to a positive image. The FOTOVIX II, a video-based viewing system, allowed for the adjustment of contrast and focus and enabled the analyst to magnify specific portions of the negative.

### **Accuracy of Recorded Speeds**

The objectives of this test were to determine the relative accuracy of the speeds recorded by each piece of equipment and determine whether the accuracy was significantly affected by the prevailing traffic and geometric conditions. The tests were carried out at Sites 1, 2, and 3. No attempt was made to conduct these tests on the Beltway because it required isolation of the test vehicles from other vehicles, a practice that is difficult and could be unsafe in high-volume, high-speed traffic.

Three test vehicles, a Chevrolet Cavalier, a Plymouth Minivan, and a larger Ford Aerostar Van, were used in this test. The speedometer of each vehicle was calibrated prior to testing. A driver was then selected for each vehicle and specifically trained to drive that vehicle at the required constant speed as the vehicle traversed the loops at a given site. The training required that numerous runs be made by each driver until he or she could isolate the target vehicle from other traffic and could attain the required velocity at a location about 150 feet from the loops, maintaining the constant speed as the vehicle traversed the loops. Each driver comfortably demonstrated his or her ability to meet the test requirements.

The next stage was to ascertain whether the speeds recorded by the loops were accurate. This was achieved by having each test driver isolate his or her vehicle from other vehicles on the highway and then drive the test vehicle at a given speed across the loops while being monitored by standard police radar. This facilitated the clear-cut identification of the speed of the vehicle as computed by a Streeter-Amet counter connected to the loops and comparison with police radar. Prior to each test, at least five runs were made on each lane by each vehicle for speeds of 40, 50, 55, and 65 mph. (It was not feasible to perform this test at speeds higher than 65 mph because of the existing maximum speed limit.) For each run, the speed of the test vehicle was recorded using standard police radar and was compared to the speed computed by the Streeter-Amet counter. The lane in which the test vehicle was driven was also recorded. In a few cases, loop speeds for several of the 20 or more runs were off by more than 1 mph and were recalibrated by VDOT personnel. Having ascertained that the vehicle's speed as measured by police radar and that computed by a Streeter-Amet counter were within 1 mph of each other, the test to determine the accuracy of the photo-radar equipment in recording the speed of an individual vehicle was conducted.

The relative accuracy of the photo-radar equipment was determined by comparing loop speeds to photo-radar speeds. The threshold speed of the photo-radar was set at 30 mph so that the speed of each vehicle passing through its beam could be recorded and its photograph taken. Each test vehicle was then driven at a constant

speed through the test site, isolating it from the other vehicles. The test was run for speeds of 40, 50, 55, and 65 mph for each lane and for each vehicle. For every run, the type of test vehicle, the speed at which the test vehicle was driven, the speed recorded by the Streeter-Amet counter, and the speed computed by the photo-radar equipment were recorded. The lane in which the test vehicle was driven was also recorded. The speed recorded by each piece of equipment was then compared with the actual vehicle speed as obtained at the loops by the Streeter-Amet counter. The accuracy of the photo-radar equipment was determined from the variation between speed recordings produced by the loops and those produced by the photo-radar equipment.

The testing was carried out under speed test conditions as specified in the federal minimum performance specifications for testing equipment accuracy with respect to temperature and supply voltage (NHTSA, *Model Minimum Performance Specifications for Police Traffic Radar Devices*, Technical Report No. DOT HS 807-415, Washington, D.C., May 1989). However, rather than the researcher using a stopwatch to determine the average speed of the vehicle over a stipulated distance, a nearly instantaneous speed reading was recorded by both the Streeter-Amet counter located at the loops and the photo-radar equipment being evaluated. Thus, the speeds recorded by both the counter and the photo-radar equipment were obtained at the same location and at the same time and, thus, were instantaneous (or nearly instantaneous) measurements. This is a much preferred and more accurate method than comparing the instantaneous speeds measured by the photo-radar equipment with "average" speeds calculated by timing the vehicles over the measured distance since the vehicle's speed would vary over the distance preceding the photo-radar equipment.

### **Effect of Vehicle Clustering on Accuracy of Speed Measurements**

The objective of this test was to determine the accuracy of the speed recorded by the photo-radar equipment when vehicles were being driven in tandem across the loops. This test was, therefore, a repeat of the speed accuracy test but with the test vehicles in a paired configuration. This required careful driving on the part of the study team. In this test, the test vehicles were driven in different lanes, with either the front of the vehicles being on an approximately straight line when traversing the loops or with each succeeding vehicle slightly offset behind the preceding vehicle. The speeds identified at the loops and by the photo-radar equipment were then recorded and compared. The results of this test indicate to what extent the arrival of two or more vehicles within the radar beam of a piece of photo-radar equipment affects the accuracy of the speed recorded.

### **Percentage of Usable Photographs of Vehicles Exceeding Threshold Speed**

This test was conducted at all sites when accuracy testing was not underway. At each site, the photo-radar equipment being tested was properly positioned and set at a threshold speed that ensured that all speeding vehicles traveling on the interstate were counted. The thresholds were also set so that photographs of speeding vehicles could be taken continuously for at least 3 minutes before the roll of film had to

60

be changed. The photo-radar operation was then initiated and allowed to continue for a given time period, ranging from 3 to 15 minutes, depending on the threshold speed, vehicle operating speeds, traffic flow, and number of exposures available in the film canister. At sites with a high volume and high operating speed (e.g., I-495), 5-minute intervals were generally used since it took about 5 minutes to generate 36 photographs (standard film canister size) without interruption. The test interval was increased to 10 or 15 minutes when a larger number of exposures was available or when volume was low. This variation in the test interval was necessary so that an adequate number of speed violators could be photographed by the photo-radar equipment. Concurrent speed data were also collected at the loops using the Streeter-Amet counter, from which the number of vehicles exceeding the speed limit for the same test period was determined. Two figures were then computed: (1) the number of photographs in which a vehicle's license plate number and recorded speed could be clearly identified (as a percentage of the total number of vehicles exceeding the threshold speed), and (2) the number of photographs in which a vehicle's license plate number, the recorded speed, and the driver's face could be clearly identified (as a percentage of the total number of vehicles exceeding the threshold speed).

### **Misalignment Flexibility (Cosine Effect)**

The objective of this test was to determine the extent to which misalignment of the photo-radar equipment affected the speed recorded by the equipment. It was anticipated that equipment might be unintentionally misaligned by untrained police officers. Each piece of equipment was, therefore, set up in the operational mode but intentionally misaligned from the manufacturer's recommendation by 2, 4, 6, and 8 degrees. The speed accuracy test was then repeated. The speeds obtained at the loop sensors by the Streeter-Amet counter were then compared with those recorded by the photo-radar devices.

### **Ease of Detection by Radar Detectors**

This test determined the maximum distance at which a commercially available radar detector could detect the presence of the photo-radar equipment being tested. The radar detector used was a Cobra Trapshooter, Model RD2100, manufactured by Dynascan Corporation, Chicago, Illinois. After the equipment was installed at the test site, a test vehicle with the radar detector installed was driven slowly toward the equipment until the microwave radiation from the equipment being tested was detectable. The location was marked, and the distance from the equipment was measured. Each test run was repeated at least five times, and the maximum detectable range for each manufacturer's photo-radar recorded.

There are two possible effects a radar detector could have on the effectiveness of photo-radar use. First, by knowing where photo-radar devices are located, drivers may avoid citation by slowing down at the photo-radar site and then speeding up once they have passed the site. Thus, radar detectors could reduce the effectiveness of photo-radar in reducing speeds on other sections of the roadway. On the other hand, radar detection of photo-radar equipment would, in itself, reduce speeds at the site, one of the objectives of its use.

## **Effect of Photo-Radar on Speed Characteristics**

Speed data were collected at each site at least 1 month before the field demonstration and again during the demonstration. No citations or warnings were given during the test period, but the minimal media attention given as a result of the Tuesday press conferences may have alerted drivers to the presence of the equipment for testing. This publicity took the form of newspaper articles and television and radio interviews in which the principle of photo-radar was described and the reasons for conducting the demonstration were explained. It was, however, made quite clear to the public that no citations would be given based on speeds observed and recorded during the demonstration. As an additional confounding factor, police consistently worked radar during the demonstration at Site 6 in Maryland. Since this was their standard procedure, it was decided that they should continue so the units could be evaluated under real-world conditions. However, the use of standard radar during the testing may have affected the speed characteristics at that site.

The researchers are of the opinion that the true impact of photo-radar on speed characteristics could not be ascertained from these results. When citations and warning letters are given, it is likely that the impact of photo-radar on speed characteristics, such as the mean and 85th percentile speeds, will be different from that reported in this study.

## **Public Acceptance**

In order to assess the potential level of acceptance for photo-radar use on the Beltway, a telephone survey was conducted. Core questions for this household-based survey were drawn from those developed by the Insurance Institute for Highway Safety for its surveys in Pasadena, California, and Paradise Valley, Arizona (Freedman, M., Williams, A. F., and Lund, A. K., 1990, "Public Opinion Regarding Photo-Radar," *Transportation Research Record 1270*, Transportation Research Board, Washington, D.C.). Obviously, only those questions that apply to potential use of the equipment, rather than actual use, were included in the questionnaire (see Appendix B).

The survey population consisted of all households with a valid telephone number in the Washington metropolitan area. Random-digit dialing techniques were used, and all interviews were computer assisted. The sample was stratified by sex and location such that (1) 55 percent of the respondents were male and 45 percent female, and (2) 45 percent of the sample was drawn from Northern Virginia, 45 percent from Southern Maryland, and 10 percent from Washington, D.C. This was done to avoid the standard sex bias that often occurs in telephone surveys (since females answer the telephone more often than males) and reflect the characteristics of drivers on the Beltway. A simple random sample was drawn from the various strata.

Telephone interviews were conducted between 5 p.m. and 9 p.m., Monday through Friday; between noon and 5 p.m. or between 5 p.m. and 9 p.m. on Saturdays; and between 1 p.m. and 4 p.m. or between 4 p.m. and 8 p.m. on Sundays. All interviewing was conducted between November 15 and December 4, 1990.

Initially, the researchers were concerned that sampling only households with a telephone might create bias. With regard to possible bias due to the lack of a telephone in poorer households, several studies have noted that sampling bias resulting from the use of telephone techniques results in very small levels of error (Freeman, H. E., Keecolt, K. J., Nicholls, W. L., and Shanks, J. L., 1982, "Telephone Sampling Bias in Surveying Disability," *Public Opinion Quarterly*, (4)3; Kuiz, F. J., 1982, "Random Digit Dialing and Sampling Bias," *Public Opinion Quarterly*, (42)4). From a combination of National Opinion Research Center surveys involving more than 7,500 respondents, tests showed that less than 2 percent of the responses on any given item asked on telephone surveys excluding households without telephones would differ from equivalent responses from a sample of the total population (Wolfe, L. M., 1979, "Characteristics of Persons With and Without Home Telephones," *Journal of Marketing Research*, (16)3). This study is somewhat dated, but there is no reason to believe that the number of households without telephones has significantly increased in the interim. Since there is no reason to believe that more households without telephones exist in the Washington metropolitan area (including Northern Virginia and Southern Maryland) than elsewhere, the researchers anticipated that the sampling bias resulting from the use of telephone interviewing would be small.

## RESULTS

The first step in this evaluation was to prepare descriptions of the various pieces of photo-radar equipment. All of the equipment, regardless of manufacturer, shares certain characteristics. For instance, all use some form of speed detection capability to identify vehicles that are traveling over a threshold speed. Electronic controls in combination with various aspects of the radar beam or cable placement then trigger the camera to take a picture of the vehicle. However, the equipment differs dramatically with regard to the characteristics and capabilities of the components used and the type of speed detection equipment and speed algorithm used. The equipment also differs in terms of the options available and the peripheral imaging/computer equipment used.

In an attempt to summarize the similarities and differences among the six manufacturers' photo-radar devices, the tables in Appendix C were prepared. These tables were assembled based on documentation by and interviews with the manufacturers themselves and their agents in the United States.

### Site Visits

This section summarizes the findings of the site visits to Arizona, California, The Netherlands, Switzerland, Germany, and Sweden. These summaries cover only the major findings. Full site visit reports are available from the authors.

## **Paradise Valley, Arizona**

Paradise Valley, a town of 14,000, receives about 1.5 million visitors annually because of its pleasant climate. The town is also on the route used by commuters to travel between Scottsdale and Phoenix. As a result of the high percentage of speeding commuter traffic, photo-radar is popular among the townspeople. Moreover, photo-radar use has resulted in 19 times more citations than mobile patrols would have produced because of the small police force and favorable town ordinances facilitating prosecution.

Traffic Monitoring Technologies (TMT) equipment is used in Paradise Valley. (TMT is the only manufacturer of photo-radar equipment in the United States.) Police set up the unit; record information regarding the time, weather conditions, and speed limit at the location chosen; and conduct a calibration. They also record the threshold speed—the speed at or above which vehicles will be photographed. (In general, officers in both Pasadena, California, and Paradise Valley initially set units at 16 mph over the speed limit on local corridors. Over time, as vehicles slowed on these corridors, thresholds were set lower, at 11 mph over the posted limit. In Paradise Valley school zones, the threshold is set at 3 mph over the limit, and in residential areas, it is set at 8 mph over.) Even though warning signs noting that photo-radar is in operation are posted, individuals still violate the speed laws. A digital display operates just beyond the photo-radar device and informs violators of their speed. A TMT representative removes the film and has it processed in Houston, and TMT returns the photographs to Paradise Valley within 2 days. Nearly 75 percent of the photographs are usable. A town employee searches DMV records to obtain information on the vehicle owner, who is then issued a citation by TMT. Citations are mailed within 2 weeks of the offense. About 60 percent of those cited do not request to see the photograph. If the offender challenges the citation, a photograph is developed for trial. At that time, only officers of the court and the driver receiving the citation may view it. If the driver photographed is not the owner, the owner is asked under oath to identify the driver. If the owner cannot or will not cooperate, the court may hold the owner in contempt of court, but this option has not been pursued. If the owner does identify a driver, a citation is issued within 30 days of the offense to satisfy due process requirements.

In Paradise Valley, a summons may be issued immediately to those who fail to pay or appear. If the summons is ignored, the owner's license is suspended indefinitely. The figure for ignored photo-radar summons, 10 percent, is about the same as for regular speed-related summons.

Under its contract with TMT, Paradise Valley pays no monthly minimum and is obligated to pay \$20 per citation only if the citation proceeds to final disposition. Finally, the total fines assessed in Paradise Valley exceed program costs since Paradise Valley has a fine schedule that exceeds \$20 and does not share its fine monies with the state.

Photo-radar has proved advantageous to Paradise Valley in other ways as well. It has freed more police time for DUI enforcement. Further, speeds on most roads have markedly decreased. Beyond the financial and safety advantages of photo-radar,

community, judicial, and media support of the enforcement technique has contributed to its success. Both police officers and court officials stress that properly orchestrating the establishment of the photo-radar program is crucial to its success and integrating the public into the process before the program begins is essential.

Town Attorney Charles Ollinger is satisfied that the use of photo-radar can withstand legal challenges and noted that it has already survived a constitutional challenge and several state law challenges.

### **Pasadena, California**

Pasadena, a city of 130,000, began testing the use of photo-radar in 1987 in response to heavy commuter traffic in its residential neighborhoods. In a 30-day trial, approximately 22,000 vehicles were monitored, with 15.2 percent of them speeding. Of the speeders, almost 75 percent were nonresidents. Speed data collected during the 30-day trial period indicated a noticeable reduction in speed. Further, the favorable response on questionnaires completed by the violators indicated a positive public perception.

After the testing, Pasadena and TMT negotiated a photo-radar contract, and full-scale operations began in 1988. In Pasadena, photo-radar was used on highways with no more than three lanes since the police reported that photographs of far-lane vehicles were unusable in most cases. Their experience indicated that only one type of radar detector was effective against the photo-radar device since the radar beam is aimed across the road rather than down the road.

In Pasadena, about 45 percent of ticketed drivers pay the fine without going to court. Nearly 32 percent automatically opt for traffic school, and about 16 percent ignore the ticket. Approximately 7 percent of the cases are dismissed. Based on their contract, the city paid TMT \$20 (or as much of the fine as was collected) for each fine paid. In exchange, TMT provided the equipment, a vehicle, an on-site technician to oversee the operation, and training for officers and judges. In addition, TMT processed and examined all pictures, oversaw the search of DMV files, prepared all citations, and provided pictures for court.

The city collected about \$39,500 during the first 7 months of operation. Unlike Paradise Valley, Pasadena was required to pay TMT \$10,000 monthly (minimum) for the 4th through 7th months (\$40,000). Pasadena's monthly payments for the next 2 years were held in trust, and if an Arizona city other than Paradise Valley (the other major TMT photo-radar site) adopted TMT's product, the full \$240,000 would be refunded. In an effort to make the program break even, the city has increased hours of enforcement.

Enforcement officials and judges identify the handling of the cases of those who ignore photo-radar citations as the greatest threat to the program. Warrants cannot be immediately issued for those drivers ignoring the citations because a signature is required before a summons can be issued. Since enforcement for an ignored citation requires that the driver's license photograph be pulled, an expensive process,

those who ignore citations suffer no consequences. The police fear that widespread knowledge of this lack of consequences could undermine the effectiveness of the program.

Commissioner Warren Haas, a sitting municipal court judge, believes that almost all legal issues regarding the use of photo-radar have been litigated, with Pasadena prevailing. Commissioner Haas noted that acceptance of the program is low among the police, who feel as though they are granting enforcement discretion to a profit-motivated private company. Although personnel at the Department of Finance saw the best potential to produce revenues in adopting a policy of 100 percent enforcement, Commissioner Haas saw the need for improvement in the initial screening of photographs to ensure that every prosecution is successful.

City Attorney Courtland Crabtree reported that recent staff expansion was required because prosecutions increase 25 percent annually. Although Crabtree noted no accident reduction, he reported that crashes inside the city are not often categorized as being speed related. He saw a major public relations advantage in using photo-radar since units can be sent to areas where residents report problems.

Personnel in the Department of Finance noted that financial incentives in the TMT contract work to the benefit of the city in regard to TMT service and maintenance. They pointed out, however, that the minimum monthly payment to TMT could be seen as a quota, which would be publicly unpopular. They identified increased public interest in the traffic school option as the primary reason for the city's failure to break even since traffic school participants pay lower fines.

## Europe

Site visits were made to four European photo-radar manufacturers: Gatsometer, Multanova, Traffipax, and Trafikanalys. (AWA Defence Industries, the Australian manufacturer participating in this evaluation, was not included in the site visits since a trip to Australia was considered impractical.)

### *Gatsometer*

Gatsometer, in The Netherlands, began producing speed measurement equipment in 1959 and began photo-speed and photo-red light production in 1966. Unlike some other photo-radar devices, the Gatsometer equipment uses a slotted wave guide antenna, developed by the company's engineers, rather than the standard parabolic antenna. The equipment can distinguish between speeding cars and trucks. Although the equipment can be used in the mobile mode for receding traffic, the manufacturer does not recommend that its photo-radar equipment be used in the mobile mode to detect speeding vehicles in oncoming traffic. Further, Thomas G. Gatsonides, Co-Director of Gatsometer, indicated that the device performs better in two-lane monitoring than in four-lane monitoring. The company recommends a complete overhaul of the equipment every 3 years, which, like critical repairs, may require return of the equipment to the factory.

All state police and half of the municipal police in The Netherlands use photo-radar and have noted speed reductions, for which photo-radar is credited.

Seeking speed reductions on particularly hazardous stretches of roadway, the police have experimented with different configurations of photo-radar devices and with placebo devices (cabinets without photo-radar devices designed to give the public the impression that photo-radar is present and operating). They found that differences in configurations and placebo placement affect speed deterrence. Road safety research supports the official position that photo-radar has had a demonstrable impact on highway safety. Decreases of up to 20 percent in mean speed and up to 60 percent in the percentage of speeding drivers have been documented.

### *Multanova*

Multanova, in Switzerland, first produced radar devices in 1956. After being bought by a larger company, Multanova was able to undertake more research and development work. Like the other brands of photo-radar equipment examined, the Multanova equipment differs from the Gatsometer device in that a parabolic antenna is used. According to Multanova representatives, the use of their equipment in the mobile mode is more limited than with Gatsometer's device because quick accelerations inside the radar beam and a 3 percent road curvature generate unreliable speed readings and photographs. However, unlike Gatsometer equipment, Multanova equipment is recommended for use in the mobile mode for oncoming traffic. Still, it is possible that these conditions similarly affect the devices of all the manufacturers. According to company representatives, the Multanova device performs better in two-lane monitoring than in four-lane monitoring.

Because the Multanova devices in Switzerland have been subject to vandalism, their design includes considerable engineering to make the equipment vandal proof. The device also features turntables, allowing for quick directional change. Additionally, Multanova offers video enhancement equipment that permits greater clarity and content control in the photographs.

As in The Netherlands, the police in Switzerland have noted improved highway safety as a result of photo-radar use, with accident reductions reaching 50 percent. For the most hazardous stretches of roadway, accident rates and violations have decreased.

### *Traffipax*

Traffipax, a subsidiary of an established German camera manufacturer, produced its first photo-radar device in 1970. Gatsometer and Traffipax are under agreement to purchase each other's products. Thus, the Traffipax device uses the same radar equipment as the Gatsometer device, and the Gatsometer device uses the same camera as the Traffipax device.

The Traffipax equipment differs from the Gatsometer device in that it can detect speeding vehicles in oncoming traffic in the mobile mode. It also differs from the devices of other manufacturers in that identifying information cannot obscure the photograph because the information appears in the film margin rather than on the photograph itself. Like some other devices, the Traffipax device can distinguish between cars and trucks on stretches of roadway where car and truck speed limits differ.

Traffipax shares some of the advantages and disadvantages of other photo-radar equipment. The Traffipax personnel indicated that photo invalidation for erroneous readings does not always operate automatically in any photo-radar device and that manual invalidation is sometimes required. Traffipax personnel also reported that the parking angle of a photo-radar vehicle may affect the device's accuracy.

### *Trafikanalys*

Trafikanalys, in Sweden, is a relatively new company that views its use of statistics and sampling theory in the development of its device as its primary distinction. The Trafikanalys device features a film viewer from which a hard copy of photographs can be obtained. Further, data are entered in the computer directly, rather than being stored on memory cards, as with other European equipment. Although the standard Trafikanalys device is comparatively bulky, it has the unique advantage of multicar detection. Its radar algorithm works much like air traffic control radar in that it can identify a vehicle even after the vehicle has been obscured by another vehicle in the radar beam. Further, the device can be used in very cold or stormy weather.

Because photo-radar has only recently been introduced in Sweden, the police are still adjusting to its use. The bulk and lack of mobility of the Trafikanalys device appear responsible in part for the less than enthusiastic response of the Swedish police. However, the Swedish police also dislike the fact that the choice of speeding incidents to enforce is not controlled by the officer. To remedy the physical shortcomings, Trafikanalys is developing a smaller, mobile device, the prototype of which is virtually complete. During the demonstrations held in Virginia and Maryland, Trafikanalys used a much-improved version of their equipment, though not the prototype.

## **Field Demonstrations**

### **Photographic Results for Each Manufacturer**

After site visit data had been analyzed, field demonstrations to test the equipment were held. Five pieces of photo-radar equipment were evaluated: AWA, Gattometer, TMT, Traffipax, and Trafikanalys participated in the demonstration. Multanova did not.

Manufacturers were encouraged to produce as many pictures as they wished under as many conditions as they wished (see Table 3). They were also given the option of producing prints or negatives. Manufacturers were further encouraged to develop their film at a local laboratory instead of sending it to their headquarters, where special developing techniques not available locally could be used to improve picture quality. In only one case was film returned to the headquarters. Local developing of TMT's TMAX film was deemed inadequate, and since no other commercial laboratory could develop such an unusual film type, TMAX film was developed at TMT. The resulting negatives were similar in quality to those developed locally.

Table 3

**NUMBER OF PHOTOGRAPHS TAKEN FOR ANALYSIS  
BY EACH MANUFACTURER**

Equipment	Number of Negatives	Number of Prints	Number of Photographs
AWA	219	948	1,167
Gatsometer	1,467	661	2,128
TMT	764	0	764*
Traffipax	0	1,910	1,910
Trafikanalys	1,667	0	1,667

\*Total is significantly lower due to the short test period requested by the manufacturer.

### AWA

The test period for AWA ran from June 11 through June 22, 1990. Warren Baker was the representative sent to demonstrate the equipment—a stationary model, VSR Model 449. This unit was not equipped for mobile surveillance, and at the discretion of the manufacturer, night demonstrations were not conducted.

The beginning of the AWA test period was hindered by several problems that were eventually corrected. The VSR Model 449 requires an alignment of a 25-degree angle to the roadway. The manufacturer's representative was unaware of how critical this angle was. After the first set of processed photographs were received, it was discovered that the radar unit was not properly aligned. As soon as the problem was identified, the researchers developed a protocol for proper alignment. In addition, the AWA timer/clock did not function correctly. Baker examined the equipment and had parts sent from New York. The unit was repaired and was working properly before the conclusion of the first week of tests.

Further, Baker had been given the wrong cables for the hookup of the laptop computer. Unfortunately, even after purchasing the proper adapters, neither Baker nor any member of the study team could get the AWA analysis software to interface with either the AWA or VTRC computer.

The manufacturer had a slight problem in preparing the 100-frame bulk-film cassettes that were used. Loading the cassette was a problem due to the inability (or unwillingness) of local camera shops to load the film. As a result, Baker loaded the film in the bathroom of his hotel room, and some of the film was exposed during loading. Also, Baker had difficulty finding 100-frame color film with an ASA rating high enough to be used with the equipment.

A total of 1,167 photographs were taken during the 2-week period. The majority of the film used consisted of 36-exposure color or black and white film with a speed of 200 ASA or 400 ASA, sold by Kodak, Fuji, or K-Mart. All film was processed and printed at a local camera shop near VTRC. Several large rolls of black and white Tri-X pan 400 ASA film, loaded in 100-frame canisters, were also used during testing

in Northern Virginia. These were processed in a camera shop near the test sites in Northern Virginia and were left as negatives for evaluation.

#### *Gatsometer*

The test period for Gatsometer ran from September 4 to September 13. Tom Gatsonides, director of the company, and several of his staff members accompanied the equipment. On the first day of testing, the VDOT traffic technician assigned to read the loops for the study team did not report for work. About half way through the day's testing, the loop readings began to diverge from the Gatsometer readings and the speedometer readings in the test vehicles. The technician recalibrated the loops later. Also on the first day, the primary engineer for Gatsometer forgot to flip the switch that allows the aperture of the camera to adjust for light conditions. After the first set of film was processed, this adjustment was made.

The American agents for Gatsometer were originally under the impression that the researchers were interested only in receding traffic (i.e., only reading license plates, rather than identifying drivers). For this reason, the van they provided was rigged to take pictures from the rear only. The tripod-mounted version, however, operated with approaching traffic, and this was provided for all testing.

A total of 2,128 photographs were taken during the 2-week test period. All photographs were taken with Kodak color negative 400 ASA film. Approximately 20 rolls of 36-exposure color film were processed into prints locally. The 2 rolls of bulk black and white film were processed at a commercial laboratory near the agent's offices in Delaware.

#### *TMT*

The test period for TMT ran from July 11 through July 19, 1990. At the request of the manufacturer, TMT was tested for only 7.5 of the 10 possible days of testing. Manuel Fuestes, President of TMT, was the representative who demonstrated the PhotoCop photo-radar unit. The device was mounted in a vehicle, facing the rear of the vehicle, to photograph oncoming traffic. The unit was not set up to run in the mobile mode and operated entirely in a stationary mode during the demonstration.

The PhotoCop unit requires an alignment of 22.5 degrees to the roadway, and the unit is equipped with a device to ensure proper alignment. Throughout the test runs, the motor in the vehicle in which the equipment was mounted had to be running because the PhotoCop unit did not have battery backup. In addition, the Losier Speed Display, a large display panel notifying the drivers passing the site of their speed, was not in operation during the demonstrations. The only other initial problem involved the TMT analysis software, which had to be amended to operate under the MS-DOS format used by VTRC.

The tests were carried out with relatively few problems. One incident, however, did affect the total number of photographs that were evaluated. On July 17, at the I-95 northbound site in Northern Virginia, Fuestes neglected to load the film into the cassette. Therefore, there were no photographs available for evaluation that day.

A total of 764 black and white photographs were taken during the 7.5 days of testing. The films used by TMT consisted of four rolls of TMAX film (3200 ASA) and five rolls of XP-1 film (400 ASA). Because TMAX film is an unusual type, it was difficult to find a local photography laboratory to develop it. One roll of the TMAX film was processed by the Army Foreign Science and Technology Center in Charlottesville, Virginia, and since the resulting negatives were too dark, the remaining TMAX film was processed by TMT in their laboratory (negatives were still very dark; according to Fuestes, this was due to a developing error). The rolls of XP-1 film were sent to the Central Office of VDOT for processing. All of the TMAX and XP-1 photographs were left in negative form.

*Traffipax*

The representatives from Traffipax arrived on July 30, 1990, to begin their 2-week test period that ended on August 9, 1990. The Traffipax equipment demonstrated was not the most current model. Instead of demonstrating the Speedophot unit, which had been observed in Europe and which can operate in the mobile mode, the older Micro Speed 09, Type 5, with an older antenna assembly was used. The company's agent, Bernd Rindt, was on site for approximately 1 day during the 2 weeks of testing. Various personnel from Electronic Data Systems Corporation (EDS) set up and ran the equipment the rest of the time (EDS is the service company for Traffipax in the United States in charge of processing film and producing citations). EDS personnel were not familiar with setting up and operating the equipment.

There were a number of problems that impeded the evaluation of the effectiveness of the Traffipax unit. Unfortunately, it was not possible to assess the unit's ability to take identifiable photographs of the driver because the unit was positioned in the vehicle in a manner that allowed photographs of only the vehicle's rear. In addition, mobile operation was not demonstrated.

On the first day of testing, the clock on the photo-radar unit was not set properly. The clock was set at zero, thus no times were available for that day, but this problem was corrected for the remainder of the test period. This problem did not affect the tests or the acquisition of data. On July 7, the motor had to be kept running in order to operate the equipment since the backup batteries had not been recharged.

Photographic quality was a problem that lingered throughout the entire demonstration period. Initially, all pictures taken by EDS personnel were overexposed. A new Robot camera was sent from New York to be used for the second week of the test period, but there was a problem with light leaking into the camera. This resulted in partial or full exposure of a significant amount of film. A member of the study team spoke to the agent, explained that there was a problem, and asked if he wished to repeat some of the testing. The agent declined, citing lack of personnel as the reason.

There were other complications throughout the course of the testing in Northern Virginia and Maryland. On the night of August 5, a heavy rain flooded the inside lane of I-95 North in Virginia. Thus, on August 6, only three lanes were scanned for testing. Blocking the inside lane slowed the traffic to lower than normal speeds, which may have affected the performance of the equipment.

Originally, the Traffipax crew stated that they could not demonstrate night photography because, after 5 years of use, their flash unit was broken and could not be repaired in time to be included in the demonstrations. However, on August 8, a flash unit was delivered from New York. The study team proceeded with the tests that night. The threshold speeds for the night demonstration were set at 56 mph for trucks and 61 mph for cars since accuracy tests were not being conducted because of safety risks. As a result of the high volume of traffic, the fuses for the flash unit were blown several times. In order to give the unit enough recovery time, the speeds at which the unit was operating were set higher.

A total of 1,910 photographs were taken during the 2-week test period. All photographs were taken using 36-exposure Kodak color negative 200 ASA or 400 ASA film. Also, since all photographs were shot in the receding mode, no pictures of drivers of oncoming vehicles were available for analysis. All film was developed and printed locally.

### *Trafikanalys*

The demonstration period for Trafikanalys began August 20 and was completed on August 31, 1990. The equipment demonstrated was not the version demonstrated in Europe. At the time of the European site visits, the only model available was the Astro 110. The Trafikanalys engineers felt that the Astro 220, the next generation, would not be available, even as a prototype, until December 1990. Thus, the RC 110, an earlier unit, was demonstrated, but with significant modifications. This unit was vehicle mounted and capable of operating in the mobile mode, characteristics that previous Trafikanalys equipment did not have. Also, this unit used a Robot camera rather than the Hasselblad used in Sweden. It was operated by manually setting the aperture, although it is possible to set the equipment in the automatic mode. The unit also operated with an 800-frame cassette, a feature also not available when the study team was in Sweden.

There was a slight software problem during the first week when the unit was being used for mobile surveillance. However, new software sent from Sweden arrived in time for the Northern Virginia demonstration. In addition, the clock on the equipment, although accurate to the minute and second, could not be reset to Eastern Standard Time, thus creating a 6-hour difference in times recorded.

During the demonstration period, there was a disproportionate number of rainy days, and since the level of light seems to play a significant role in enhancing or obscuring the driver's face in the photograph for certain equipment, Trafikanalys equipment may have operated under different conditions than the other equipment.

A total of 1,667 photographs were taken during the 2-week test period. Two types of black and white film were used: Kodak Tri-X pan (400 ASA) and Ilford HP5 (400 ASA). Three rolls were processed locally, and the remaining bulk film was processed by Trafikanalys personnel in their hotel rooms, since that was their preference. All the film was left in negative form.

## Comparisons Among Manufacturers on Photographic Quality

Tables 4 through 12 summarize the conditions under which photo-radar photographs were taken. In an attempt to rate each manufacturer with regard to photographic quality itself, the results for oncoming traffic and for receding traffic were analyzed separately. This was done because not all equipment operated in both the oncoming and receding modes and because the quality criteria would be different for each direction. For instance, for oncoming traffic, possible legal criteria could include identification of the driver, an objective that would be impossible when photographing receding traffic. Traffipax did not photograph vehicles in the oncoming direction. TMT and Trafikanalys did not photograph vehicles in the receding mode.

The comparative results for the various manufacturers that took photographs of receding vehicles are shown in Table 13. The three possible legal requirements that could be applied to manufacturers photographing receding traffic are (1) that the license plate number and state of issue be readable, (2) that the travel speed of the speeding vehicle be clearly indicated, and (3) that the speeding vehicle in multi-vehicle photographs be identifiable.

The comparative results for the various manufacturers that took photographs of oncoming vehicles are shown in Table 14. There are several performance criteria that the courts could apply to pictures of oncoming traffic: (1) that the license plate and state of issue be readable, (2) that the driver's face be identifiable, (3) that the

Table 4

### LOCATIONS OF PHOTOGRAPHS TAKEN (%)

Manufacturer	I-64 VA	I-81 VA	I-295 VA	I-95 VA	I-95 MD	I-495 VA
AWA n = 1,167	9.1	15.7	11.1	37.0	9.4	17.7
GATSOMETER n = 2,128	20.7	5.8	4.5	24.9	17.3	26.8
TMT n = 764	12.3	14.1	10.5	11.8	28.1	23.2
TRAFFIPAX n = 1,910	15.2	17.0	17.4	20.9	11.9	17.5
TRAFIKANALYS n = 1,667	15.4	18.1	3.0	22.0	13.9	27.7

Table 5

## WEATHER CONDITIONS UNDER WHICH PHOTOGRAPHS WERE TAKEN (%)

Manufacturer	Bright Sun	Hazy Sun	Overcast	Dark Sky	Nighttime	Rain
AWA n = 1,167	74.1	14.7	11.1	—	—	—
GATSOMETER n = 2,128	45.2	16.9	11.6	—	12.8	13.5
TMT n = 764	65.1	—	18.8	—	9.0	7.1
TRAFFIPAX n = 1,910	53.1	22.8	7.2	—	3.0	13.8
TRAFIKANALYS n = 1,667	48.9	18.6	17.5	6.0	6.1	3.0

Table 6

## VEHICLE LOCATION IN PHOTOGRAPHIC FRAME (%)

Manufacturer	No Vehicle	Out of Range Left	Left	Center	Right	Out of Range Right
AWA n = 1,167	0.9	18.4	22.5	30.1	14.6	13.6
GATSOMETER n = 2,128	0.4	9.2	13.7	54.7	16.5	5.5
TMT n = 764	1.8	20.5	41.9	31.9	1.7	2.1
TRAFFIPAX n = 1,910	3.7	8.0	58.0	26.5	1.2	2.7
TRAFIKANALYS n = 1,667	4.1	39.4	26.3	18.6	7.0	4.6

Table 7

## DIRECTION OF OPERATION OF PHOTOGRAPHS TAKEN (%)

Manufacturer	Oncoming	Receding
AWA n = 1,167	74.1	25.9
GATSOMETER n = 2,128	17.2	82.8
TMT n = 764	100.0	—
TRAFFIPAX n = 1,910	—	100.0
TRAFIKANALYS n = 1,667	100.0	—

Table 8

## MODE OF OPERATION WHEN PHOTOGRAPHS WERE TAKEN (%)

Manufacturer	Stationary	Mobile
AWA n = 1,167	100.0	—
GATSOMETER n = 2,128	98.4	1.6
TMT n = 764	100.0	—
TRAFFIPAX n = 1,910	100.0	—
TRAFIKANALYS n = 1,667	88.3	11.7

Table 9  
 FORMAT OF PHOTOGRAPHS TAKEN (%)

Manufacturer	Prints	Negatives
AWA n = 1,167	81.2	18.8
GATSOMETER n = 2,128	31.1	68.9
TMT n = 764	—	100.0
TRAFFIPAX n = 1,910	100.0	—
TRAFIKANALYS n = 1,667	—	100.0

Table 10  
 NUMBER OF VEHICLES IN PHOTOGRAPH (%)

Manufacturer	One	Two	Three	Four or More
AWA n = 1,167	54.0	31.4	11.7	2.9
GATSOMETER n = 2,128	41.9	26.9	17.2	14.0
TMT n = 764	64.5	25.8	8.8	0.9
TRAFFIPAX n = 1,910	47.6	28.0	15.1	9.3
TRAFIKANALYS n = 1,667	71.9	22.6	4.6	0.9

Table 11  
TYPE OF VEHICLE IN PHOTOGRAPH (%)

Manufacturer	Passenger Car	Van/Small Truck	Large Truck or Bus	Other
AWA n = 1,694	61.5	31.4	7.1	—
GATSOMETER n = 3,354	59.6	27.2	13.0	0.2
TMT n = 1,022	62.6	31.2	5.8	0.4
TRAFFIPAX n = 2,842	57.9	31.8	9.9	0.4
TRAFIKANALYS n = 2,067	54.8	32.4	12.7	0.1

Table 12  
LANE IN WHICH PHOTOGRAPHED VEHICLES WERE TRAVELING (%)

Manufacturer	Shoulder Lane One	Two	Three	Median Lane Four
AWA n = 1,694	21.7	26.5	26.3	25.4
GATSOMETER n = 3,354	18.8	32.6	30.0	18.6
TMT n = 1,022	18.0	31.9	30.5	19.6
TRAFFIPAX n = 2,842	24.0	33.7	23.4	19.0
TRAFIKANALYS n = 2,067	24.9	37.7	24.4	13.0

Table 13

## PHOTOGRAPHIC PERFORMANCE MEASURES: RECEDING TRAFFIC

Manufacturer	% License Plates Read	% Plates Read and Speeding Vehicle Identified
AWA n = 432	39.6	24.1
GATSOMETER n = 2,935	8.5	7.4
TMT n = 0	—	—
TRAFFIPAX n = 2,842	58.6	51.9
TRAFIKANALYS n = 0	—	—

Table 14

## PHOTOGRAPHIC PERFORMANCE MEASURES: ONCOMING TRAFFIC

Manufacturer	% License Plates Readable	% Drivers Identifiable	% Drivers and Plates Identifiable	% Plates, Drivers, and Speeding Vehicles Identifiable
AWA n = 1,262	35.7	11.5	8.6	4.2
GATSOMETER n = 419	55.6	25.5	9.1	8.4
TMT n = 1,022	20.8	16.6	13.1	7.5
TRAFFIPAX n = 0	—	—	—	—
TRAFIKANALYS n = 2,067	46.5	26.4	23.1	13.3

travel speed of the speeding vehicle be clearly indicated, and (4) that the speeding vehicle be identifiable.

In addition to the differences among manufacturers on the quality of the photographs, the reasons the photographs could not be used also differed. Table 15 lists the results with regard to readable license plates. Table 16 lists the results with regard to the reason the driver's face was not identifiable.

The types of conditions under which each manufacturer performed best are given in Appendix D. In these tables, the percentage of total photographs taken under each condition is compared to the percentage of pictures meeting the most stringent requirements. In the case of receding traffic, this means that the license plate and the speeding vehicle were identifiable. In the case of oncoming traffic, it means that the license plate, the driver's face, and the speeding vehicle were identifiable. A score of more than 1.00 indicated that "usable" pictures were overrepresented in the condition and, thus, that the manufacturer performed unusually well in the condition. Of all participants in the demonstrations, Trafikanalys equipment was the only piece of equipment to perform best in high-volume conditions.

In an attempt to determine the effect of each of the environmental and highway variables, a regression model was constructed for oncoming and receding traffic. For photography of receding traffic, the dependent variable used was whether the license plate number and state of the first vehicle in the photograph could be read. For oncoming traffic, the dependent variable used was whether the license plate number and state of the first vehicle in the photograph could be read and the driver's face identified. The results of these analyses appear in Tables 17 and 18. In each analysis, each categorical variable (such as weather) was converted into a number of dichotomous variables, each representing one condition. In order to avoid colinearity problems inherent in including all categories, the dichotomous variable in each category with the lowest relationship to the dependent variable was omitted from the actual analysis and, thus, was used as a standard.

There were insufficient numbers of cases to include several of the environmental and highway factors. For the analysis of receding traffic, the weather conditions of "dark sky" and "nighttime" did not occur often enough for each manufacturer to be included. For oncoming traffic, the Interstate 64 and Interstate 81 locations were not photographed enough and the weather conditions of "dark sky," "rain," "overcast," and "nighttime" were not included.

For receding traffic, the best conditions for reading the rear license plate occurred on Interstate 295; the worst occurred on Interstate 495. Passenger vehicles and small trucks photographed better than large trucks, and photographs taken in hazy sunshine were better in terms of reading the license plate than those taken in bright sun. Vehicles in nearby lanes photographed better than those in lanes further away; the number of vehicles in a photograph had no significant effect on readability. Finally, there was a small but positive relationship between traffic volume and photographic quality.

For oncoming traffic, the best conditions for reading the license plate and identifying the driver's face occurred on Interstate 95 in Maryland; these conditions were

Table 15  
 REASONS LICENSE PLATES IN PHOTOGRAPHS COULD NOT BE READ (%)

Manufacturer	Rain	Glare	Out of Frame	Too Far Away	View Obstructed	Reflectorization	Film Exposure	No Plate/Other
AWA n = 1,075	—	0.5	18.8	58.3	5.6	1.0	0.7	15.1
GATSOMETER n = 2,862	0.4	6.3	6.5	67.7	5.0	10.4	1.6	2.0
TMT n = 809	—	2.1	7.1	55.5	3.0	17.2	0.1	15.1
TRAFFIPAX n = 1,178	—	5.0	9.9	46.4	17.0	6.8	13.0	2.0
TRAFIKANALYS n = 1,106	1.2	0.5	27.4	37.3	6.9	6.2	1.0	19.4

Table 16  
**REASONS DRIVER'S FACE IN PHOTOGRAPHS COULD NOT BE IDENTIFIED (%)**

Manufacturer	Rain	Glare	Out of Frame	Too Far Away	View Obstructed	Film Exposure	Other
AWA n = 1,540	—	22.6	7.2	40.8	3.5	0.6	25.3
GATSONETER n = 3,246	—	9.9	19.8	53.7	9.9	5.1	5.1
TMT n = 852	0.1	14.4	6.1	75.2	3.6	0.3	0.1
TRAFFIPAX n = 2,842	—	—	—	—	—	—	—
TRAFIKANALYS n = 1,521	—	15.7	17.9	60.9	4.2	1.4	—

Table 17

**EFFECT OF HIGHWAY AND ENVIRONMENTAL CHARACTERISTICS ON PHOTOGRAPHIC QUALITY FOR RECEDING TRAFFIC\***

<b>Vehicle Type**</b>	
1. Passenger vehicles and small trucks	Best
2. Large trucks	Worst
<b>Location</b>	
1. Interstate 295	Best
2. Interstate 81	
3. Interstate 64	
4. Interstate 95 (in Virginia)	
5. Interstate 95 (in Maryland)	
6. Interstate 495 (Beltway)	Worst
<b>Weather</b>	
1. Hazy sun	Best
2. Overcast	
3. Rain	
4. Bright sun	Worst
Traffic Volume (Flow): Higher volumes produce a slight but significant increase in the number of usable pictures.	
Vehicle Lane: Vehicles in nearby lanes photograph better than those in far lanes.	
Number of Vehicles: Not significant.	

\*Usable photographs include those in which the rear license plate number and state could be read.

\*\*Variables with insufficient cases for analysis: weather conditions of "dark sky" and "night."

Table 18

**EFFECT OF HIGHWAY AND ENVIRONMENTAL CHARACTERISTICS ON PHOTOGRAPHIC QUALITY FOR ONCOMING TRAFFIC\***

<b>Vehicle Type**</b>	
1. Passenger vehicles and small trucks	Best
2. Large trucks	Worst
<b>Location</b>	
1. Interstate 95 (in Maryland)	Best
2. Interstate 495	
3. Interstate 95 (in Virginia)	
4. Interstate 295	Worst
Traffic Volume (Flow): Lower volumes produce a slight but significant increase in the number of usable pictures.	
Vehicle Lane: Vehicles in nearby lanes photograph better than those in far lanes.	
Number of Vehicles: Situations with fewer vehicles in the picture produce more usable photographs.	
Weather: Not significant.	

\*Usable photographs include those in which the front license plate number could be read and the driver's face identified.

\*\*Variables with insufficient cases for analysis: locations of Interstate 64 and Interstate 81; weather conditions of "dark sky," "rain," "overcast," and "night."

worst on Interstate 295 (Interstate 64 and 81 were omitted due to insufficient sample size). As with receding traffic, passenger vehicles and small trucks photographed better than large trucks and nearby vehicles photographed better than those further away. Pictures taken under low-volume conditions were most often readable, as were those with fewer vehicles included in the photograph. Finally, the two weather conditions with sufficient sample size to be included in the analysis, "bright sun" and "hazy sun," were not significantly related to photographic quality for oncoming traffic.

### **Accuracy of Recorded Speeds**

As previously noted, the accuracy testing and reliability testing reported here were never intended to replace or supplant the kind of product testing performed by the Law Enforcement Standards Laboratory of the National Institute of Standards and Technology. These tests were designed for the sole purpose of comparing the capabilities of the five brands of photo-radar equipment proposed for deployment on the Beltway. Because it was unknown whether or not any of the manufacturers had obtained, or even sought, the approval of the Bureau of Standards, the evaluators felt that enforcement officers and legislators in Virginia and Maryland would want assurance that the equipment met reasonable expectations for accuracy and reliability. The data reported here support a reasonable level of confidence in those aspects of the equipment's performance.

It should also be noted that several sources of error contributed to the inaccuracies cited for each piece of photo-radar equipment. First, the instrumentation error associated with the loop sensors is  $\pm 1$  mph. Also, in some cases, since inexperienced local agents representing manufacturers operated the devices during the demonstrations, some error may have been generated by their lack of familiarity with the equipment. The research team sought to detect, and where possible correct, these operational errors; however, it is possible that some went undetected and thus were beyond the researchers' control. In addition, because the units were tested under the same conditions that would prevail if they were to be used by the police, some error may have been generated purely by the operational conditions. For instance, the exact radio frequency at which each unit was operating was not checked prior to testing. It was assumed that, with the exception of AWA, the frequencies were checked as required by law prior to the units leaving the factory by generating Doppler signals electronically and comparing the signal to the photo-radar reading. Since it is unlikely that police agencies or officers will check frequencies more than once every 6 months, this test measured performance just as it would be measured under typical police use.

Additionally, it should be emphasized that these data have no bearing on the accuracy of radar devices currently in use in the United States. The equipment in these tests uses some components that are different from those used in standard U.S. police radar equipment. For instance, two of the manufacturers use a slotted wave guide antenna rather than the parabolic antenna generally used in the United States. The slotted wave guide antenna has been approved by bureaus of standards for use in a number of countries but has not been in use in the United States. Also, because

6.11

these units are designed to be used with other electronic and photographic equipment, many use algorithms for discerning adequate Doppler signals and calculating vehicle speeds that are vastly different from those used in standard police radar equipment. Thus, the results of these tests of accuracy may be applied only to the photo-radar equipment under investigation in this study and should be used only to compare units to one another. These results should *not* be used to judge whether each meets required performance specifications or belongs on a qualified products list.

In field testing the accuracy of the speed readings registered by photo-radar equipment, the first problem is to determine which standard of accuracy to apply. For instance, one standard might require that photo-radar equipment readings exactly match the true speed of a vehicle under observation 100 percent of the time. This extremely stringent standard exceeds even the laboratory standards against which police radar equipment commonly used in the United States is judged. Laboratory testing has shown that the speed readings of police radar used in the United States is accurate within +1 mph and -2 mph of the true speed of a vehicle under observation 100 percent of the time. For the purposes of this study, the researchers decided that photo-radar should be judged by the same standard as police radar.

A second problem in field testing the accuracy of photo-radar equipment concerns the error of the instrument used to measure the true speed of the vehicle. That is, in a laboratory setting, radar equipment can be tested under such a controlled environment that the true speed of an object being measured is known and the accuracy of the measurement equipment can be exactly established. In the field, the true speeds of vehicles are unknown and an instrument other than the photo-radar equipment must be used to calculate the speed of a vehicle within the limits of that instrument. The photo-radar equipment can then be compared to the other instrument's calculation of the vehicle's speed to produce a best estimate of the vehicle's true speed.

For example, the typical manner in which drivers calculate their vehicle's speed is to look at the speedometer. However, the reading on the speedometer is a "ball park" estimate of the true speed of the vehicle. Inherent in the speedometer is the error of the instrument—the deviation that a speedometer will typically have from a vehicle's true speed. So, even though the true speed of a vehicle is unknown, if the error of the instrument is known, the true speed of the vehicle will fall within a specified range of error a specified percentage of the time.

As mentioned previously, readings from calibrated Streeter-Amet loop detectors were used as the measure of a vehicle's true speed. A properly calibrated loop detector has a possible error of  $\pm 1$  mph 100 percent of the time, which means that the true speed of a vehicle is within 1 mph of that recorded by a Streeter-Amet loop detector. The error of a loop detector is greater than that of an instrument used in a laboratory setting. Thus, if the standard being applied to the photo-radar equipment is within +1 mph and -2 mph of the true speed, the error of a loop detector must also be considered.

Figure 2 graphically depicts an example of how the researchers compensated for the error of a loop detector. If the true speed of a given vehicle is 60 mph, given the error of a loop detector, the loop would give a reading between 59 mph and 61 mph 100 percent of the time. Since the loop reading is the best estimate of the true speed of a vehicle in the photo-radar beam, the loop reading is compared to that of the photo-radar equipment. Allowing the photo-radar equipment to have an error of +1 mph and -2 mph, the standard for police radar, readings between 58 mph and 61 mph by the photo-radar equipment would be within the acceptable range.

At a true speed of 60 mph, a worst case scenario would occur when the loop reading and the photo-radar reading were in error at the maximum acceptable range in opposite directions. Hence, the loop could read 61 mph (1 mph over the true speed) and the photo-radar equipment 58 mph (2 mph below the true speed) and yet each would be within the acceptable limits of error. Likewise, it is possible that a loop detector could provide a speed estimate of 59 mph (1 mph below the true speed) and the photo-radar equipment could provide a speed estimate of 61 mph (1 mph above the true speed) but both would be within acceptable error ranges for the specific piece of equipment. Therefore, since the error limit of a loop detector is known, the police radar error standard of +1 mph and -2 mph would place acceptable readings of the photo-radar equipment at no more than 3 mph below or more than 2 mph higher than the speed readings provided by a loop detector. Thus, if the photo-radar reading is between +2 mph and -3 mph of the loop detector reading 100 percent of the time, the photo-radar unit will be considered to be within the accuracy limits commensurate with police radar, that is, within +1 mph and -2 mph of the true speed.

The bias in this strategy is in favor of the photo-radar equipment. In fact, it is possible that being within +2 mph and -3 mph of a loop detector reading might actually place the photo-radar reading outside of the acceptable experimental condition standards used by police radar. For instance, if the true speed were 60 mph and the loop detector registered a reading of 59 mph and the photo-radar equipment a reading of 56 mph, the accuracy of the photo-radar equipment would not be brought into question. This is because, in the field, the true speed of the vehicle is never known, the direction of the error of the loop detector is likewise not known, and the magnitude of the error of the loop detector is known only within limits. Under this scenario, the data would show only that the photo-radar reading is 3 mph below that of the loop detector, not the deviation of the photo-radar reading from the unknown true speed of a vehicle. Hence, always providing for the worst case scenario will give the benefit of the doubt to the photo-radar equipment, i.e., the research widens the confidence interval by using a range rather than a single point.

The results of applying these standards to the accuracy data collected appear in Table 19. When the mean difference between the loop and photo-radar readings is considered, AWA is the most accurate piece of equipment and TMT the least accurate. However, when the police radar standard is applied, Traffipax has the highest level of accuracy and AWA the lowest. One additional consideration in judging the accuracy of photo-radar equipment is the direction of the error. Clearly, for application in a court, it is better for the equipment to be more likely to underestimate a

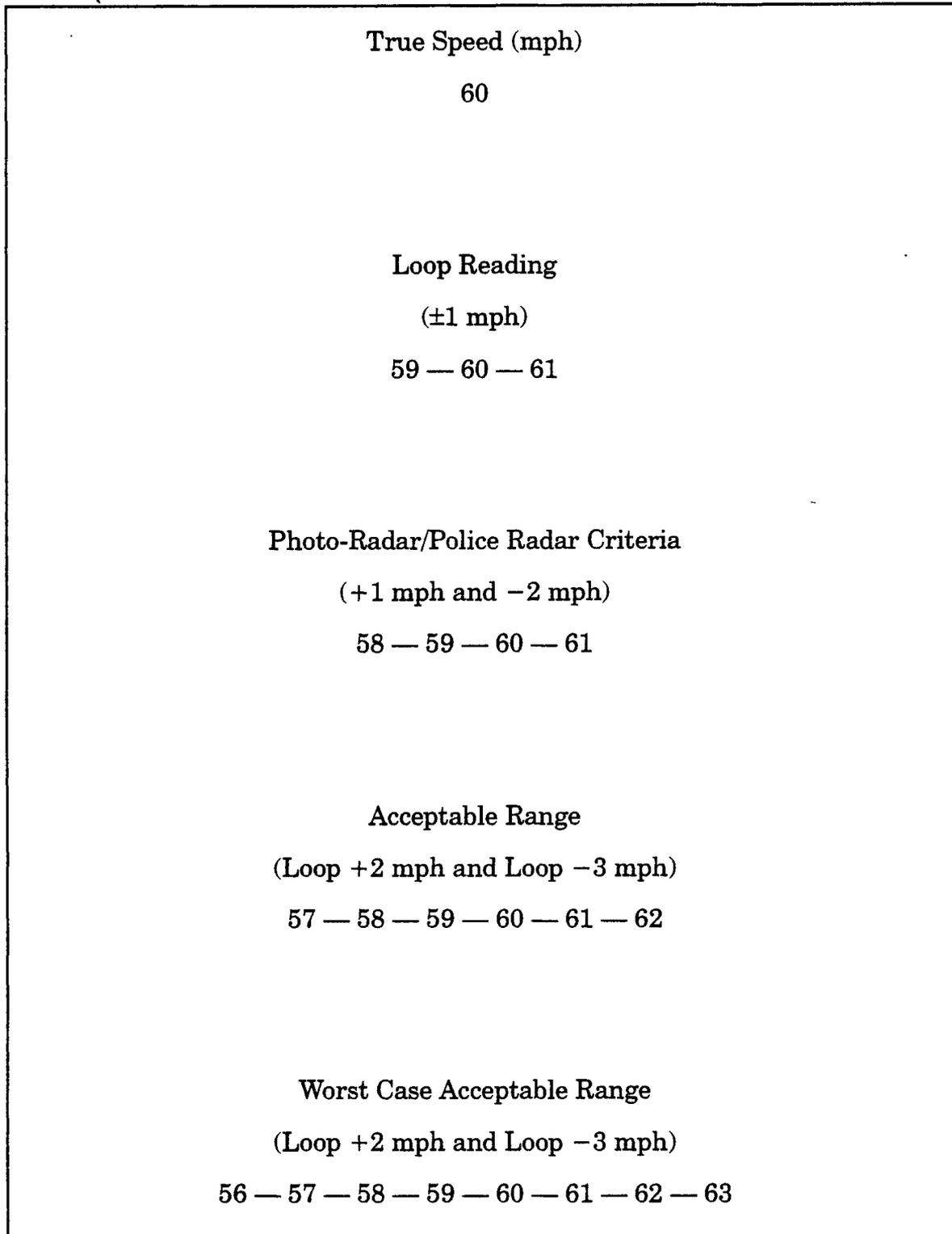


Figure 2. Allowable Differences Between Photo-Radar and Loop Readings.

Table 19

DIFFERENCES BETWEEN LOOP AND PHOTO-RADAR SPEED READINGS

	AWA	Gatsometer	TMT	Traffipax	Trafikanalys
Mean difference	0.29	0.63	-0.90	-0.37	-0.81
Percentage within +2 mph and -3 mph	83.7	93.8	87.2	96.3	86.7
Primary direction of the error	Higher	Higher	Lower	Lower	Lower

driver's speed incorrectly and, thus, come down on the side of the driver than to overestimate the speed incorrectly and, thus, be biased against the driver. Both AWA and Gatsometer tend to overestimate the driver's speed, and TMT, Traffipax, and Trafikanalys tend to underestimate the speed.

A detailed examination of the data did not indicate that the vehicle type or the lane in which the vehicle was driven influenced the accuracy of the data. However, the accuracy of the equipment was found to be dependent on the test site at which the accuracy data were collected. Overall, tests conducted on Interstate 64 produced the most accurate readings (average difference = 0.06), followed by Interstate 295 (average difference = 0.13), and Interstate 81 (average difference = -0.53). These findings are significant at the .05 level. More interesting, however, was that the accuracy of the individual pieces of equipment was different for each of the test sections ( $F = 7.60, df = 12, p < .01$ ). This would indicate that the geometric and perhaps the environmental characteristics of the various sections affected each piece of equipment differently.

**Effect of Vehicle Clustering on Accuracy of Speeds/Measurement**

As stated earlier, analysis of the data collected during this test did not reveal any consistent significant effect on the error of the speeds recorded due to the lane in which the test vehicle was being driven or the pairing of test vehicles. A detailed analysis of the data was, therefore, not undertaken.

**Percentage of Usable Photographs of Vehicles Exceeding Threshold Speed**

Tables 20 and 21 summarize the number of speeding vehicles photographed by each piece of equipment. Table 20 shows the results for oncoming traffic, and Table 21 shows those for receding traffic.

The results for oncoming traffic indicate that where identification of the license plate and identification of the speeding vehicle in multivehicle photographs are the minimum conditions that may be required by the courts, the percentage of speeding vehicles identified varied from about 1 percent to a maximum of about 44 per-

Table 20  
HIT RATE FOR ONCOMING TRAFFIC

Photographic Criterion	Traffic Flow (vph)	Average No. of Viol./Hr. Recorded by Loop Sensors	Hit Rate*	Expected No. of Usable Photographs/Hr.
<b>AWA</b>				
License plate & speed	<1000	—	—	—
	1000-3000	—	—	—
	3001-5000	452	4.60	21
License plate, speed, & driver	<1000	—	—	—
	1000-3000	—	—	—
	3001-5000	452	2.04	9
<b>GATSOMETER</b>				
License plate & speed	<1000	396	31.82	126
	1000-3000	324	35.19	114
	3001-5000	—	—	—
License plate, speed, & driver	<1000	396	1.52	6
	1000-3000	324	1.85	6
	3001-5000	—	—	—
<b>TMT</b>				
License plate & speed	<1000	—	—	—
	1000-3000	504	11.90	60
	3001-5000	697	1.12	8
License plate, speed, & driver	<1000	—	—	—
	1000-3000	504	3.97	20
	3001-5000	697	0.52	4
<b>TRAFIKANALYS</b>				
License plate & speed	<1000	492	43.90	216
	1000-3000	594	7.07	42
	3001-5000	1,641	4.05	66
License plate, speed, & driver	<1000	492	4.88	24
	1000-3000	594	1.01	6
	3001-5000	1,641	2.11	35

\*The hit rate is the number of photographs meeting the criterion divided by the number of available speeding vehicles.

Table 21

## HIT RATE FOR RECEDING TRAFFIC

Photographic Criterion	Traffic Flow (vph)	Average No. of Viol./Hr. Recorded by Loop Sensors	Hit Rate*	Expected No. of Usable Photographs/Hr.
<b>AWA</b>				
License plate & speed	<1000	—	—	—
	1000-3000	—	—	—
	3001-5000	907	0.58	5
	>5000	—	—	—
<b>GATSOMETER</b>				
License plate & speed	<1000	—	—	—
	1000-3000	745	2.15	16
	3001-5000	719	0.63	5
	>5000	1,640	0.73	12
<b>TRAFFIPAX</b>				
License plate & speed	<1000	—	—	—
	1000-3000	507	12.58	64
	3001-5000	494	10.83	54
	>5000	362	7.73	28

\*The hit rate is the number of photographs meeting the criterion divided by the number of available speeding vehicles.

cent, depending on traffic volume. For receding traffic, this percentage varied from a minimum of 0.6 percent to a maximum of about 13 percent.

The results also indicate that, in general, the higher the traffic volume, the lower the percentage of speeding vehicles properly photographed. This is an expected result: not only are vehicles more closely aligned in high-volume situations, but each piece of equipment has a maximum rate at which photographs can be taken.

When the conditions required the license plate, speeding vehicle, and driver to be identified in the photograph, there was a significant drop in the number of usable photographs that were taken by each type of equipment (this can be done only for on-coming vehicles).

At first glance, the percentages may seem rather low, giving the impression that photo-radar is not efficient. A further examination of Tables 20 and 21, however, shows that, even with these low percentages, the estimated number of speeding vehicles that can be properly photographed is at least several times higher than the number of speeding tickets the average police officer can write in 1 hour. Taking into consideration that the test locations were not necessarily the best for photography, the results suggest that when the police are trained to select locations where clear, usable pictures are likely to be taken, an even higher percentage of speeders could be apprehended and convicted.

After the original analyses had been completed and critiqued, additional analyses concerning lane location and high-speed operation were requested. The first additional analysis was carried out to determine the lane distribution of the usable photographs taken. This analysis took into consideration only photographs taken by AWA and Traffipax. The viewer capable of changing negative to positive images was no longer available to the researchers at the time this analysis was done. The photographs for TMT, Trafikanalys, and Gatsometer were mainly in negative form. The percentage distribution of photographs by the lane in which the vehicle was traveling is given in Table 22. This table shows that there was a reasonable spread across all lanes of the usable photographs apart from the AWA photographs taken at I-95 in Maryland, in which no photographs were taken of vehicles traveling in lanes 3 or 4.

Additional analysis was carried out to determine the distribution of speeds for those speeding vehicles photographed. Again, since only the AWA and Traffipax photographs could be rescreened, only these two manufacturers were considered. Table 23 shows the speed distributions of the speeding vehicles photographed by the manufacturers. The table does not indicate that the percentage of usable photographs taken was consistently influenced by the speed of the speeding vehicles.

Table 22  
LANE DISTRIBUTION OF USABLE PHOTOGRAPHS (%)

Test Site	AWA (Oncoming and Receding Traffic)				Traffipax (Receding Traffic Only)			
	Lane 1	Lane 2	Lane 3	Lane 4	Lane 1	Lane 2	Lane 3	Lane 4
I-495	38	38	12	12	20	30	50	0
I-95 (MD)	40	60	0	0	10	20	20	0
I-95 (VA)	29	21	43	0	—*	28	56	16

\*Lane was closed during demonstration period for this equipment.

Table 23  
HIT RATES BY DISTRIBUTION OF SPEEDS  
OF SPEEDING VEHICLES PHOTOGRAPHED

Threshold (mph)	Speeds of Speeding Vehicles (mph)	AWA (Oncoming and Receding Traffic)		Traffipax (Receding Traffic Only)	
		Number of Speeding Vehicles	% Speeding Vehicles Photographed	Number of Speeding Vehicles	% Speeding Vehicles Photographed
66	66-70	538	1.86	580	7.76
	71-75	309	0.32	153	3.27
	76-80	—	—	18	5.56
71	71-75	187	6.95	101	11.88
	76-80	43	6.98	18	0.00
	81-85	16	6.25	6	16.67
76	76-80	53	7.55	—	—
	81-85	16	6.25	—	—

Table 24

**MAXIMUM ERROR IN RECORDED SPEED  
FOR MISALIGNMENTS UP TO 8 DEGREES  
(Cosine Effect)**

Equipment	Maximum Error (mph)
AWA	+9
Gatsometer	+3
TMT	+3
Traffipax	+3
Trafikanalys	+3

**Misalignment Flexibility (Cosine Effect)**

The maximum error of the recorded speeds for all misalignment angles up to 8 degrees is shown in Table 24. These results show maximum errors of 3 mph for all equipment except AWA, which had a maximum error of 9 mph. These results suggest that correct alignment of the equipment is critical in obtaining accurate speed readings. Therefore, manufacturers should clearly indicate the operating angle of the radar antenna and how that angle should be obtained. Further, police officers should be trained in proper alignment of the equipment.

**Ease of Detection by Radar Detectors**

Table 25 shows the distance at which the photo-radar equipment was first detected by a radar detector. The TMT equipment was not detected by the radar detector since the Trapshooter, the model of detector used during these tests, could not detect the Ka band.

Table 25

**RADAR DETECTION DISTANCE FOR EACH PIECE OF EQUIPMENT**

	AWA	Gatsometer	TMT	Traffipax	Trafikanalys
Operating frequency	24.15 GHz	24.125 GHz	34.6 GHz	24.125 GHz	10.530 GHz
Detection distance (ft)	2,250	1,056	Not detected	1,056	2,250

## Effect of Photo-Radar on Speed Characteristics

Table 26 shows the speed characteristics for I-64, I-81, I-495, and I-95 in Virginia and Maryland both before and during the test period for each piece of equipment. There is consistency in the results with respect to the mean and 85th percentile speeds, but some inconsistency in the speed variance measured. In almost all cases, there was a reduction in the mean speed when the equipment was in opera-

Table 26

### COMPARISON OF SPEED CHARACTERISTICS AT STUDY SITES

Site	Mean Speed (mph)		85th Percentile Speed (mph)		Variance (mph) <sup>2</sup>	
	Before	During	Before	During	Before	During
<b>AWA</b>						
I-495	61.53	60.66	73	68	47.01	55.63
I-95 (VA)	63.15	63.57	73	73	48.37	43.93
I-95 (MD)	62.30	58.53	73	73	58.38	39.71
<b>GATSOMETER</b>						
I-81	64.80	63.19	73	73	53.19	55.50
I-495	60.15	57.13	68	68	50.19	57.39
I-95 (VA)	64.29	63.54	73	73	45.36	47.85
I-95 (MD)	63.05	63.53	73	73	52.22	51.07
I-64	68.40	68.01	78	78	35.39	47.80
<b>TMT</b>						
I-495	60.20	59.20	73	73	50.19	45.40
I-95 (VA)	63.07	59.82	73	68	57.30	49.31
I-95 (MD)	62.40	60.45	73	68	57.38	49.30
I-64	65.82	64.98	73	73	40.17	58.78
I-81	64.40	65.66	73	73	42.95	59.52
<b>TRAFFIPAX</b>						
I-81	63.74	65.83	73	73	62.76	45.62
I-495	60.65	59.48	68	68	44.34	50.38
I-95 (VA)	63.55	55.50	73	73	46.46	71.45
I-95 (MD)	62.72	56.80	73	73	50.26	51.48
<b>TRAFIKANALYS</b>						
I-81	63.90	63.29	78	78	48.81	48.03
I-495	58.67	57.24	68	68	56.49	50.34
I-95 (VA)	63.54	57.90	73	73	54.00	36.74
I-95 (MD)	62.93	59.16	73	73	58.15	33.71

tion, although the reductions were not statistically significant. Also, in almost all cases, the operation of the equipment did not affect the 85th percentile speed. The changes in speed variance differed from one piece of equipment to the other, and in some cases, from one site to the other. A review of the operational and site conditions was carried out to identify any factors that might have led to the inconsistency in the effect of photo-radar use on speed variance. Unfortunately, no such factors were identified.

It should be emphasized that it was not possible to determine the full impact of photo-radar on speed characteristics because most motorists were not aware of photo-radar use, and among those who knew about the equipment, many may have known that they could not be given a speeding citation. The full impact can be ascertained only if (1) motorists can be sent a citation for speeding and can be required to pay a fine and/or have negative points included in their driving record, and (2) a widespread public information campaign is successful in increasing motorists' awareness of photo-radar and its operation.

### Public Acceptance Survey

A total of 366 interviews were conducted as part of the public acceptance survey. Given the accepted levels of confidence ( $\alpha = .95$ );  $\beta = .80$ ), the survey results are accurate within  $\pm 4$  percentage points (see Appendix E for sample size calculations). The sample drawn during this survey was stratified only by sex and location of residence. The final sample consisted of 45.5 percent Maryland residents, 44.9 percent Virginia residents, and 9.6 percent residents of Washington, D.C. With regard to gender, 54.5 percent were men and 45.5 percent were women. These figures were within the limits set in the sampling plan. (The response rate overall was 79.8 percent. The response rate for men alone was 76.4 percent. The response rates for Virginia, Maryland, and Washington, D.C., were roughly equivalent to the response rate for the full sample. More telephone calls were made to the District since the proportion of residences is lower within the city than in the surrounding suburbs.) About 93 percent were drivers, of whom 19 percent drove on the Beltway every day and 61 percent drove on the Beltway at least once a week.

With regard to their awareness of photo-radar as an enforcement tool, less than 2 percent were able to name photo-radar as a tool for enforcing speed limits without having it suggested as an option. However, once mentioned, 78 percent said that they had heard of the technique. Slightly over 4 percent were sure that they had seen photo-radar in operation, and another 8 percent thought they might have seen the equipment on the roadside.

As seen in Table 27, about 60 percent of those questioned approved or strongly approved of the potential use of photo-radar as an enforcement tool on the Beltway only. Approximately 35 percent disapproved or strongly disapproved. Only 6 percent had no opinion.

As noted in Table 28, the differences between the opinions of drivers and non-drivers, between Beltway drivers and non-Beltway drivers, and among residents of

Table 27

OPINIONS CONCERNING POTENTIAL USE OF PHOTO-RADAR ON BELTWAY

Response	Number of Respondents (%)
Strongly approve	56 (16.7)
Approve	143 (42.6)
Disapprove	67 (19.9)
Strongly disapprove	51 (15.2)
No opinion	19 (5.7)
Total	366

Table 28

OPINIONS ON PHOTO-RADAR USE BY DEMOGRAPHIC CHARACTERISTICS

Characteristic	Approve (%)	Disapprove (%)	Chi Square (df)
Drivers	61.3	38.7	2.6 (1)
Nondrivers	81.1	18.2	
Beltway drivers	53.0	47.0	2.9 (1)
Non-Beltway drivers	75.4	24.5	
Males	54.3	45.7	12.1 (1)*
Females	73.2	26.7	
Virginia residents	62.7	37.3	0.4 (2)
Maryland residents	61.8	38.2	
D.C. residents	67.7	32.3	

\*Significant at the .05 level.

Washington, D.C., Virginia, and Maryland were not statistically significant. However, the difference between the opinions of males and females toward photo-radar were statistically significant.

**SUMMARY OF FINDINGS**

**Background**

- Photo-radar technology has been used in Europe for more than 30 years to apprehend speeders. Although most of the European manufacturers of photo-radar equipment are well established, at least one is less than 5 years old.

- In the United States, photo-radar has been in use for several years in Pasadena, California, and Paradise Valley, Arizona. Photo-radar has traditionally been used in residential areas in cities in the path of commuter traffic. In these instances, most of those speeders cited are nonresidents.
- The use of photo-radar technology appears to satisfy constitutional standards. Special evidentiary requirements may have to be met for successful prosecution of speeding cases.
- Additional legislation may be required to provide for the service of traffic citations by mail to the registered owner of the speeding vehicle.

**Photographic Quality**

- Three manufacturers took pictures of receding traffic as part of the demonstration, with two of these also taking pictures of approaching traffic. Of these three companies, the license plate number could be determined from the photograph in 58.6 percent, 39.6 percent, and 8.5 percent, respectively. With the additional requirement that the speeding vehicle be identifiable in multivehicle pictures, these percentages dropped to 51.9 percent, 24.1 percent, and 7.4 percent, respectively.
- Four manufacturers took pictures of oncoming traffic as part of the demonstration. In these pictures, both the license plate and the driver's face were required to be identifiable. For these four firms, 23.1 percent, 13.1 percent, 9.1 percent, and 8.6 percent, respectively, of the pictures met this requirement. When the requirement that the speeding vehicle be identifiable in a multivehicle photograph was added, the percentages for the four firms dropped to 13.3 percent, 7.5 percent, 8.4 percent, and 4.2 percent, respectively.

**Accuracy of Recorded Speeds**

- When all test speeds were considered, the speeds recorded by the various units fell within the standards for police radar between 96.3 percent of the time and 83.7 percent of the time, respectively.
- Speed readings recorded by three of the units tended to be lower than those recorded by loops, thus favoring the driver in a prosecution. The readings made by the other two tended to be higher.
- The accuracy of the recorded speed was not significantly affected by the lane in which the vehicle was traveling or by the clustering of the vehicles.

## **Efficiency of Photo-Radar**

- The estimated number of speeding vehicles per hour that could be photographed with the results suitable for citation purposes (i.e., under operational conditions with the license plate and the speed of the vehicle clearly shown) varied from about 5 per hour to 216 per hour, depending on the brand of equipment, number of speeding vehicles, traffic volume, and threshold speed. These photographic rates are based on the actual number of speeding vehicles recorded during the periods of data collection.
- For oncoming traffic only, the estimated number of speeding vehicles that could be photographed with the license plate, speed of the vehicle, and driver's face clearly shown varied from 4 per hour to 35 per hour, depending on the type of equipment and number of speeding vehicles.

## **Misalignment Flexibility (Cosine Effect)**

- Misaligning the equipment to a maximum of 8 degrees had a significant effect on the error of the speed recorded by the equipment. Four units had a maximum error of up to 3 mph, and one unit had a maximum error of up to 9 mph.

## **Radar Detection**

- Two of the units tested were detected by radar detectors at 2,250 feet. Two units were detected at 1,056 feet. One unit was not detected by the radar detector used in the test since the model of radar detector used could not detect the Ka band.

## **Public Acceptance**

- Approximately 60 percent of the residents of the Washington metropolitan area polled approved of the potential use of photo-radar on the Beltway.

## **CONCLUSIONS AND RECOMMENDATIONS**

In interpreting the results of this study, it must be realized that the demonstration could not be conducted in the pristine conditions of a laboratory. Rather, the objective of this project was to determine the feasibility of using photo-radar technology on high-volume, high-speed expressways, such as the Beltway. It was concluded that:

1. It is operationally feasible to use photo-radar technology to detect and photograph speed violators on high-speed, high-volume roads, such as the Beltway. The costs of running such a program are unknown.
2. Photo-radar technology can produce clear photographs that can be used to prosecute speeding drivers in court. Since the testing was conducted in the field under less than ideal conditions, it is likely that photo-radar equipment used as part of an actual speed enforcement program will produce a larger percentage of usable photographs, as experienced in Paradise Valley, Arizona, and Pasadena, California.
3. All equipment tested is capable of detecting and properly photographing a much higher percentage of speed violators than can the average police officer in a patrol car.
4. There is an intimation that the use of photo-radar as an enhancement to speed enforcement efforts may reduce the mean speed on the Beltway. However, the extent of this reduction could not be determined in this study because no citations were given and no public information campaign was conducted.
5. It is feasible to propose legislation for the use of photo-radar technology that could safeguard individual rights, meet constitutional requirements, and enhance the litigation of speed violations. Proposed legislation for Maryland and Virginia was developed and is presented in Appendix F. The legislation is designed to safeguard individual rights while establishing lawful procedures for implementing automated speed enforcement in both states.

### LESSONS LEARNED

Based on information gathered from the operational site visits and field demonstrations, it appears that the use of photo-radar on high-volume, high-speed roadways is feasible in terms of the equipment's ability to detect and photograph speeders. (This study, however, did not deal with the funding and staffing needs of photo-radar programs or whether such programs would be cost-effective.)

A number of additional inferences can be drawn from the findings of this study and, in particular, the results of the site visits to manufacturers of photo-radar overseas and to users of photo-radar in the United States. Photo-radar should be used as a part of an agency's overall speed enforcement program to help reduce speed-related crashes, fatalities, and injuries at those locations identified as having traffic safety and enforcement problems. In addition, photo-radar equipment should be chosen to meet the particular needs of the police agency and the community. The number of sites using photo-radar, and other sites using different types of equipment, should be alternated to create a general deterrent effect except in cases where "spot"

deterrence is required. This will also minimize the impact of radar detectors. A speed enforcement program utilizing photo-radar, as with other new enforcement initiatives, should be preceded by efforts to inform judges and prosecutors of the details of the program and should be accompanied by a well-focused and coordinated public information and education program. Operational procedures for a photo-radar program should include the following:

- providing equipment-specific training programs for police officers to ensure the equipment is properly operated
- providing for the availability of properly trained technical support personnel to ensure the continuing accuracy of the equipment
- selecting operational sites and times to deal with identified traffic safety and enforcement problems and ensure optimum use of the equipment (accounting for angle of the sun, weather, etc.)
- setting speed thresholds that are realistically determined and are consistent with the agency's overall speed enforcement goals (the thresholds should first be set for excessive speeds that present the greatest potential danger)
- establishing specific procedures for the handling of film and photographs to maintain proper chain of custody and ensure that individual rights and privacy are safeguarded.

Preparation of the procurement for equipment should include the following:

- an understanding of where the U.S. distributor has technical support available and what the process and time requirements are to replace or add equipment
- use of specifications allowing demonstration of alternate equipment (e.g., lenses, strobes, films)
- specifications in the purchase requirement that the operating angle for the radar antenna is set and clearly marked on the equipment so that it may be easily seen in day or at night (this ensures that there is proper alignment of the camera and radar antenna each time the equipment is used).

There are a number of other "common sense" issues to be considered when police agencies establish a photo-radar program or purchase photo-radar equipment. The agency should first determine if a speed-related accident problem exists in its locality or if there are locations where the use of standard speed enforcement techniques is unsafe or impractical. In addition, periodic reporting on the operations of the program as well as speed- and/or crash-reduction statistics should be instituted for local governments and the public. This information could also be used to adjust plans for a speed enforcement program and deployment of equipment.

With regard to the equipment itself, common sense dictates that enforcement officials be aware of what the photo-radar equipment will and will not do. Arrangements should be made for the development of film, particularly in cases where an odd film type or size is used. Also, police agencies should not be afraid to ask manufacturers to deviate from standard lenses and filters to meet the photographic needs of

the area more adequately. Finally, the police agency should insist that the equipment be warranted and that there is easy and quick access to repair and maintenance facilities, especially in cases where continuous photo-radar use is required.

### NOTES

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8. *Id.* (citing *City of Webster Groves v. Quick*, 323 S.W.2d 386, 388-389 (Mo. Ct. App. 1959)).
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11. W. S. Smith & C. S. LeCraw, Jr., *Traffic Speed Enforcement Policies* 26 (1948).
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13. E. C. Fisher, *supra* note 2, at 54; Cal. Veh. Code §§40801-804; Wash. Rev. Code §46.61-470.
14. D. K. Witheford, *supra* note 5, at 34.
15. Smith & LeCraw, *supra* note 11, at 21.
16. D. K. Witheford, *supra* note 5, at 34.
17. *Id.* at 35; 7A Am. Jur. 2d *supra* note 9, at §371.
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19. *State v. Dantonio*, 18 N.J. 570, 574, 115 A.2d 35, 37 (1955).
20. *People v. Martindale*, 6 Misc. 2d 85, 162 N.Y.S.2d 806 (1957).
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22. *Dooley v. Commonwealth*, 198 Va. 32, 35, 92 S.E.2d 348, 350 (1956).

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30. E. C. Fisher, *supra* note 2, at 4.
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38. *Id.*
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76. McKenna, *supra* note 63, at 1067.
77. *See Moore v. City of East Cleveland*, 97 S. Ct. 1932 (1977) (Invalidating a city ordinance that prohibited family members who were not members of the nuclear family from inhabiting the same residence on the basis of freedom of intimate association); compare *Village of Belle Terre v. Boraas*, 416 U.S. 1 (1974) (affirming the validity of a zoning ordinance preventing unrelated adults from living in the same residence from a freedom of intimate association challenge). Note that in *Roberts*, the Supreme Court indicated that the right of intimate association could extend to regulations interfering with intimate relationships outside the family context, *Roberts*, 468 U.S. at 620, although successful freedom of intimate association claims have thus far involved only impediments to familial relationships.
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87. *Id.*
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95. *Id.* at 672; G. Lilly, *supra* note 66, at 520.
96. G. Lilly, *supra* note 66, at 520.
97. C. McCormick, *supra* note 65, at 672.
98. *Id.*
99. 14B *Michie's Jurisprudence of Virginia and West Virginia*, §5 (1988).
100. *Ferguson v. Commonwealth*, 212 Va. 745, 187 S.E.2d 189 (1972), *cert. denied*, 409 U.S. 861 (1972), *reh'g. denied*, 409 U.S. 1050 (1972).
101. *Id.*
102. *Id.* at 747, 187 S.E.2d at 190.
103. *Id.* at 746, 187 S.E.2d at 190.
104. *Id.*
105. *Saunders v. Commonwealth*, 1 Va. App. 396, 339 S.E.2d 550 (1986).
106. *Id.* at 397-399, 339 S.E.2d at 551-552.
107. *Id.*
108. *Ferguson*, 212 Va. at 747, 187 S.E.2d at 191.
109. *Id.*
110. *Sisk v. State*, 236 Md. 589, 204 A.2d 684 (1964).

111. *Id.* at 592, 204 A.2d at 685.
112. *Id.* at 593-596, 204 A.2d at 686-687.
113. *Id.* at 592, 204 A.2d at 685.
114. *Id.* at 596, 204 A.2d at 688.
115. Va. Code Ann. §46.2-936 (1989).
116. Va. Code Ann. §§46.2-870 *et seq.* and §46.2-937.
117. Va. Code Ann. §46.2-936 (1989).
118. Md. Transp. Code Ann. §26-203 (1987).
119. 64 Op. Att’y Gen. 314 (1979).
120. *Id.*
121. Md. Transp. Code Ann. §26-201(a) (1987).
122. *Id.*
123. *Reedy v. Commonwealth of Virginia*, 9 Va. App. 386, 387, 388 S.E.2d 650, 650-651 (1990), citing *Washington v. Commonwealth of Virginia*, 228 Va. 535, 550, 323 S.E.2d 577, 587 (1984).
124. *Ferguson v. Commonwealth*, 212 Va. 745, 745, 187 S.E.2d 189, 190 (1972).
125. *Robertson v. Commonwealth of Virginia*, 12 Va. App. 854, 856-857, 406 S.E.2d 417, 418-419 (1991).
126. *State of Maine v. Young*, 303 A.2d 113, 116 (1973). *See also State of New Jersey v. Bunting*, 455 A.2d 531, 532-533 (1983).
127. *Groves v. State of Indiana*, 456 N.E.2d 720 (1983).
128. *Id.* at 721.
129. 553 So.2d 701 (1988).
130. *Id.* at 711.
131. *Id.* quoting C. Scott, 3 Photographic Evidence § 1297 at 95 (2d ed. 1969 and Supp. 1987).
132. 489 N.E.2d 43 (1986).
133. *Id.* at 48.
134. *Parker v. State of Maryland*, 531 A.2d 1035, 1038 (1987). *See also Hawkins v. State of Maryland*, 550 A.2d 416, 420 (1988); *Van Meter v. State of Maryland*, 352 A.2d 850, 855 (1976).

135. Md. Cts. & Jud. Proc. Code Ann. Sections 10-1001 *et seq.* (1991).
136. *See also Wilkinson v. State of Maryland*, 554 A.2d 1280 (1989) (holding that couriers are not part of the chain of custody in the controlled dangerous substance context).
137. 566 A.2d 126, 127 (1989).
138. *Id.* at 127.
139. Va. Code Ann. §§2.1-377 *et seq.* (Michie 1987). In addition, Va. Code Ann. §8.01-40 prohibits the unauthorized use of an individual's picture for the purposes of advertising or trade. This section is not relevant in the photo-radar context, however, since no commercial use is planned for the photographs taken by photo-radar devices.
140. Several other guidelines, which are not applicable to photo-radar use, are not discussed here.
141. *Carson v. Commonwealth of Virginia*, 12 Va. App. 497, 500, 404 S.E.2d 919, 920, 924. *See also Shirley v. Commonwealth of Virginia*, 218 Va. 49, 53, 235 S.E.2d 432, 434 (1977) (stating "an automobile[']s . . . exterior and much of its interior are within plain view of the casual or purposeful onlooker, and thus are not protected by the Fourth Amendment from searching eyes").
142. *Josephs v. Commonwealth of Virginia*, 10 Va. App. 87, 98, 390 S.E.2d 491, 497 (1990).
143. *Brown v. American Broadcasting Co.*, 704 F.2d 1296, 1302-1303 (4th Cir. 1983).
144. *See, e.g., Cardwell v. Lewis*, 417 U.S. 583, 591 (1974). *See also Arsenon v. American Broadcasting Co.*, 269 Ca.Rptr 379 (1990) (no invasion of privacy occurred when plaintiff was videotaped walking to his car since the cameraman did not encroach on the plaintiff's property); *State v. Louis*, 672 P.2d 708 (Or. 1983) (holding that photographing a defendant with a 135 mm lens was not an illegal search or invasion of privacy since the camera provided only minimal enhancement to what could be observed with the unaided eye); *State of Wisconsin v. Owen*, 350 N.W.2d 741 (holding that taking a picture of a car in a driveway did not violate any reasonable expectations of privacy that the owner could have); *State of Michigan v. Ward*, 308 N.W.2d 664 (Mich. 1981) (holding that no reasonable expectation of privacy existed with regard to telephoto photography of an individual's car from a neighbor's house across the street); *State of Utah v. Wettstein*, 501 P.2d 1084 (Utah 1972) (holding that photographing of a vehicle in an apartment building parking space did not constitute an illegal search or seizure); *State of New York v. Christman*, 307 N.Y.S.2d 545 (holding that no reasonable expectation of privacy existed with automobile parked in plain and open view since the conduct of putting it there explicitly disclaimed any privacy rights).
145. 558 A.2d 446 (Md. 1989).

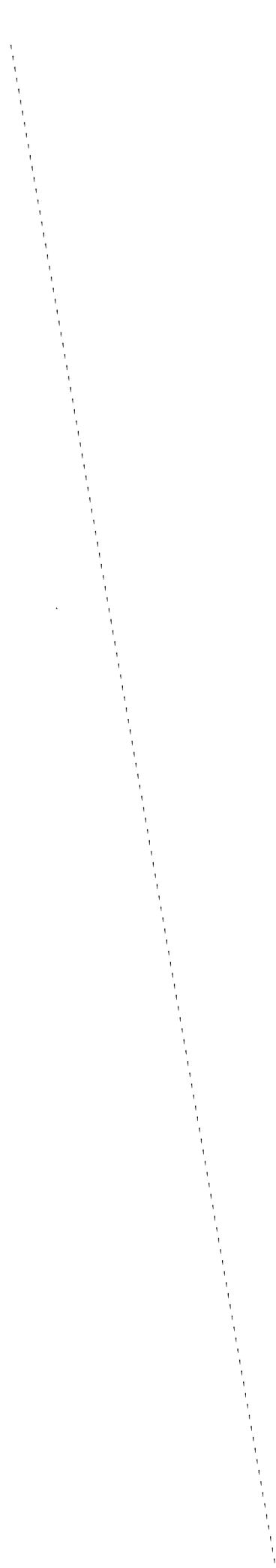
- 114
146. *Id.* 450 (quoting *Scales v. State of Maryland*, 284 A.2d 45 (Md. 1971)).
  147. 474 A.2d 191 (Md. 1984).
  148. *Id.* at 198 (quoting *Venner v. State of Maryland*, 367 A.2d 949 (Md. 1977)). *See also Conner v. State of Maryland*, 366 A.2d 385 (Md. 1976) (holding that a citizen had no privacy right in a serial number that was clearly visible on his motorcycle); *McDonald v. State of Maryland*, 487 A.2d 306 (Md. 1984) (holding that a visual inspection of the exterior of a car did not violate the owner's Fourth Amendment privacy interest).
  149. As to unmanned operation, Mr. Thompson stated that the FCC has not promulgated any guidelines that turned on this distinction, and thus the mode of operation was irrelevant from an FCC compliance viewpoint. With regard to drone radar, Mr. Thompson noted that photo-radar is not classified as drone radar since the return radar signal is used by the unit and thus previous policies restricting drone radar use did not apply to photo-radar. In addition, Mr. Thompson noted that the FCC policy on drone-radar use that had raised these concerns had recently been modified to allow drone-radar units that comply with the provisions of NHTSA's Police Traffic Services Division, thus further mitigating any concerns about photo-radar's compliance with FCC guidelines (see "Drone Radar Operational Guidelines," DOT Publication No. HS-807-753).

## **APPENDIX A**

### **Standard Criterion Photographs**

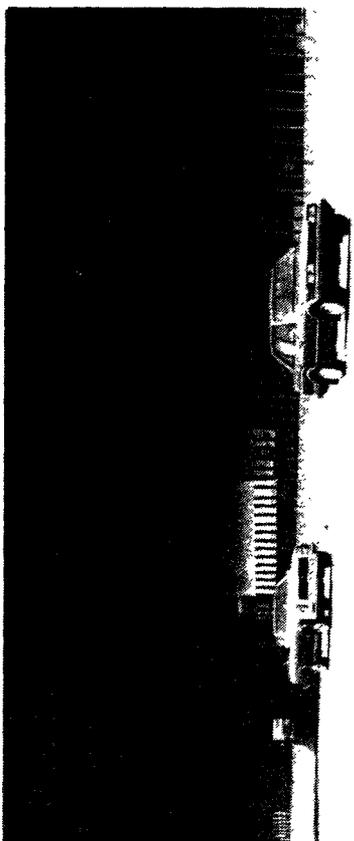
(The photographs contained in this appendix are half-tone reproductions of the photographs used to make legibility and visibility decisions. Because they are half-tones, these reproductions are not as clear and readable as the original photographs.)

127

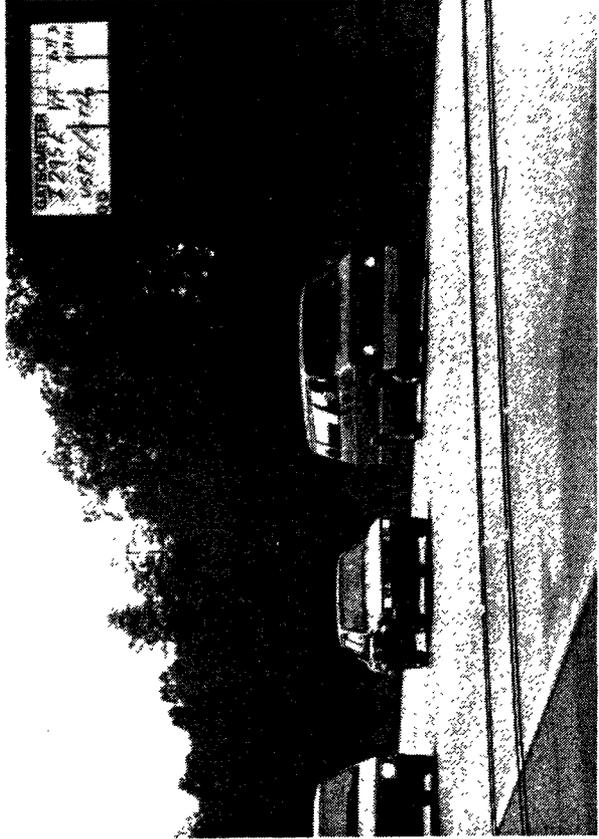
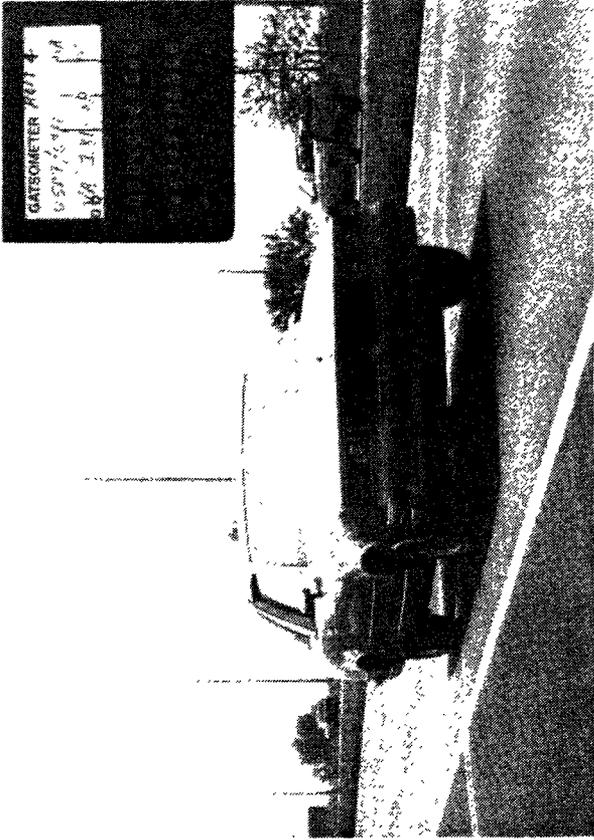




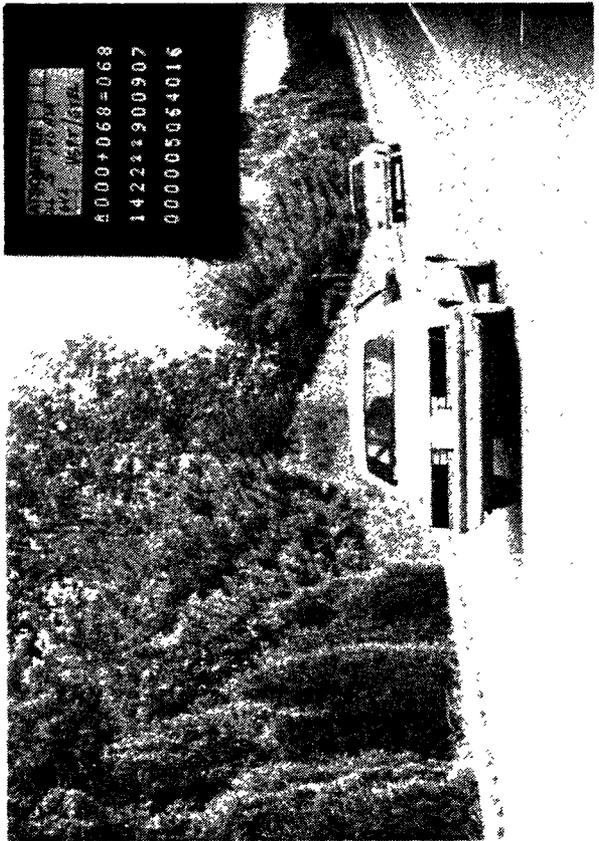
A W A DEFENCE INDUSTRIES







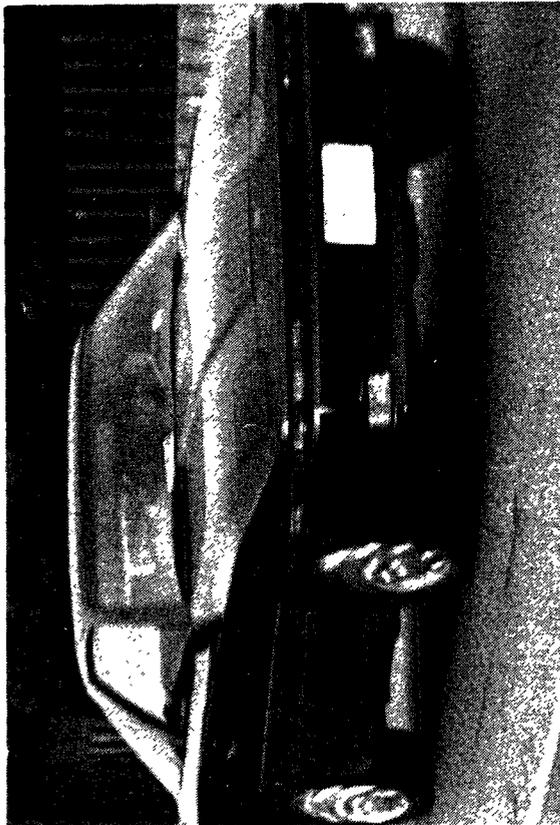
GATSOMETER



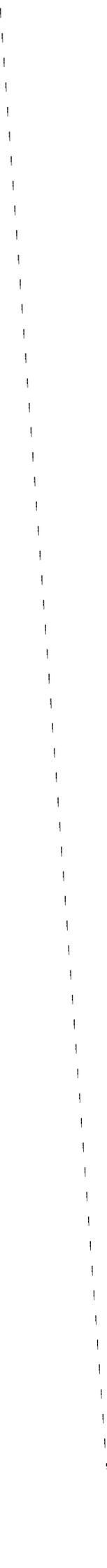




**TRAFFIC MONITORING TECHNOLOGIES**

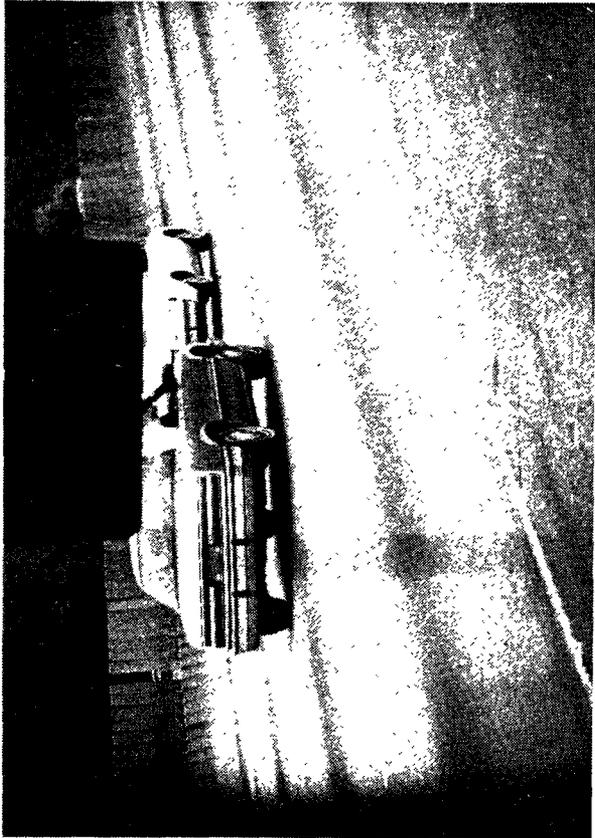
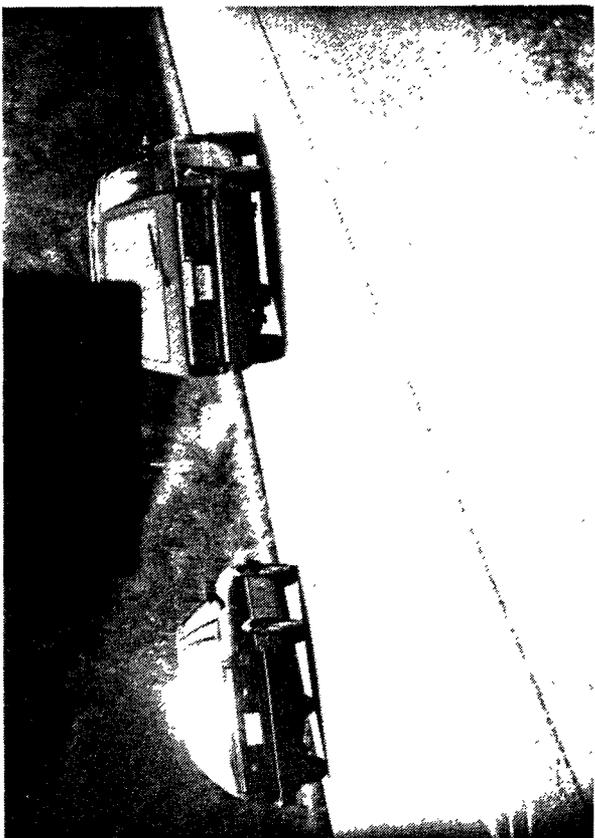


100

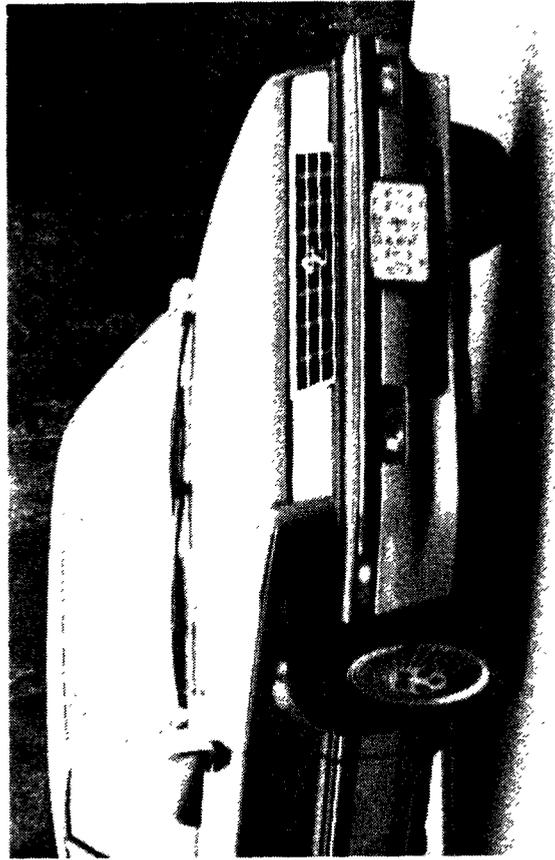




TRAFFIPAX



120



TRAFIKANALYS





**APPENDIX B**

**Public Acceptance Poll Questionnaire**

120

121

## Photo-Radar Telephone Survey

November 1990

Good afternoon (evening). My name is \_\_\_\_\_. I'm conducting a brief survey for the Virginia Transportation Research Council at the University of Virginia in Charlottesville. May I speak with someone in your household who is 16 years of age or older?

[CONFIRM AGE PRIOR TO PROCEEDING]

I'd like to ask you a few questions concerning the enforcement of speed limits in your area. Your answers will be very valuable and will remain strictly confidential. (GO RIGHT TO THE FIRST QUESTION)

1. First, do you drive?

- 1 . . . . . Yes
- 2 . . . . . No \_\_\_\_\_ SKIP TO QUESTION 3
- 3 . . . . . Don't know/Can't remember

2. In a typical week, how often do you drive on the Capital Beltway? Would you say you drive the Beltway . . . [READ RESPONSES]

- 1 . . . . . Every day
- 2 . . . . . 3 to 6 times per week
- 3 . . . . . Once or twice a week, or
- 4 . . . . . Not at all during the typical week
- 9 . . . . . Don't know/Can't remember

3. In a typical week, how often do you ride as a passenger on the Beltway? [READ RESPONSES]

- 1 . . . . . Every day
- 2 . . . . . 3 to 6 times per week
- 3 . . . . . Once or twice a week, or
- 4 . . . . . Not at all during the typical week
- 9 . . . . . Don't know/Can't remember

4. What kinds of technologies do the police use to enforce speed limits where you drive? [PROBE FOR THREE ANSWERS OR UNTIL PERSON SAYS HE OR SHE HAD NO MORE ANSWERS]

- 1 . . . . . Mobile patrols
- 2 . . . . . Stationary speed traps
- 3 . . . . . Constant radar signals
- 4 . . . . . Photo-radar
- 5 . . . . . Something like photo-radar
- 88 . . . . . Other
- 99 . . . . . Don't know/Can't remember

5. The police in your area are considering using an enforcement tool known as photo-radar to help enforce the speed limit on the Capital Beltway *only*. Photo-radar automatically photographs the license plate and the driver of only those vehicles traveling significantly faster than the speed limit. Have you heard of this type of speed enforcement technology?

- 1 . . . . . Yes
- 2 . . . . . No
- 9 . . . . . Don't know/Can't remember

6. Have you ever seen or driven by a photo-radar unit being used on the Capital Beltway?

- 1 . . . . . Yes
- 2 . . . . . Maybe
- 3 . . . . . No
- 9 . . . . . Don't know/Can't remember

7. Do you approve or disapprove of the use of the photo-radar on the Beltway **ONLY**? Would you say you . . . . . [READ RESPONSES] . . . . .

- 2 . . . . . Approve [NOTE CODING]
- 1 . . . . . Strongly approve
- 3 . . . . . Disapprove, or
- 4 . . . . . Strongly disapprove
- 9 . . . . . Don't know/Can't remember——SKIP TO QUESTION 8

8. Why do you approve (disapprove) of photo-radar on the Capital Beltway **ONLY**? [PROBE FOR **THREE** REASONS OR UNTIL PERSON SAYS HE OR SHE HAS NO MORE REASONS]

8a. APPROVE:

- 1 . . . Need to reduce speeds on the Beltway
- 2 . . . Will reduce speeds
- 3 . . . *Not* entrapment, illegal, unconstitutional, violates privacy, personal freedom
- 4 . . . Will reduce accidents on the Beltway
- 5 . . . Will reduce congestion on the Beltway
- 88 . . . Other (Specify)

8b. DISAPPROVE:

- 1 . . . Wrong person could get ticket
- 2 . . . Gives the police an unfair advantage (sneaky)
- 3 . . . Entrapment, illegal, unconstitutional, violates privacy, personal freedom
- 4 . . . Big Brotherism/too much government
- 5 . . . Waste of taxpayers' money
- 6 . . . Person can't tell his or her side of story (personal contact)

- 7 ... Will not reduce speeding
- 88 ... Other (Specify)
- 99 ... Don't know/Can't remember

This survey was sponsored by the Virginia and Maryland Departments of State Police. I would like to thank you for your time and cooperation.

Sex: 1 .. Male                      Number  
      2 .. Female

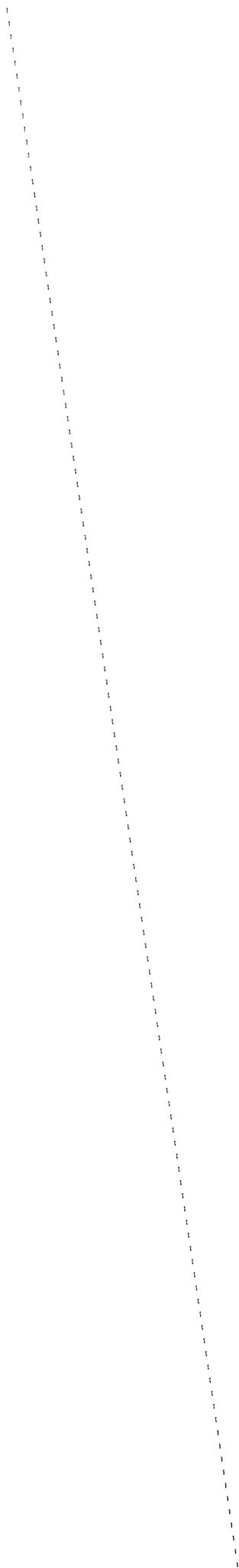
State



**APPENDIX C**

**Description of Photo-Radar Equipment**

63



## EQUIPMENT COMPARISON

Company: AWA Defence Industries

### PART ONE: BASED ON EUROPEAN AND AMERICAN SITE VISITS

#### 1. MODEL

system: Vehicle Speed Radar  
radar: (Ka band)  
camera: Canon

#### 2. PRODUCER OF:

radar: AWA  
camera: Canon F-1  
electronics: AWA  
lenses: Canon  
flash: Unknown

#### 3. FCC APPROVAL

experimental: Yes  
standard waiver: No

#### 4. RADAR

antenna type (parabolic, slotted wave guide, etc): Parabolic  
frequencies: 24.15 GHz  
published accuracy:  $\pm 1\%$  or  $\pm 1$  kph, whichever is greater  
self-calibration (internal): Yes, at factory  
external calibration (tuning fork, etc): No  
independent testing (standards): Yes, by Australia 2898.1-Z (1986) standard  
radio frequency interference: None

#### 5. PHOTOGRAPHY

standard shutter speed: 1/1000 sec  
optional shutter speed: Can be varied  
aperture priority: No, set for F4 F-stop (preset with a low light indicator)  
shutter priority: No, set for F4 F-stop (preset with a low light indicator)  
standard lenses: 85 mm  
optional lenses: No  
system recycle time w/ flash: < 0.5 sec  
system recycle time w/o flash: 0.2 sec  
daytime flash standard: No, but available  
slave camera available: No

6. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: No

7. MOBILE MODE: No

8. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: No

9. OPTIONS

night operation: Yes  
day operation with flash standard: No, but available  
remote control: No  
manual override: Yes  
computer interface: Yes  
comes with computer for traffic data collection: No  
software available: Yes  
video available: No

PART TWO: BASED ON THE VIRGINIA DEMONSTRATIONS

1. MODEL DEMONSTRATED

system: Vehicle Speed Radar  
radar: (Ka band)  
camera: Canon

2. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: No  
one direction at a time: Yes  
both directions simultaneously: No

3. MOBILE MODE: No

4. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: No

5. OPTIONS ACTUALLY DEMONSTRATED

night operation: No (is available)  
day operation with flash standard: No (is available)  
remote control: No  
manual override: Yes

software available: Yes  
 video available: No

## EQUIPMENT COMPARISON

**Company: Gatsometer**

### PART ONE: BASED ON EUROPEAN AND AMERICAN SITE VISITS

#### 1. MODEL

system: Gatsometer Type 24  
 radar: Gatsometer Type 24 Microradar  
 camera: Robot Motor Recorder 36CE

#### 2. PRODUCER OF:

radar: Gatsometer  
 camera: Robot Foto & Electronic  
 electronics: Gatsometer  
 lenses: Schneider-Tele-Xenar  
 flash: Gatsometer with Hella lens

#### 3. FCC APPROVAL

standard waiver: Yes—type acceptance

#### 4. RADAR

antenna type (parabolic, slotted wave guide, etc): Slotted wave guide  
 frequencies: 24.125 GHz, 13.5 GHz  
 published accuracy: +2 kph up to 100 kph, +2% above 100 kph  
 self-calibration (internal): Yes  
 external calibration (tuning fork, etc): Yes  
 independent testing (standards): Yes, by W. German and Dutch governments  
 radio frequency interference: None—enclosed in nickel-plated sheeting

#### 5. PHOTOGRAPHY

standard shutter speed: 1/1000 fixed (flash synchronized) automatic  
 optional shutter speed: Yes  
 aperture priority: Yes  
 shutter priority: No  
 standard lenses: 90 mm Schneider-Tele-Xenar  
 optional lenses: 75 mm, 150 mm  
 system recycle time w/ flash: 0.5 sec  
 system recycle time w/o flash: 0.001 sec  
 daytime flash standard: Yes, if necessary

750  
slave camera available: Yes  
flash triggered: Yes  
radar triggered: No

6. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: Yes

7. MOBILE MODE: Yes

oncoming only: No  
receding only: Yes  
both directions: No  
both simultaneously: No

8. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: Yes

separate measurements for cars and trucks: Yes  
simultaneous measurements of each: Yes

9. OPTIONS

night operation: Yes  
day operation with flash standard: Yes  
remote control: Yes  
manual override: Yes  
computer interface: Yes, memory card  
comes with computer for traffic data collection: No  
software available: Yes  
video available: Yes

PART TWO: BASED ON THE VIRGINIA DEMONSTRATIONS

1. MODEL DEMONSTRATED

system: Gatsometer  
radar: Gatsometer Type 24  
camera: Robot Motor Recorder 36CE

2. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: No

- 3. MOBILE MODE: Yes
  - oncoming only: No
  - receding only: Yes
  - both directions: No
  - both simultaneously: No
- 4. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: Yes
  - separate measurements for cars and trucks: Yes
  - simultaneous measurements of each: Yes
- 5. OPTIONS ACTUALLY DEMONSTRATED
  - night operation: Yes
  - day operation with flash standard: Yes
  - remote control: No
  - manual override: Yes
  - computer interface: Yes—memory card
  - comes with computer for traffic data collection: No
  - software available: Yes
  - video available: Yes

**EQUIPMENT COMPARISON**

**Company: Multanova**

**PART ONE: BASED ON EUROPEAN AND AMERICAN SITE VISITS**

- 1. MODEL
  - system: Multanova 6F Photo-radar
  - radar: Multanova
  - camera: Jacknau Automated Recording Camera
- 2. PRODUCER OF:
  - radar: Multanova
  - camera: Jacknau
  - electronics: Multanova
  - lenses: Nikon
  - flash: Multanova
- 3. FCC APPROVAL: Yes
  - standard waiver: Yes—type acceptance
- 4. RADAR
  - antenna type (parabolic, slotted wave guide, etc.): Parabolic antenna
  - frequencies: 34.3 GHz, 24 GHz

published accuracy:  $\pm 1$  kph up to 100 kph,  $\pm 1\%$  over 100 kph  
self-calibration (internal): Yes  
external calibration (tuning fork, etc): Yes  
independent testing (standards): Yes, by W. German and Swiss governments  
frequency interference: None, enclosed in sheeting

## 5. PHOTOGRAPHY

standard shutter speed: 1/500 sec  
optional shutter speed: No  
aperture priority: Yes, can have automated or manual  
shutter priority: Can't change  
standard lenses: Nikon 85 mm  
optional lenses: None  
system recycle time w/ flash: 0.5 sec  
system recycle time w/o flash: 0.5 sec  
daytime flash standard: Yes  
slave camera available: Yes  
    flash triggered: Yes  
    radar triggered: No

## 6. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: Yes

## 7. MOBILE MODE: Yes

oncoming only: No  
receding only: Yes  
both directions: No  
both simultaneously: No

## 8. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: Yes

separate measurements for cars and trucks: Yes  
simultaneous measurements of each: Yes

## 9. OPTIONS

night operation: Yes  
day operation with flash standard: Yes, if necessary  
remote control: Yes  
manual override: Yes  
computer interface: Yes to PC or to card recorder  
comes with computer for traffic data collection: Yes  
software available: Yes  
video available: Yes

PART TWO: BASED ON THE VIRGINIA DEMONSTRATIONS

Declined to participate.

**EQUIPMENT COMPARISON**

**Company: Traffic Monitoring Technologies (TMT)**

PART ONE: BASED ON EUROPEAN AND AMERICAN SITE VISITS

1. MODEL

system: PhotoCop  
radar: Macom Radarhorn  
camera: Hasselblad 70 mm

2. PRODUCER OF:

radar: Macom  
camera: Hasselblad  
electronics: TMT  
lenses: Zeiss  
flash: Lumadyne or Norman

3. FCC APPROVAL

standard waiver: Yes—type acceptance

4. RADAR

antenna type (parabolic, slotted wave guide, etc): Parabolic  
frequencies: 34.6 GHz + 20 MHz  
published accuracy: ±1 mph @ 20–100 mph, ±1% over 100 mph  
self-calibration (internal): Yes  
external calibration (tuning fork, etc): Can check with tuning fork  
independent testing (standards): FCC testing done by private company  
radio frequency interference: None, enclosed in sheeting

5. PHOTOGRAPHY

standard shutter speed: 1/650 sec  
optional shutter speed: No  
aperture priority: Yes  
shutter priority: No  
standard lenses: 70 mm  
optional lenses: 150 mm  
system recycle time w/ flash: 2 sec  
system recycle time w/o flash: 2 sec, but can run faster if needed  
daytime flash standard: Yes  
slave camera available: Yes

flash triggered: No  
radar triggered: No  
computer triggered: Yes  
tripod mounted: No  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: No

6. MOBILE MODE: No

7. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: No

8. OPTIONS

night operation: Yes  
day operation with flash standard: Yes  
remote control: Yes  
manual override: Yes  
computer interface: Yes  
comes with computer for traffic data collection: Yes  
software available: Yes  
video available: Yes

## PART TWO: BASED ON THE VIRGINIA DEMONSTRATIONS

1. MODEL DEMONSTRATED

system: PhotoCop  
radar: (Ka band)  
camera: Hasselblad 70 mm

2. STATIONARY MODE: Yes

tripod mounted: No  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: No

3. MOBILE MODE: No

4. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: No

5. OPTIONS ACTUALLY DEMONSTRATED

night operation: Yes  
day operation with flash standard: Yes  
remote control: No

manual override: No  
computer interface: Yes  
comes with computer for traffic data collection: Yes  
software available: Yes  
video available: Yes

## EQUIPMENT COMPARISON

**Company: Traffipax**

### PART ONE: BASED ON EUROPEAN AND AMERICAN SITE VISITS

#### 1. MODEL

system: Speedophot  
radar: Gatsometer Type 24 Microradar  
camera: Robot Motor Recorder 36 DFT

#### 2. PRODUCER OF:

radar: Gatsometer  
camera: Robot Foto and Electronic  
electronics: Traffipax  
lenses: Schneider-Tele-Xenar  
flash: Bosch

#### 3. FCC APPROVAL

standard waiver: Yes—type acceptance FCC #F3T4MA Radar Type 5

#### 4. RADAR

antenna type (parabolic, slotted wave guide, etc): Slotted aerial  
frequencies: 24.125 GHz, 13.5 GHz  
published accuracy:  $\pm 2$  kph up to 100 kph, +2% above 100 kph  
self-calibration (internal): Yes  
external calibration (tuning fork, etc): No  
independent testing (standards): Yes, by German Postal Service and FCC  
radio frequency interference: None—enclosed in metal sheeting

#### 5. PHOTOGRAPHY

standard shutter speed: 1/1000 sec  
optional shutter speed: 1/500 sec  
aperture priority: Yes  
shutter priority: No  
standard lenses: 75 mm Schneider-Tele-Xenar  
optional lenses: 90 mm, 150 mm  
system recycle time w/ flash: 0.5 sec  
system recycle time w/o flash: 0.1 sec

daytime flash standard: Yes—auto exposure control  
slave camera available: Yes—but not necessary  
flash triggered: No  
radar triggered: Yes

6. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: Yes

7. MOBILE MODE: Yes

oncoming only: Yes  
receding only: Yes  
both directions: Yes  
both simultaneously: Yes

8. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: Yes

separate measurements for cars and trucks: Yes  
simultaneous measurements of each: Yes

9. OPTIONS

night operation: Yes  
day operation with flash standard: Yes  
remote control: Yes  
manual override: Yes  
computer interface: Yes, memory card  
comes with computer for traffic data collection: No  
software available: Yes  
video available: Yes

PART TWO: BASED ON THE VIRGINIA DEMONSTRATIONS

1. MODEL DEMONSTRATED

system: LeMarquis Microspeed  
radar: Gatsometer  
camera: Robot

2. STATIONARY MODE: Yes

tripod mounted: No  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: No

3. MOBILE MODE: No

4. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: Yes

separate measurements for cars and trucks: Yes  
simultaneous measurements of each: Yes

5. OPTIONS ACTUALLY DEMONSTRATED

night operation: Yes  
day operation with flash standard: Yes  
remote control: No  
manual override: Yes  
computer interface: No  
comes with computer for traffic data collection: No  
software available: No  
video available: No

**EQUIPMENT COMPARISON**

**Company: Trafikanalys**

**PART ONE: BASED ON EUROPEAN AND AMERICAN SITE VISITS**

1. MODEL

system: Astro 110  
radar: RC110  
camera: Hasselblad

2. PRODUCER OF:

radar: Sensys Traffic  
camera: Hasselblad  
electronics: Gatsometer  
lenses: Zeiss (Planar CF 75 mm)  
flash: Sensys Traffic

3. FCC APPROVAL

experimental: Yes  
standard waiver: No

4. RADAR

antenna type (parabolic, slotted wave guide, etc): Parabolic  
frequencies: 10.530 GHz + 1-20 GHz  
published accuracy: ±1 kph up to 250 kph, ±1% between 100–250 kph  
self-calibration (internal): Yes, every 15 min  
external calibration (tuning fork, etc): No  
independent testing (standards): Yes, by various governments  
radio frequency interference: No

## 5. PHOTOGRAPHY

standard shutter speed: 1/1000 sec  
optional shutter speed: Yes  
aperture priority: Yes  
shutter priority: No  
standard lenses: Zeiss Planar CF 75 mm  
optional lenses: No, but available on request  
system recycle time w/ flash: 1 sec  
system recycle time w/o flash: .001 sec  
daytime flash standard: Optional  
slave camera available: Yes  
flash triggered: No  
radar triggered: Yes

## 6. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: Yes  
one direction at a time: Yes  
both directions simultaneously: Yes

## 7. MOBILE MODE: No

## 8. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: Yes

separate measurements for cars and trucks: Yes  
simultaneous measurements of each: Yes

## 9. OPTIONS

night operation: Yes  
day operation with flash standard: Optional  
remote control: Yes  
manual override: Yes  
computer interface: Yes  
comes with computer for traffic data collection: Yes  
software available: Yes  
video available: Yes

## PART TWO: BASED ON THE VIRGINIA DEMONSTRATIONS

### 1. MODEL DEMONSTRATED

system: RC 110 (prototype created for this demonstration)  
radar: RC 110  
camera: Robot

### 2. STATIONARY MODE: Yes

tripod mounted: Yes  
vehicle mounted: No  
one direction at a time: Yes  
both directions simultaneously: No

3. MOBILE MODE (INCOMPLETE DEMONSTRATION)

oncoming only: No  
receding only: Yes  
both directions: No  
both simultaneously: No

4. DIFFERENT SPEED LIMITS FOR CARS AND TRUCKS: No

5. OPTIONS ACTUALLY DEMONSTRATED

night operation: Yes  
day operation with flash standard: Yes  
remote control: No  
manual override: Yes  
computer interface: Yes  
comes with computer for traffic data collection: Yes  
software available: Yes  
video available: No



**APPENDIX D**

**Conditions Under Which Manufacturers' Photographs  
Were of Highest Quality**



Table D-1

**INFLUENCE OF LOCATION ON  
PICTURE QUALITY: RECEDING TRAFFIC**  
(Can the license plate be read and the speeding vehicle identified)

Manufacturer	I-64 Virginia	I-81 Virginia	I-295 Virginia	I-95 Virginia	I-95 Maryland	I-495 Virginia
AWA	---	1.98	2.21	0.43	0.13	---
GATSOMETER	4.30	---	---	0.57	0.33	0.12
TMT*	---	---	---	---	---	---
TRAFFIPAX	1.65	1.71	1.54	0.41	0.50	0.25
TRAFIKANALYS*	---	---	---	---	---	---

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of receding traffic produced.

Table D-2

**INFLUENCE OF WEATHER ON  
PICTURE QUALITY: RECEDING TRAFFIC**  
(Can the license plate be read and the speeding vehicle identified)

Manufacturer	Bright Sun	Hazy Sun	Overcast	Nighttime	Rain
AWA	0.54	1.81	2.22	—	—
GATSOMETER	1.54	0.65	0.29	0.65	0.42
TMT*	—	—	—	—	—
TRAFFIPAX	1.28	0.85	0.83	0.17	0.43
TRAFIKANALYS*	—	—	—	—	—

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of receding traffic produced.

Table D-3

**INFLUENCE OF MODE OF OPERATION  
ON PICTURE QUALITY: RECEDING TRAFFIC**  
(Can the license plate be read and the speeding vehicle identified)

Manufacturer	Stationary	Mobile
AWA	1.00	—
GATSOMETER	0.86	8.00
TMT*	—	—
TRAFFIPAX	—	1.00
TRAFIKANALYS*	—	—

$$\text{Representation ratio} = \frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$$

\*No pictures of receding traffic produced.

Table D-4

**INFLUENCE OF FILM FORMAT  
ON PICTURE QUALITY: RECEDING TRAFFIC**  
(Can the license plate be read and the speeding vehicle identified)

Manufacturer	Prints	Negatives
AWA	1.00	—
GATSOMETER	4.30	0.34
TMT*	—	—
TRAFFIPAX	1.00	—
TRAFIKANALYS*	—	—

$$\text{Representation ratio} = \frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$$

\*No pictures of receding traffic produced.

Table D-5

INFLUENCE OF TIME ON PICTURE QUALITY: RECEDING TRAFFIC  
(Can the license plate be read and the speeding vehicle identified)

Manufacturer	Night	Mid Morning	Late Morning	Lunch	Early Afternoon	Late Afternoon
AWA	—	0.43	0.13	—	2.16	1.88
GATSOMETER	0.65	0.67	1.23	4.93	—	—
TMT*	—	—	—	—	—	—
TRAFFIPAX	0.17	0.72	1.31	1.34	0.61	1.37
TRAFIKANALYS*	—	—	—	—	—	—

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of receding traffic produced.

Table D-6

INFLUENCE OF NUMBER OF VEHICLES  
ON PICTURE QUALITY: RECEDING TRAFFIC  
(Can the license plate be read and the speeding vehicle identified)

Manufacturer	One	Two	Three	4 or more
AWA	1.76	0.00	0.00	0.00
GATSOMETER	2.06	0.78	0.34	0.08
TMT*	—	—	—	—
TRAFFIPAX	1.80	0.46	0.10	0.01
TRAFIKANALYS*	—	—	—	—

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of receding traffic produced.

Table D-7

**INFLUENCE OF LOCATION ON  
PICTURE QUALITY: ONCOMING TRAFFIC**  
(Can the license plate be read and the driver and speeding vehicle identified)

Manufacturer	I-64 Virginia	I-81 Virginia	I-295 Virginia	I-95 Virginia	I-95 Maryland	I-495 Virginia
AWA	2.30	2.68	0.19	0.67	—	0.39
GATSOMETER	0.51	0.26	2.69	—	—	—
TMT	3.49	1.01	2.10	0.33	0.28	0.39
TRAFFIPAX*	—	—	—	—	—	—
TRAFIKANALYS	0.26	0.38	0.00	0.88	1.29	1.87

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of oncoming traffic produced.

Table D-8

**INFLUENCE OF WEATHER ON  
PICTURE QUALITY: ONCOMING TRAFFIC**  
(Can the license plate be read and the driver and speeding vehicle identified)

Manufacturer	Bright Sun	Hazy Sun	Overcast	Dark Sky	Nighttime	Rain
AWA	1.29	0.00	1.96	—	—	—
GATSOMETER	2.61	0.42	—	—	0.43	—
TMT	0.49	—	1.17	—	2.31	3.47
TRAFFIPAX*	—	—	—	—	—	—
TRAFIKANALYS	1.52	0.75	0.44	0.18	0.47	0.00

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of oncoming traffic produced.

Table D-9

INFLUENCE OF MODE OF OPERATION  
ON PICTURE QUALITY: ONCOMING TRAFFIC

(Can the license plate be read and the driver and speeding vehicle identified)

Manufacturer	Stationary	Mobile
AWA	1.00	—
GATSOMETER	1.00	—
TMT	1.00	—
TRAFFIPAX*	—	—
TRAFIKANALYS	0.66	3.49

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of oncoming traffic produced.

Table D-10

INFLUENCE OF FILM FORMAT  
ON PICTURE QUALITY: ONCOMING TRAFFIC

(Can the license plate be read and the driver and speeding vehicle identified)

Manufacturer	Prints	Negatives
AWA	1.01	0.96
GATSOMETER	1.00	—
TMT	—	1.00
TRAFFIPAX*	—	—
TRAFIKANALYS	—	1.00

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of oncoming traffic produced.

Table D-11

**INFLUENCE OF TIME ON PICTURE QUALITY: ONCOMING TRAFFIC**  
 (Can the license plate be read and the driver and speeding vehicle identified)

Manufacturer	Night	Early Morning	Mid Morning	Late Morning	Lunch	Early Afternoon	Late Afternoon	Early Evening
AWA	—	—	0.63	1.56	0.91	2.29	0.00	—
GATSOMETER	0.44	—	1.16	1.85	1.74	0.52	1.53	—
TMT	2.37	—	0.29	0.87	2.96	1.03	0.81	1.72
TRAFFIPAX*	—	—	—	—	—	—	—	—
TRAFIKANALYS	0.56	0.01	1.50	1.79	6.74	0.44	—	—

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

\*No pictures of oncoming traffic produced.

Table D-12

INFLUENCE OF NUMBER OF VEHICLES  
ON PICTURE QUALITY: ONCOMING TRAFFIC

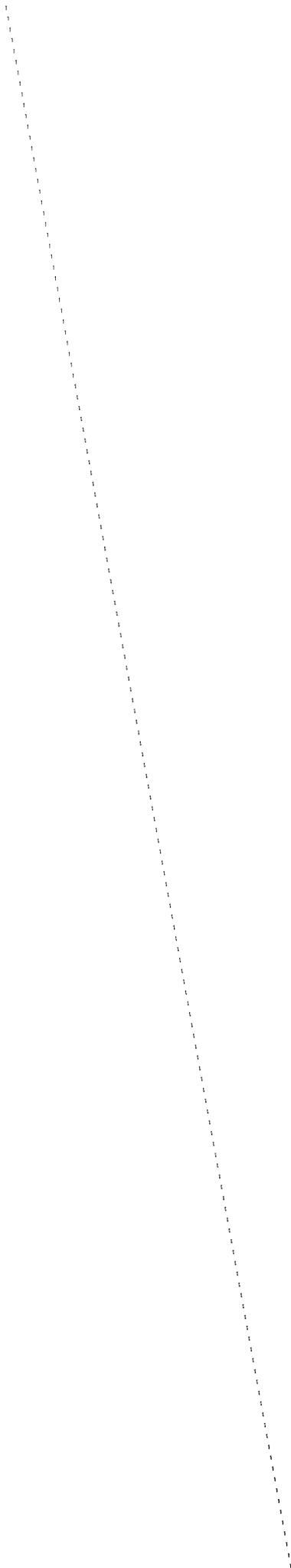
(Can the license plate be read and the driver and speeding vehicle identified)

Manufacturer	One	Two	Three	4 or more
AWA	1.89	0.00	0.00	0.00
GATSOMETER	1.15	0.20	0.00	—
TMT	1.55	0.00	0.00	0.00
TRAFFIPAX*	—	—	—	—
TRAFIKANALYS	1.36	0.09	0.00	0.00

Representation ratio =  $\frac{\% \text{ usable photographs in category}}{\% \text{ of all photographs in category}}$

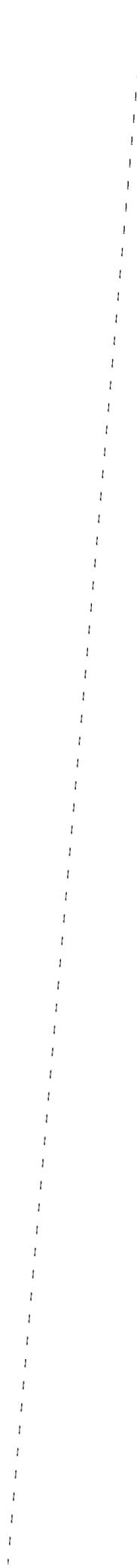
\*No pictures of oncoming traffic produced.

750



**APPENDIX E**

**Calculations of Sample Accuracy for the Public Acceptance Poll**



**Table E-1**

Sample accuracy in testing the difference between two proportions in a binary distribution or between a proportion and a standard or between a proportion and the population value using the actual variance in Question 7.

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2 (pq)^2}{(M_1 - M_2)^2}$$

$$\text{Corrected } n = \frac{\text{Population size} \times n}{\text{Population size} + n}$$

where:

- $\alpha, \beta$  are the power and confidence levels  
 $Z_{1-\alpha}, Z_{1-\beta}$  are the normal values for the confidence and power  
 $p$  is the probability of event 1  
 $q$  is the probability of event 2 or is  $(1 - p)$ , the probability of event 1 not happening  
 $M_1 - M_2$  is the smallest detectable difference between the proportions, the proportion and the standard, or the proportion and the population value

$$Z_{1-\alpha} = 1.96$$

$$Z_{1-\beta} = 0.85$$

$$p = 0.593$$

$$q = 0.407$$

$$M_1 - M_2 = 0.037$$

$$\text{Population size of group 1} = 1100000$$

$$\text{Population size of group 2} = 1100000$$

Uncorrected sample size is: 335.97

Corrected sample size is (group 1): 335.87

**Table E-2**

Sample accuracy in testing the difference between two proportions in a binary distribution or between a proportion and a standard or between a proportion and the population value using the maximum variance in Question 7.

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2 (pq)^2}{(M_1 - M_2)^2}$$

$$\text{Corrected } n = \frac{\text{Population size} \times n}{\text{Population size} + n}$$

where:

- $\alpha, \beta$  are the power and confidence levels
- $Z_{1-\alpha}, Z_{1-\beta}$  are the normal values for the confidence and power
- $p$  is the probability of event 1
- $q$  is the probability of event 2 or is  $(1 - p)$ , the probability of event 1 not happening
- $M_1 - M_2$  is the smallest detectable difference between the proportions, the proportion and the standard, or the proportion and the population value

$$Z_{1-\alpha} = 1.96$$

$$Z_{1-\beta} = 0.85$$

$$p = 0.5$$

$$q = 0.5$$

$$M_1 - M_2 = 0.039$$

$$\text{Population size of group 1} = 1100000$$

$$\text{Population size of group 2} = 1100000$$

Uncorrected sample size is: 333.76

Corrected sample size is (group 1): 333.66

**APPENDIX F**

**Model Photo-Radar Statutes for Maryland and Virginia**



## INTRODUCTION

### Maryland

The enabling legislation for photo-radar proposed for the state of Maryland was drafted with two important objectives in mind. First, the legislation establishing photo-radar use should be limited until use of photo-radar gains acceptance by the courts and the motoring public. Second, the legislation *must* address the myriad constitutional and evidentiary issues posed by the introduction of photo-radar. By embodying these principles in the enabling legislation, a statute is produced that not only ensures fair application of the technology but also provides guidance for law enforcement officers and state courts in interpreting the law.

Proposed Maryland Code Section 26-201(n)(i) restricts the use of photo-radar to Beltway speed enforcement by the State Police and limits its duration with a sunset clause that expires in 1994. Limiting the scope, duration, and control of photo-radar increases its attractiveness to the legislature by emphasizing that this legislation is intended to address the specific problem created by speeding drivers on the Beltway.

Sections 26-201(h)(3) and (4) of the Maryland legislation adopt guidelines for admissibility of photo-radar evidence. The statutory requirement that the photograph be of sufficient quality to identify the driver will aid implementation of the statute in two ways. First, it will signal to the legislature that the purpose of the statute is to target those drivers who are speeding on the Beltway, not to impose strict liability on the registered owners and lessees of photographed vehicles. Second, by providing a guideline for law enforcement officers as to the quality of picture required for admission of photo-radar evidence, the statute will minimize the charging of individuals with violations a court might dismiss. Requiring the police officer who activated the photo-radar equipment to testify about the camera placement and accuracy of the scene depicted satisfies the rule of evidence that someone must testify that the photograph is an accurate representation of the scene portrayed. However, if the State of Maryland decides that it will use unstaffed photo-radar, then the Maryland legislature should also codify the silent witness theory.

Sections 26-201(h)(5) and (6) accomplish the same objective as a rebuttable presumption that the registered owner or lessee is the driver of the photographed vehicle while avoiding the ruling under *Sandstrom v. Montana* (442 U.S. 510 (1979)) that use of a rebuttable presumption on an element of a criminal offense is unconstitutional, since it shifts the burden of proof from the state to the defendants. Section (5) under the Maryland statute imposes liability on the registered owner or lessee of the photographed vehicle for violation of the statute, but Section (6) provides an affirmative defense to a registered owner or lessee who identifies the driver at the time of the violation.

The provisions under Section 26-201(h)(7) in the Maryland statute create a mechanism for targeting the actual driver of the photographed vehicle once the regis-

tered owner or lessee identifies the driver. This will also aid passage by indicating to the legislature that the only individuals who will be charged with violation of this statute are speeding drivers and recalcitrant owners and lessees. Section 26-201(h) will also aid the passage of this legislation by providing lesser sanctions for those violators detected by photo-radar as compared with those sanctions imposed for speed violations detected by police officers. This emphasizes that the goal of this legislation is the reduction of Beltway speeds, not the creation of technologically advanced speed traps.

Section 26-201(h)(8)(I) outlines the procedures for citation of registered owners, lessees, and drivers. In providing the additional procedures for the citation of identified drivers, this section enhances the process for ticketing speeding drivers, furthering the objective of speed reduction on the Beltway. More important, this section's provision that citations be sent by certified mail preempts a potential Constitutional challenge by ensuring that the alleged violator is given adequate notice of any violation.

As written, this legislation presents a coherent policy for the implementation of photo-radar equipment on the Beltway. It confronts the variety of legal issues arising from the introduction of such an innovative technology but roots itself in the language and sanctions of the codes of Maryland. Further, it does so by providing significant constitutional and evidentiary protection to alleged violators as well as guidance to the legal system on the adjudication of violations detected by photo-radar.

## Virginia

The enabling legislation for photo-radar for Virginia proposed by the Virginia Department of State Police does not address the aforementioned constitutional and legal issues. It does not have a sunset provision or any provision for limiting its use to the Beltway and to the State Police, and it does not actually mention photo-radar. The State Police believe that photo-radar is not a new technology but is instead only the continuation of two known technologies, photography and radar. No new admissibility standards are necessary under this view. For the same reason, no additional testing or calibration standards are required.

Proposed Section 46.2-882.1(A) establishes a rebuttable presumption that the registered owner, unless a rental or leasing company, is guilty of the violation charged. Both reckless driving (with which the driver is charged if he or she is traveling 20 mph or more over the speed limit), a class 1 misdemeanor, and speeding are subject to this presumption. In support of the use of rebuttable presumption, the State Police cite the high-occupancy vehicle (HOV) statute, although violation of that statute is a noncriminal offense.

Proposed Section 46.2-882.1(B) provides for service on the owner to be executed by first-class mail. This, too, tracks the HOV statute, although the due process challenge appears far stronger given the potential for incarceration. If the

summoned person fails to appear, that person will be served notice by the Sheriff. However, if successful, photo-radar use is likely to increase significantly the number of speeding tickets written on the Beltway. This is likely to place considerable burden on the Sheriff's Office. There are to be no contempt charges or arrests for failure to appear in response to the initial summons. Thus, as written, the proposed Virginia legislation is open to a number of constitutional and evidentiary challenges that the proposed Maryland legislation would not face.

**PROPOSED MARYLAND STATUTE**

**A BILL ENTITLED**

AN ACT concerning

**Vehicle Laws—Photo-Radar Devices—Speeding Citations**

For the purpose of requiring a police officer who, based on evidence obtained by means of a photo-radar device, has probable cause to believe that the driver of a vehicle has exceeded the posted speed limit, to mail a citation to the registered owner of the vehicle and to keep a copy of the citation; *charging the registered owner, lessee, or identified driver of the vehicle with violation of this Act*; providing that certain requirements relating to the signing of a citation by the person charged do not apply to a citation issued under this Act; defining a certain term; making stylistic changes; and generally relating to the issuance of citations for speeding based on evidence obtained by photo-radar devices.

By repealing and reenacting, without amendments,

Article—Transportation  
Section 21-807  
Annotated Code of Maryland  
(1987 Replacement Volume and 1989 Supplement)

By repealing and reenacting, with amendments,

Article—Transportation  
Section 26-201 and 26-203  
Annotated Code of Maryland  
(1987 Replacement Volume and 1989 Supplement)

**SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, That the Laws of Maryland read as follows:**

700

Article—Transportation

21-807.

In each charge of a violation of any speed regulation under the Maryland Vehicle Law, the charging document shall specify:

- (1) The speed at which the defendant is alleged to have driven;
- (2) If the charge is for exceeding a maximum lawful speed, the maximum speed limit applicable at the location; and
- (3) If the charge is for driving below a minimum lawful speed, the minimum speed limit applicable at the location.

26-201.

(a) A police officer may charge a person with a violation of any of the following, if the officer has probable cause to believe that the person has committed or is committing the violation:

- (1) The Maryland Vehicle Law, including any rule or regulation adopted under any of its provisions;
- (2) A traffic law or ordinance of any local authority;
- (3) Title 9, Subtitle 2 of the Tax—General Article;
- (4) Title 9, Subtitle 3 of the Tax—General Article;

or

- (5) Article 56, Sect. 148 of the Code.

(b) A police officer who charges a person under this section, *except for a violation of Title 21, Subtitle 8 of this article detected by a "photo-radar device,"* shall issue a written traffic citation to the person charged. *A written traffic citation shall be issued by the police officer or authorized representative of any other state agency or contractor designated by the State for any violation of Title 21, Subtitle 8 of this article detected by a "photo-radar device" as described in this section.*

(c) A traffic citation issued to a person under this section shall contain:

- (1) A notice to appear in court;
- (2) The name and address of the person;
- (3) The number of the person's license to drive, if applicable;
- (4) The State registration number of the vehicle, if applicable;
- (5) The violation charged;

(6) Unless otherwise to be determined by the court, the time when and place where the person is required to appear in court;

(7) A statement acknowledging receipt of the citation, to be signed by the person;

(8) On the side of the citation to be signed by the person, a clear and conspicuous statement that:

(i) The signing of the citation by the person does not constitute an admission of guilt; and

(ii) The failure to sign may subject the person to arrest; and

(9) Any other necessary information.

(d) Unless the person charged demands an earlier hearing, a time specified in the notice to appear shall be at least 5 days after the alleged violation.

(e) A place specified in the notice to appear shall be before a judge of the District Court, as specified in Sect. 26-401 of this title.

(f) An officer who discovers a vehicle stopped, standing, or parked in violation of Sect. 21-1003 of this article shall:

(1) Deliver a citation to the driver or, if the vehicle is unattended, attach a citation to the vehicle in a conspicuous place; and

(2) Keep a copy of the citation, bearing [his] the officer's certification under penalty of perjury that the facts stated in the citation are true.

(g) (1) A law enforcement officer who discovers a motor vehicle parked in violation of Sect. 13-402 of this article shall:

(i) Deliver a citation to the driver or, if the motor vehicle is unattended, attach a citation to the motor vehicle in a conspicuous place; and

(ii) Keep a copy of the citation, bearing the law enforcement officer's certification under penalty of perjury that the facts stated in the citation are true.

(2) In the absence of the driver, the owner of the motor vehicle is presumed to be the person receiving the citation or warning.

(h) (1) *The Maryland State Police are authorized to use "photo-radar" technology on the Maryland portion of the Capital Beltway (I-495) and I-95 for the purpose of detecting speeding violations. This authorization will expire July 1, 1994, unless re-enacted prior to that date.*

(2) *In this subsection, "Photo-Radar Device" means a device that:*

(I) *Uses radio-micro waves to measure and indicate the speed of a moving object; and*

100

(II) *Photographs the moving object for which speed is being measured.*

(3) *Photographs by a photo-radar device must be of the vehicle's registration plate and of the driver of the vehicle and must be of sufficient quality to identify the driver of the vehicle.*

(4) *Such photographs shall be accepted as prima facie evidence of the speed of the motor vehicle in any court or legal proceeding under this section where the speed of the motor vehicle is at issue provided that the police officer or authorized representative of any other state agency or contractor designated by the State who activated the equipment shall testify as to the placement of the camera and the accuracy of the scene depicted.*

(5) *A person is in violation of Title 21, Subtitle 8 of this article if the person is the registered owner or the lessee of the vehicle driven in excess of the posted speed limit. In the case of leased or rented vehicles, the companies holding title to such vehicles shall inform the police, under authority of Sect. 18-103(d), as to the identity of the lessee.*

(6) *It shall be an affirmative defense to a violation of Title 21, Subtitle 8 of this article by the registered owner or lessee of the photographed vehicle that the registered owner or lessee of the photographed vehicle identifies another person who drove the vehicle at the time of the violation or that the vehicle was stolen or used by an unauthorized person at the time of the violation.*

(7) *In the event that the registered owner or lessee of the photographed vehicle identifies the person who drove the vehicle at the time of the violation, the person so identified will be charged with violation of Title 21, Subtitle 8 of this article for driving the vehicle in excess of the posted speed limit.*

(8) *If a police officer or authorized representative of or any other state agency or contractor designated by the State, based on photographic evidence obtained by means of a Photo-Radar Device, has probable cause to believe that a vehicle has been driven in violation of Title 21, Subtitle 8 of this article by being driven in excess of the posted speed limit, the police officer or any other state agency or contractor designated by the State shall:*

(I) *Promptly send a citation by certified mail to the registered owner or lessee of the vehicle charging the registered owner or lessee with the violation or promptly send a citation by certified mail to the identified driver of the vehicle charging the identified driver with the violation in the event that the registered owner or lessee of the vehicle identifies the person who was driving the vehicle at the time of the violation; and*

(II) *Keep a copy of the citation, bearing the police officer's certification under penalty of perjury that the facts stated in the citation are true.*

(9) *A person charged with violation of this section who does not elect to contest the charge must sign the citation and return it along with any fines that the*

*State assesses for violation of Title 21, Subtitle 8 of this article. If a person wishes to contest a charge for violation of Title 21, Subtitle 8 of this article, that person must sign the citation and appear in court at the time and place designated in the citation.*

*(10) Signs to indicate the use of photo-radar devices for measuring speed shall be clearly posted along the Capital Beltway at locations selected by the Department of Transportation Commissioner.*

*(11) The penalties for violations under this section shall be as prescribed under the Schedule of Pre-set Fines and/or Penalty Deposits set out in Sect. 21, Subsect. 801.1.*

**26-203.**

(a) This section applies to all traffic citations issued under this subtitle, unless:

(1) The person otherwise is being arrested under Sect. 26-202(a)(1), (2), (3), or (4) of this subtitle;

(2) The person is incapacitated or otherwise unable to comply with the provisions of this section;

(3) The citation is being issued to an unattended vehicle in violation of Sect. 21-1003 of this article;

(4) The citation is being issued to an unattended motor vehicle in violation of Sect. 13-402 of this article; or

(5) *The citation is being issued by certified mail to the registered owner, lessee, or identified driver of a vehicle in accordance with Sect. 26-201(h) of this subtitle.*

(b) On issuing a traffic citation, *except a traffic citation issued by certified mail to the registered owner, lessor, or identified driver of a vehicle in accordance with Sect. 26-201(h) of this subtitle*, the police officer shall request the person to sign the statement on the citation acknowledging its receipt. If the person refuses to sign, the police officer shall advise the person that failure to sign may lead to the person's arrest.

(c) On being advised that failure to sign may lead to his arrest, the person may not refuse to sign. If the person continues to refuse to sign, the police officer may arrest the person for violation of this section or, as provided in Sect. 26-202(a)(5) of this subtitle, for the original charge, or both.

(d) *If a person acknowledging receipt of a citation through certified mail refuses to sign the citation, the issuing authority shall advise the person that failure to sign may lead to the person's arrest. On being advised that failure to sign may lead to his arrest, the person may not refuse to sign. If the person continues to refuse to sign, the police officer may arrest the person for violation of this section, as provided in Sect. 26-202(a)(5) of this subtitle, for the original charge, or both.*

## PROPOSED VIRGINIA STATUTE

§ 46.2-882.1 *Presumption that registered owner is driver; summons by mail. — A. In the prosecution of an offense of exceeding the posted speed limit, or of reckless driving in violation of § 46.2-862, proof that the vehicle described in the summons was operated in excess of the posted speed limit, together with proof that the defendant was at the time of such violation the registered owner of the vehicle, shall constitute in evidence a rebuttable presumption that such registered owner of the vehicle was the person who committed the violation. Such rebuttable presumption shall not arise when the registered owner of the vehicle is a rental or leasing company.*

*B. Notwithstanding the provisions of § 19.2-76, whenever a summons for operating a motor vehicle in excess of the posted speed limit, or for reckless driving in violation of § 46.2-862, is served in any county, city, or town, it may be executed by mailing by first-class mail a copy thereof to the address of the owner of the vehicle as shown on the records of the Department of Motor Vehicles. If summoned person fails to appear on the date of return set out in the summons mailed pursuant to this section, the summons shall be executed in the manner set out in § 19.2-76.3. No proceedings for contempt or arrest of a person summoned by mailing shall be instituted for his failure to appear on the return date of the summons.*

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16. Abstract <p>Congestion on our nation's highways, especially in urban areas, is a serious problem that is growing steadily worse. In Virginia, it is estimated that 28 percent of the daily vehicle miles of travel (VMT) occurring during peak hour traffic is congested (volume/service flow ratio &gt; 0.75). Further, it is estimated that the cost of urban area congestion in Virginia will amount to more than \$4 billion in the year 2000.</p> <p>Transportation professionals in Virginia need to be cognizant of and familiar with congestion-reducing measures so as to implement them at every opportunity. Accordingly, this research was conducted to (1) develop a categorical list of congestion-reducing measures, and (2) document the implementation of and experiences with these measures in Virginia. The latter included a subjective evaluation of each measure's effectiveness, cost, and barriers to implementation. The scope was limited to a literature review and a survey of transportation officials in Virginia.</p> <p>Based on the literature, 53 congestion-reducing measures were categorized by whether they manage the existing supply of transportation facilities, add to that supply, manage the existing transportation demand, or control demand growth. Experiences with these measures were documented from the survey of transportation professionals in Virginia. Conclusions were reached regarding the effectiveness, cost, and ease of implementation of individual measures as well as categories of measures.</p>					
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67

