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16. Abstract

Information was collected and analyzed on recent advances in speed enforcement technology and enforcement strategies employing these technologies. Both automated and manually operated equipment was reviewed, and both radar and nonradar technologies were included. Automated enforcement of red light violations was also examined.

The new technologies are all foreign, and are being employed widely throughout the world. All of them have the capability of automatically photographing the vehicle that the equipment identifies as being in violation. Most of the systems use some sort of radar, either a narrow beam cross-the-road-technology or a short range, low power down-the-road technology. One new system incorporates digital signal processing, and can simultaneously track multiple vehicles in several lanes. All of the systems represent technical advances over the state of the art used in Europe and elsewhere 10 years ago.

Recently, some of this equipment has been placed in use in a few communities in the United States. The most recent experiences have been well received by the public and the courts. In some cases new legislation has been passed dealing explicitly with this technology. It appears that the use of this type of equipment and the related enforcement strategies is a viable alternative to traffic law enforcement in the United States. The equipment described is not endorsed nor is any device recommended over another.

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INTRODUCTION

1.1 NEED FOR THE STUDY

Speed limits and their enforcement have long been considered important contributors to maintaining safety on highways. It is well recognized that accidents occurring at higher speeds are more likely to result in fatal or serious injuries than those at lower speeds. For this and other safety reasons, states and municipalities have passed laws and placed speed limits on their roads, and instructed their police personnel to enforce these limits. The National Highway Traffic Safety Administration (NHTSA) has, for years, funded research and provided funds through its 403 and 402 programs to support more effective speed enforcement efforts.

The OPEC oil embargo of 1973, which created a temporary fuel shortage in the United States, resulted in a great impetus toward reducing speeds and speed limits and increasing speed enforcement. The Emergency Highway Energy Conservation Act[1] and the Federal-Aid Highway Amendments of 1974[2] required each state to enact and enforce a maximum 55-mph speed limit (now referred to as the 55-mph National Maximum Speed Limit or NMSL). The 55-mph NMSL was in effect in all states by March 1974. Subsequently, the U.S. Congress required the states to establish speed-monitoring programs. Compliance goals were set for a multiple-year period and sanctions were developed in the Surface Transportation Assistance Act of 1978.[3]

There is little doubt that these actions did, indeed, reduce average speeds (and speed variances) on the highways. Likewise, it is generally agreed that fuel consumption decreased and that safety benefits were realized, including a dramatic drop in traffic fatalities (from 55,511 in 1973 to 46,402 in 1974). The magnitude of the safety effects of the 55-mph NMSL have been debated for some time and are discussed in considerable detail in the Transportation Research Board Special Report 204, prepared at the request of Congress in 1984 and titled "55: A Decade of Experience."

Speed data collected by the states and numerous other sources revealed that whereas average speeds dropped appreciably in 1974, they began to increase noticeably thereafter, reaching averages in the 58- to 62-mph range. Federal Highway Administration (FHWA) data[4] indicated that most, if not all states met the 1979 compliance goal on 55-mph roads (at least 30% compliance on a vehicle-miles-of-travel basis). However, the progressively more stringent goals of the next several years became difficult to satisfy. Approximately a dozen states, located mostly in the western half of the nation, did not meet the 1980 goal.

Achieving increased compliance was extremely difficult, according to most law enforcement officials. A majority of the public said they supported the 55-mph NMSL; nevertheless, most drivers violated it, at least some of the time. To increase compliance, a variety of public information and education campaigns was devised. These campaigns were both national and local in scope, but their impact was largely unmeasured or unmeasurable.

Enforcement efforts were increased to meet compliance requirements. Many states utilized special patrol strategies, such as saturation techniques, selective enforcement, covert techniques, use of CB radios, combining enforcement with public information, etc. Officials began to express doubts as to further increases in effectiveness of such approaches, primarily because of manpower limitations (as well as budgetary constraints). Some also indicated difficulties in ticketing and convicting those traveling at just slightly over the speed limit--e.g., 56 or 57 mph, or in stopping speeders safely in heavy traffic.

Speed enforcement has long been enhanced by the application of technology. Of particular importance have been the use of radio communications, computerized data bases, aircraft surveillance and radar. The latter, in particular, has been used by nearly every law enforcement agency to enforce speed limits. Radar units are available from numerous manufacturers in the United States. Models can be purchased for operation in either fixed or moving modes, in either hand-held or vehicle-mounted configurations, and in either continuous or burst power modes. Over the last dozen years NHTSA has developed test standards and training programs, and commercially available units have been improved. The National Institute of Standards and Technology (formerly the National Bureau of Standards) has stated that the U.S. radar units are accurate and reliable "when carefully installed and properly operated by skilled and knowledgeable operations."[5]

Clearly, the problem of achieving better compliance with the 55-mph NMSL, and with speed limits in general, was very difficult. Increased compliance required continued development and application of new ideas. These ideas included experimentation with manpower deployment strategies, public information and education, and their coordination. However, education and the increased efforts by personnel alone was not enough. Cost-effective approaches to improving compliance were sought through application of modern technology. To this end, a multiyear study was awarded to Midwest Research Institute (MRI) by NHTSA in 1978 to identify the technologies that may be applicable to speed enforcement--particularly automatic speed enforcement--and second, to assess the practical feasibility of such technologies in the United States. Many devices were identified and described in the study reports[6,7] for use in speed measurement and enforcement. One such technology identified was particularly well suited for automated speed enforcement. That technology used a camera coupled with across-the-road radar to record automatically the license plate of speeding vehicles. The technology was used extensively in Europe and Japan, both in manned and unmanned operations, and in manned operations in South Africa and Australia. The technology continues to be used in Europe, South Africa, and Australia and has been used recently in selected areas of the United States.

By 1987 fuel had become more plentiful and cheaper, travel speeds had increased considerably, and support for the 55-mph NMSL had eroded. The public, many legislatures, and the media no longer supported the 55-mph NMSL. For these and other reasons, congressional legislation in April 1987 allowed states to raise the speed limit to 65 mph on rural interstate highways outside of urbanized population areas of 50,000 or more and on other specially designated rural, multilane highway facilities. By September 1987, 37 states had raised their speed limits on some facilities.

In the report accompanying the U.S. Department of Transportation's fiscal year 1988 appropriation bill, the House Appropriations Committee directed NHTSA to conduct "a comprehensive and definitive study of the safety impact of raising the speed limit to 65 mph on rural interstate highways." The Senate Appropriation Committee, in their report, also directed NHTSA to "assess the current state of monitoring/enforcement methodologies; assess information strategies that support enforcement efforts; assess new radar enforcement technologies; and assess speed compliance and the relationship to crashes." Both committees required NHTSA to prepare a detailed study plan for their review. NHTSA's study plan for assessing the safety effects of the speed limit increase and for evaluating speed limit measurement technologies and enforcement strategies was submitted in October 1987. Part of the study plan calls for an update of enforcement technology and speed measurement devices.

NHTSA has received numerous requests for information on new technological advances in speed measurement and enforcement. NHTSA's available information[6,7] was collected by MRI almost 10 years ago and is no longer current. Consequently, this study was initiated to update the previous MRI study and expand its scope to satisfy the congressional requirements. The current study concentrated on the identification of technologies that may be applicable to speed enforcement--particularly, automated speed enforcement--and on technologies applicable to the automatic detection of red-light violations.

1.2 SCOPE OF WORK

The scope of the work conducted under the contract involved collecting and analyzing existing information on (1) recent advancements in speed measurement and enforcement technologies that can be used to assist police in speed enforcement, (2) speed enforcement strategies and how speed measuring devices are employed in such strategies, and (3) automated equipment for enforcement of red-light violations. The speed measurement technologies addressed in the study include both automated and nonautomated methods, as well as radar and nonradar technologies. The study emphasized technology and related enforcement practices which are commonly employed elsewhere in the world and are just starting to be used in this country. The work focused primarily on automated systems (both speed and red-light detection) which may contribute to more efficient use of enforcement manpower.

The term "automated" refers to a technology that relieves the police officer of one or more normally manual functions. For speed enforcement, these functions include determining the speed of the vehicle, identifying the vehicle(s) exceeding a set speed, and documenting the violation. Thus, the definition is quite broad. It includes devices (such as radar) which measure speed, up to and including totally automatic systems that measure speeds, "identify" speeding vehicles and photograph them together with their speed, time, date, etc.--all without need for police officer presence. The systems available for detection of red-light violations are totally automatic in that they "identify" the offending vehicle(s) and photograph them together with data that establishes the conditions at the time of the violation. Here again, the recording of the offense is done without the need for a police officer's presence.

Technical information on the speed measurement and red-light detection devices was obtained from the manufacturers, both in the United States and abroad. Results of experiments or demonstrations of the devices were obtained from law enforcement and highway safety personnel. In addition, results from United States and foreign experience of regular use in the field are documented from contacts made with law enforcement personnel and from material received through judicial and legislative channels. No field tests of strategies or devices were conducted under the contract. Finally, any plans to implement the new speed detection and red-light violation detection technologies in the United States are also covered.

1.3 ORGANIZATION OF THE REPORT

Section 2 summarizes the three-step methodology followed in arriving at the research findings presented in this report. This methodology included: a search for updated information on speed measurement devices, concentrating on automated speed enforcement (ASE) devices, and information on enforcement technologies, including red-light violation detection equipment; a search for updated information on speed enforcement strategies and on how speed measurement devices are employed in such strategies; and the collection, analysis and documentation of the information identified concerning speed measurement devices and enforcement technologies and speed measurement strategies.

Section 3 presents a summary of the extant speed measurement devices and enforcement technologies identified in the study. Particular emphasis is given to the ASE devices and red-light violation detection equipment identified. This section also includes a brief summary of the trends noted in the enforcement technology over the last 10 years.

Section 4 presents a summary of the range of enforcement strategies used or usable with the speed measurement devices. The federal involvement with these strategies along with strategies used at the state and local levels are presented. A brief summary is also given of the trends noted in the enforcement strategies over the last 10 years.

Section 5 presents a brief summary of the trends in the legal issues associated with the use of ASE devices. The foreign experience is discussed along with the legal considerations and attitudes in the United States toward the use of ASE in this country.

Section 6 brings together information and data obtained during the contract for the purpose of comparing the selected ASE devices and red-light violation detection devices. The comparative data are presented in tabular format and are based on manufacturer specifications.

The last two sections present the conclusions and recommendations based upon the findings of the research. Some of the recommendations address follow-on implementation and tests of ASE devices and deployment strategies in the United States.

SECTION 2

RESEARCH METHODOLOGY

The research findings presented in this report resulted from a three-step methodology. These three steps are briefly described in the following sections.

2.1 SEARCH FOR SPEED MEASUREMENT DEVICES AND ENFORCEMENT TECHNOLOGIES

In this part of the study, new speed measurement devices and enforcement technologies were identified and a plan was developed for collecting data on each device identified. The plan also indicated the means for assessing the general merits of each enforcement technology identified and how all the information would be summarized. The speed enforcement technologies addressed included both automated and nonautomated systems as well as radar and nonradar technologies.

The search for speed measurement and enforcement technology was patterned after the successful approach used in the earlier MRI study of technology advancement for deterrence of speeding for National Highway Traffic Safety Administration (NHTSA) under Contract No. DOT-HS-8-02030. Included in the search were devices specifically designed for speed control and monitoring, as well as devices and concepts that might be so used even though they have not yet been implemented. No restrictions were placed on the national origin of the devices, i.e., both U.S. and foreign devices were investigated.

The search for devices was a multidirected activity that drew upon the knowledge and expertise of many sources of information. These included:

- Various U.S. government agencies.

    - National Highway Traffic Safety Administration (NHTSA)
    - Federal Highway Administration (FHWA)
    - National Bureau of Standards (NBS)
    - Federal Communication Commission (FCC)

- Contractors working on related projects.

- U.S. and foreign manufacturers known to MRI as a result of our previous study.

- International Association of Chiefs of Police (IACP).

- American Association of Radar Manufacturers.

- Various State Highway Patrol agencies.

- Departments of Transportation of various states.

- Various state highway safety personnel.

- Law enforcement personnel of various cities.

- Representatives of foreign governments (embassies and consulates).

- Foreign trade councils.

- Overseas research colleagues of MRI.

- Organization for Economic Cooperation and Development (OECD).

- Trade journals.

- Computerized literature search.

Many of the initial contacts with the above groups lead to secondary overseas sources (e.g., other manufacturers, researchers, traffic agencies, testing/certification laboratories, and law enforcement agencies) that were also contacted.

The standard, down-the-road, U.S.-made radar devices were excluded from the study, with one exception. The Hawk model radar unit manufactured by Kustom Electronics was considered because of its use also as a time/distance-measuring device. The effort that would have been spent on U.S.-made, down-the-road radars was shifted to identifying and evaluating: (1) speed measurement devices that employ time/distance-measuring capabilities, (2) devices used in billboard-type radar applications, and (3) devices used for enforcement of red light violations. Non-U.S.-made, down-the-road radar devices were considered in the study, especially if the devices incorporate innovative ideas in logic circuitry for speed detection.

A series of computerized literature searches was conducted during this portion of the study to identify recent research regarding speed detection devices, associated speed enforcement strategies, and devices used for red light violation. The searches were conducted using both the TRIS (Transportation Research Information System) and NTIS (National Technical Information Service) data bases. The following key words and combinations of them were used during the searches:

- Speed
- Measuring

- Enforcement
- Radar
- Red light

Searches using each of the above key words or combination of key words resulted in 100 to 3,000 hits per data base. Restrictions were subsequently added to the searches to delete nonapplicable documents. The restrictions disregarded documents dated before 1978 (the approximate time of our last computerized search for speed detection devices) and those involving airplanes, aircraft, trains, boats, and spacecraft. A total of 150 citations remained from both data bases after the restriction was applied. Abstracts of these citations were printed and examined manually. This review resulted in the identification of a few citations of potential value to the project. These documents were obtained from various technical libraries and thoroughly reviewed.

2.2 IDENTIFICATION OF SPEED ENFORCEMENT STRATEGIES

In this part of the study, the various speed enforcement strategies were identified and a plan was developed to collect information on speed enforcement strategies and on how speed measurement devices are employed in such strategies. A list was developed of 11 law enforcement agencies to be contacted for detailed information relative to their speed enforcement strategies. The sample of agencies (on the state, local, and municipal levels) selected was representative of the technologies being used. These technologies included air surveillance, Hawk radar, VASCAR-Plus, billboard-type radar, and ASE devices. An additional agency was contacted concerning its past and future use of red-light violation detection equipment. Enforcement activities that rely solely on the use of down-the-road radar units were excluded from consideration.

The list of recommended agencies was developed from contacts with several sources. These sources included manufacturers (or distributors) of speed enforcement equipment, law enforcement agencies known for their past interest in innovative speed enforcement technologies, and law enforcement agencies referred to us through preliminary contacts with other police agencies.

Information on speed enforcement strategies was also obtained from published reports (unattended radar used in Kentucky) and from correspondence with European law enforcement agencies regarding their use of ASE equipment.

2.3 COLLECT AND ANALYZE DATA

The objective of this step was to collect, analyze, and document the information identified in the other two steps concerning speed measurement devices and enforcement technologies and speed measurement strategies. The sources of data were threefold--manufacturers, law enforcement users, and research evaluations. As soon as a device was identified, its manufacturer was contacted, generally by letter, and asked to provide information on the product(s) in the form of brochures, descriptions, and technical data. Also requested were the names and addresses of agencies or law enforcement jurisdictions that were using the systems. The information and technical data sought, as a minimum, for each device were as follows:

- Device name and model number, manufacturer's name, mailing address, and telephone number.
- Basic operational characteristics of the equipment.
- Costs, including purchase, operation, training, and maintenance.
- Jurisdictions where the device has been used.
- Results of evaluations, demonstrations of field tests, if available.
- Real-world usefulness and effectiveness of the technology.
- Acceptability of the technology, including acceptability from the legal community, courts, police, and public.

Information on the above elements was obtained as best as possible through written, telephone, and in one case in-person discussions with the manufacturer of speed measuring and red light violation detection equipment and through contacts with law enforcement personnel. The U.S. experience with particular ASE technology was documented through telephone contacts, reports, and a personal visit to two jurisdictions. The foreign (European and Australian) experience with particular ASE technology was documented as carefully as possible from private communications and reports.

Selected users of technology were canvassed to obtain information on speed enforcement strategies and any evaluations they might have on the technology employed. The discussions with the law enforcement personnel relative to these two issues were meant to provide, as a minimum, the following information:

- General information about the jurisdiction.
- Speed measuring equipment used.
- Maintenance needs.
- Annual costs.
- Photographic evidence, where applicable.
- Personnel requirements, including training and certification needs.

- System effectiveness.
- Legal considerations.
- Attitudes about speed enforcement strategies.

Information on the above elements was obtained as best as possible through telephone and, in three cases, through in-person discussions with law enforcement personnel.

The third source of information on equipment capabilities was previous evaluations conducted by research organizations and law enforcement agencies. These evaluations were somewhat dated but did provide some additional insights into the operational limitations of selected systems.

The materials obtained from the various sources were cataloged and dated immediately upon receipt. The responses were quickly reviewed and then filed for later, more detailed review. During the detailed review of the data from the manufacturers, tabulations were made of the characteristics of the systems. These tabulations were used to identify necessary missing data that were needed to complete the documentation of the systems. Follow-up letters to most of the manufacturers were faxed and/or mailed to request the missing information.

Comparisons of selected ASE devices and selected red light violation detection devices were made from the tabulation of device characteristics. No formal utility assessment of the devices was performed because of limited information. A formal utility assessment was performed in our previous study based on information obtained firsthand from visits to manufacturers of ASE devices and foreign law enforcement users of ASE equipment. Such visits were not possible in the current study because of budgetary constraints.

SECTION 3

SUMMARY OF EXTANT SPEED MEASUREMENT DEVICES AND ENFORCEMENT TECHNOLOGY

This section summarizes the technology that was identified as being potentially useful in speed enforcement and for detection of red-light violations. Over 30 concepts were identified, most of which have actually resulted in devices that are either being used operationally for speed enforcement somewhere in the world or were used for research purposes.

Many systems were found to be of special interest because of their potential to substantially enhance police manpower efforts in speed enforcement by making the function less labor intensive. These systems have in common some means of automatically identifying, from among the traffic flow, those particular vehicles exceeding a preset limit and then providing evidence. Typically, this evidence is in the form of a photograph, although video evidence is also considered. These systems can, in principle if not in actual practice, be operated totally automatically without a police officer in attendance. The ASE systems, representing the products of 10 European, Australian, and South African* firms, are one of two major focuses of this section. The second major focus is the red-light violation detection equipment identified in the study.

Of the 10 systems (more than 10 if the various models of each are counted), six use Doppler radar. However, the physical principle of Doppler radar is applied in a manner quite different than is used in the United States. The way in which four of these systems use the radar principle, sometimes referred to as cross-the-road radar, is presented in Section 3.1. Then follows in Section 3.2 a technical description of the six radar-based systems (in alphabetical order by name of the manufacturer) and the other four systems of particular interest, also in alphabetical order. Specific characteristics of the ASE systems are presented

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* Certain products may not be imported into the United States from South Africa under the Anti-Apartheid Act of 1986, 22 U.X.C. § 5001, et seq. and 31 C.F.R. Part 545. In addition, no article which is produced, manufactured, marketed, or otherwise exported by a parastatal organization of South Africa may be imported into the United States under the Anti-Apartheid Act of 1986, supra, and 31 C.F.R. § 545.208(a). A parastatal organization is a corporation, partnership, or entity owned, controlled, or subsidized by the Government of South Africa. See, 31 C.F.R. § 545.315.

later in the report in Section 6. A comprehensive listing of all speed enforcement technologies identified in the study is given in Section 3.3. Presented also in this section are the technical descriptions of several of the non-ASE devices that have unique characteristics for speed enforcement needs. The technical descriptions of the red-light violation detection equipment identified in the study are given in Section 3.4. The trends in enforcement technology over the last 10 years are presented in Section 3.5.

3.1 CROSS-THE-ROAD RADAR

Radar devices commonly used in the United States emit a microwave beam that is directed down the road, usually head-on into oncoming traffic. The reflected Doppler frequency is then converted into a speed measurement. While the radar principle is highly accurate (as are the U.S. devices), the down-the-road concept has some operational limitations. Although the radars often can determine vehicle speeds at long range (1/4 to 1 mile), they are not able to discriminate between vehicles. If two or more vehicles are visible to the beam, officer judgment must be used as to which vehicle is producing a "reading." With some units it is the vehicle presenting the largest target, which is a function of size, nearness to the transmitter, and flatness of the frontal area. Other units produce the speed of the fastest vehicle in view. These units are usually not recommended for use in heavy traffic. Also, since their use requires the officer to stop the offending vehicle, they may not be appropriate where high speed chase is against policy, or where the roadway does not provide safe areas for pulling offenders out of traffic. Finally, the long range of the radars, coupled with their moderately high power, enable them to be detected by drivers with radar detectors and possibly avoid arrest.

The cross-the-road radar systems use a very narrow, low-power beam directed at an angle on the order of 20° from the direction of traffic, as shown in Figure 3-1. (The exact angle differs from manufacturer to manufacturer.) Then, signal-processing logic corrects the reflected Doppler frequency for the cosine effect* and ascertains whether a stable speed is being observed. Upon passing the logic tests designed by the particular manufacturer, a speed reading is displayed. The vehicle to which it applies is readily apparent to an observer viewing along the beam. If more than one vehicle is in the beam at once, normally no reading will be displayed. Most such systems also enable the incorporation of a camera which can be triggered to photograph the vehicle after it leaves the beam. The cross-the-road systems are most frequently used to view receding traffic, as illustrated by Figure 3-1, but they can also be set up to look at oncoming vehicles, again by aligning the beam at a prescribed angle across the roadway.

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* For any angle of 20° the directly measured "speed" is cos20° times the actual speed, or roughly 94% of the actual speed. The logic makes a mathematical correction to determine actual speed.

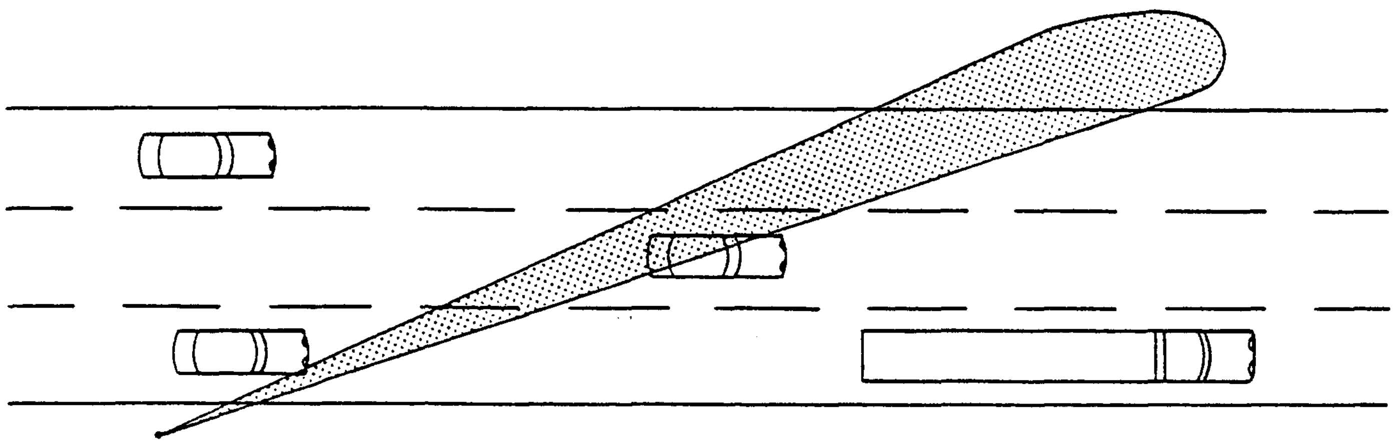


FIGURE 3-1. ILLUSTRATION OF THE CROSS-THE-ROAD CONCEPT.

Among the advantages claimed for cross-the-road radar systems are their ability to make positive identification of speeding vehicles; to detect nearly all speeders, even in dense traffic (time-headway separations of only 1/2 to 1 sec are required); to be relatively free from effects of electrical and other interferences; and to be effective even against vehicles with radar detectors (the vehicle is in the beam and its speed is noted before a driver could react).

3.2 DESCRIPTIONS OF ASE DEVICES

A technical description of each of the 10 ASE systems identified is presented in this section. The systems employing Doppler radar are presented first followed by those using other concepts for speed determination. A list of 10 ASE systems is given below. A tabulation is given in the Appendix of the ASE manufacturer's name; mailing address; telephone number; fax number, if known; and the identification of any known manufacturer's U.S. representative. The systems described are not endorsed nor are any of them recommended over another.

AWA Defense Industries Pty. Ltd. (Australia)
Gatsometer B.V. (Netherlands)
Plessey South Africa, Ltd. (South Africa)
Traffipax-Vertrieb (West Germany)
Trafikanalys AB (Sweden)
Zellweger Uster AG (Switzerland)
Eltraff S.r.l. (Italy)
Proof Digitalsystemer A/S (Denmark)
Trans-Atlantic Equipment Pty, Ltd. (South Africa)
Truvelo Manufacturers (West Germany)

3.2.1 AWA Defense Industries Pty. Ltd.

This Australian firm, formerly named Fairey Australasia Pty. Ltd. and originally a subsidiary of Fairey Aviation Ltd. of Britain, has manufactured radar speed detection devices for about 14 years. The currently produced Vehicle Speed Radar (VSR) Model 449 is a manned, portable, self-contained device that uses cross-the-road Doppler radar which is controlled by a microprocessor. The unit can be connected to a camera for obtaining photographic evidence of speeding vehicles. The back of the radar unit with the camera mounted on top is shown in Figure 3-2.

The radar used in the VSR has a frequency of 24.15 GHz and a beam width of 4°. The narrow beam enables the detection of closely spaced vehicles as are commonly found in urban areas. The VSR has an operating range of 50 m and can automatically discriminate between approaching and receding traffic. A switch is provided for the user to select the direction of traffic being monitored. The microprocessor in the VSR is programmed to analyze the Doppler signals and to reject a speed measurement if the instantaneously derived velocities vary more than a preset limit. Built-in automatic testing verifies continuously that the equipment is operating correctly and accurately.

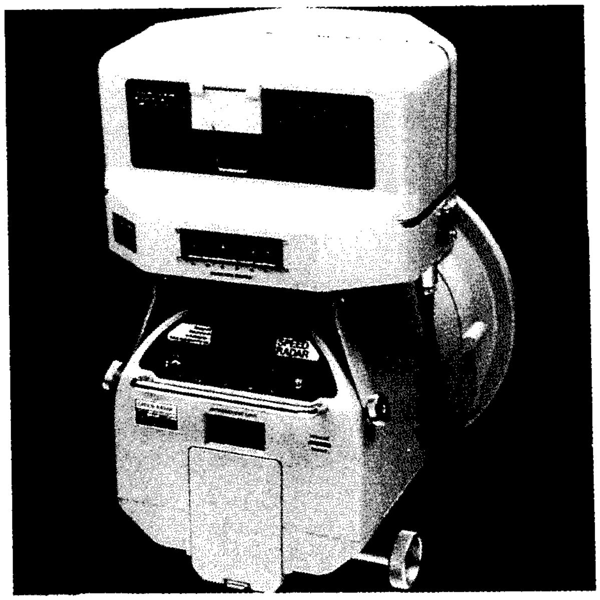


FIGURE 3-2. VEHICLE SPEED RADAR.

Photo courtesy of AWA Defense Industries Pty. Ltd.

The design of the system is such that the unit can be quickly and easily set up on the roadside or on an overpass. The unit is typically mounted on a tripod. The carrying handle on the radar also incorporates a protractor which is used to correctly set the angle (25°) of the radar antenna to the road. The unit is self-contained in that it is powered with a rechargeable, sealed battery pack that provides 6 hr of operation.

The optional photographic camera unit provides a record of the speeding vehicle along with the speed, location, direction of travel, time, and date of the offense. Examples of rear photographs taken with the system are given in Figure 3-3. The unit can, alternatively, output speed, time, and date of the offense by way of an RS232 interface.

The radar performance complies with the current issue of the Standards Association of Australia, Specification Radar Speed Detection 2898, and is approved for use in Australia. Application has been made with the Federal Communications Commission for type acceptance in the United States.

3.2.2 Gatsometer B.V.

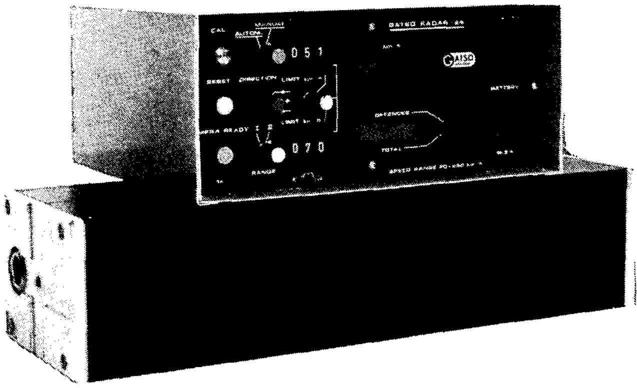
This firm was founded in Holland in 1958 and manufactures several traffic speed detection and surveillance systems. The firm makes four speed detection systems that are divided into two groups: Gatso mini radar MK3 and MK4, and Gatso micro radar Type 24 and Type RadCam 24. The Gatso mini radar MK3 and MK4 are older units that were described in MRI's earlier study.[6,7] They are tripod-mounted, roadside ASE devices that use cross-the-road radar operating at 13.45 GHz. The Gatso micro radar Type 24 and Type RadCam 24 are the newest and most advanced ASE systems offered by the firm. The latter two devices are similar in their operations but differ slightly in their components. The Gatso micro radar Type 24 consists of a radar subsystem which contains a cross-the-road radar operating at 24.125 GHz, an antenna, and a microprocessor control unit; a robot traffic camera; a flash unit, a flash generator, and an independent electrical power supply; and a hand-held override control unit. The components of the Gatso micro radar Type RadCam 24 are the same as the Type 24, except the microprocessor control unit is somewhat different and the camera used is a motor-driven, single-lens reflex camera with a zoom lens.

When a speeding vehicle has been detected, the camera of each system (Type 24 and RadCam 24) automatically photographs the vehicle. Superimposed in the top right-hand corner of the photograph are the time, date, and speed of the offending vehicle.

The two ASE systems (Type 24 and RadCam 24) can be used for stationary, as well as moving, speed enforcement with only one officer required for each mode of operation. When used for stationary operations, these systems are either mounted on a tripod next to the roadway (see Figure 3-4), built into a trailer that is located alongside the roadway, or built into a patrol car (see Figure 3-5) that is positioned

FIGURE 3-3. EXAMPLES OF REAR PHOTOGRAPHS TAKEN WITH THE VSR.

Photos courtesy of AWA Defense Industries Pty. Ltd.



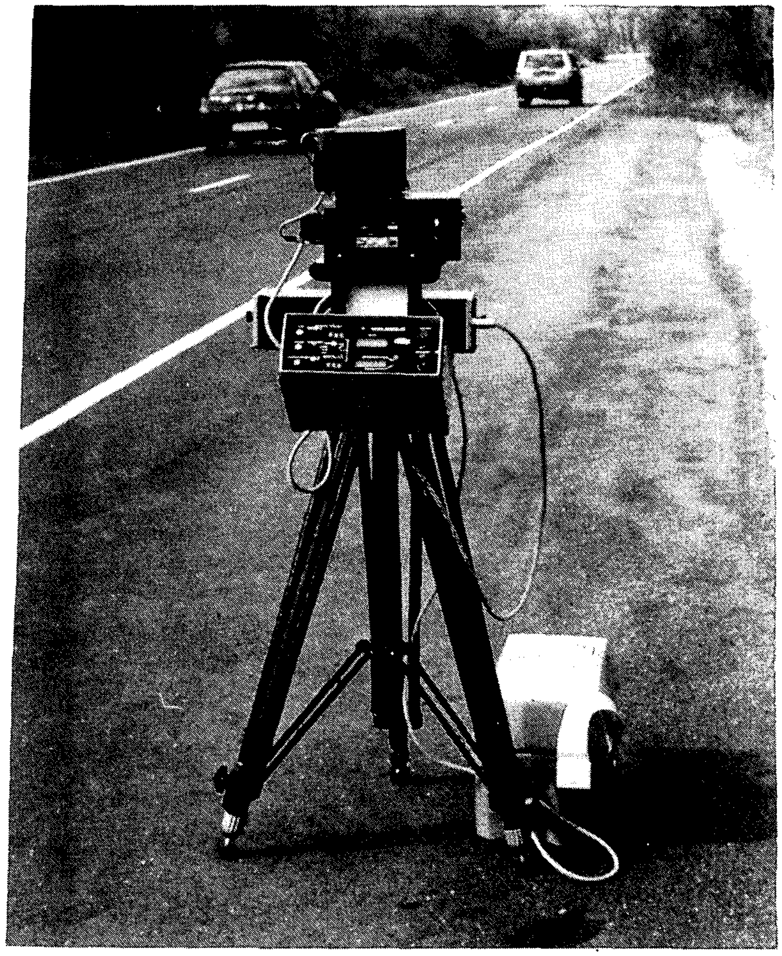


FIGURE 3-4. GATSO MICRO RADAR TYPE 24 MOUNTED ON A TRIPOD.

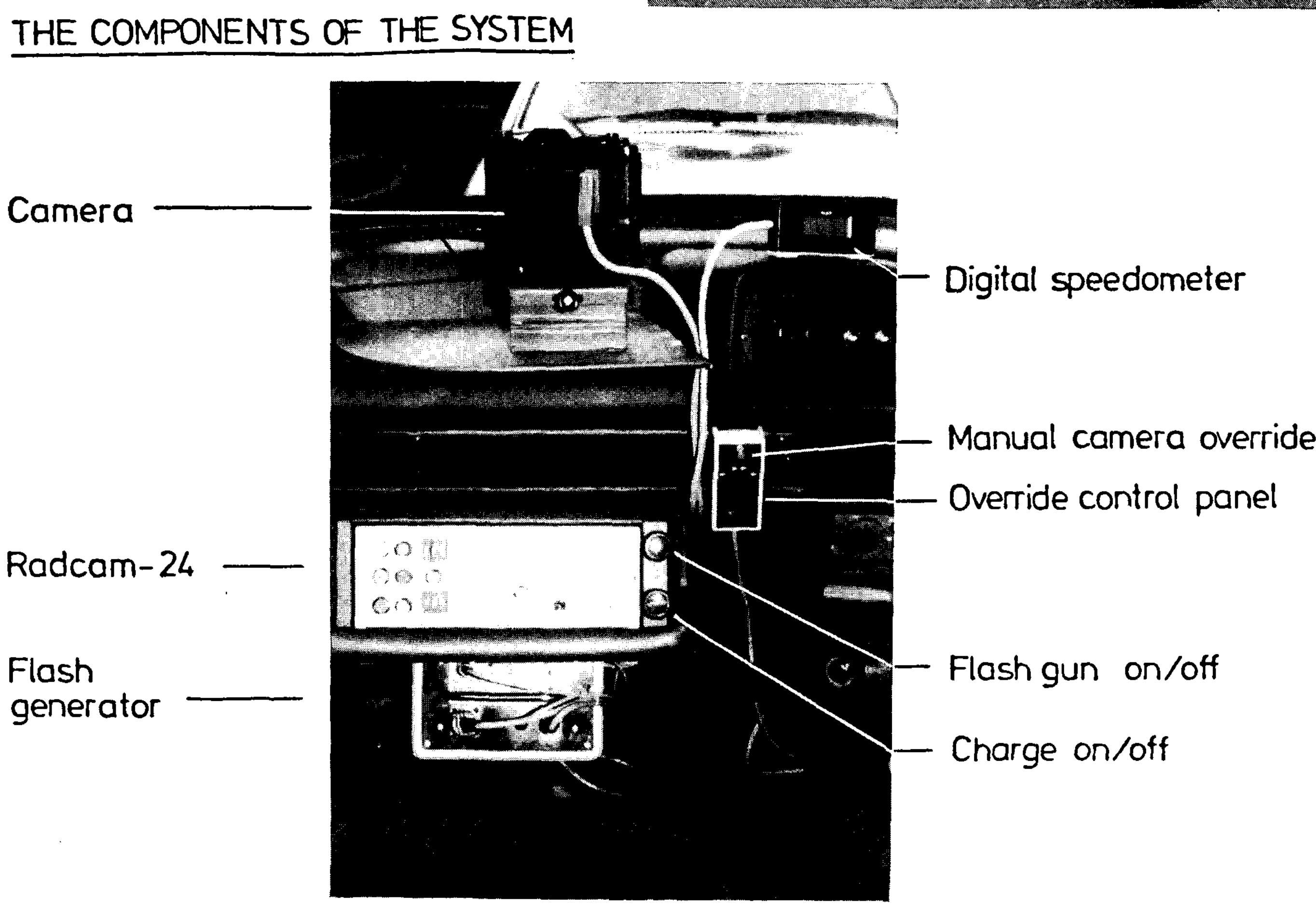


FIGURE 3-5. GATSO MICRO RADAR TYPE RADCAM 24 MOUNTED IN A PATROL CAR.

to monitor traffic. The systems can also be unmanned and located on a fixed installation post. In these stationary operations, the systems can be set to photograph approaching or receding vehicles, or they can be set to automatically photograph speeding vehicles in both approaching and receding directions of travel.

When the systems are used for moving speed enforcement, they are referred to as mobile-radar-camera (MRC) systems. When installed in a patrol car, the antenna is either fitted behind a nonmetal engine grill or on a roof rack, while the flash is incorporated into a fog lamp. The traffic camera and the radar control unit are fitted within easy reach of the driver or in the dashboard of the patrol car. A digital speedometer is provided also with the MRC systems.

In the moving operation, the systems will automatically take rear photos of vehicles passing the patrol car at a speed above a preset limit (threshold speed). In this case, the patrol car needs to be traveling at a steady speed. The speeds of the patrol car and the overtaking vehicle are both displayed in the photo. In this situation, the speed of the patrol car is measured with a digital speedometer and the speed of the passing vehicle relative to the patrol car is measured with the onboard radar unit. The speed of the offending vehicle is the sum of the patrol car's speed plus the relative speed (also displayed on the photograph) of the passing vehicle. The systems' camera is blocked from taking photographs of approaching traffic during moving operations. The MRC systems can also be used, with a hand-held control unit, to photograph speeding vehicles during following conditions. In this case, the photos are taken by hand and show the driving speed of the patrol car and the traffic situation. Examples of photographs taken by the Gatso systems are shown in Figure 3-6.

Both the Type 24 and RadCam 24 are capable of operating with separate speed limit settings for passenger cars and for trucks. The two speed settings can only be used when observing receding (not oncoming) traffic during either stationary or moving operations. The details of how the two speed limit settings are used in the detection logic were not revealed by the manufacturer.

The Gatso speed detection devices are used in many European countries, including Holland, as well as in South Africa, New Zealand, and Australia. In 1987 the Gatso MRC system (Type RadCam 24) was thoroughly evaluated over a six-month period by the Nottinghamshire Constabulary Traffic Department in the United Kingdom.[8] The Gatso MRC system was installed in an unmarked police vehicle and tested on all classes of roads and under different road, weather, and lighting conditions. No citations were issued to speeding motorists during the evaluation. The Constabulary thought the system was a reliable, robust piece of equipment. They also thought the equipment had potential for enforcement use in a variety of different road types and conditions, especially in circumstances where the use of conventional speed detection devices was not practical.

Result photos

Stationary control of approaching traffic ▶

--   : range radar beam - = 1-2 lanes
-- = 1-4 lanes
F   : front measurement
000   : own speed of the patrolcar km/h
101   : speed of the offending vehicle km/h
101   : total speed km/h
12:07:36 : time; 12 hours, 07 min. and 36 sec.
89.06.20 : date; June 20th 1989

◀ Stationary control of receding traffic

--   : range radar beam - = 1-2 lanes
-- = 1-4 lanes
A   : tail measurement
000   : own speed of the patrolcar km/h
103   : speed of the offending vehicle km/h
103   : total speed km/h
12:05:21 : time; 12 hours, 05 min. and 21 sec.
89.06.20 : date; June 20th 1989

Moving control of receding traffic ▶

--   : range radar beam - = 1-2 lanes
-- = 1-4 lanes
A   : tail measurement
097   : own speed km/h
075   : overtaking speed of the offending vehicle km/h
162   : total speed km/h
11:31:28 : time; 11 hours, 31 min. and 28 sec.
89.06.20 : date; June 20th 1989

Pursuing control ▲

H   : hand control
134   : speed of 134 km/h
---   : no information
---   : no information
11:40:38 : time; 11 hours, 40 min. and 38 sec.
89.06.20 : date; June 20th1989

Moving Control of receding traffic at night ▼

FIGURE 3-6. EXAMPLES OF PHOTOGRAPHS TAKEN WITH GATSO SYSTEMS.

Photographs courtesy of Gatsometer B.V.

3.2.3 Plessey South Africa Ltd.

This company in South Africa has recently developed a prototype system which is designed for use in speed enforcement and speed data collection. The device, called the Plessey Dual-Antenna Speed Monitor, is currently being demonstrated to law enforcement agencies in South Africa. The system is composed of a main control unit connected to two Doppler radar units, one operating at a frequency of 24.225 GHz and the other at a frequency of 24.175 GHz. The control unit contains a microprocessor and uses state-of-the-art digital signal processing to determine vehicle speeds. An RS232 port is provided for connection to a printer, remote display, computer, or camera. At present, no specific camera has been selected for use with the device.

In operation, the two antennas are deployed about 80 m apart, aimed essentially parallel to traffic flow (not cross-the-road radar), and oriented such that they "illuminate" a common or capture area as shown in Figure 3-7. The capture area is typically 30 m long and two traffic lanes wide. In an attempt to minimize speed detection errors, the antennas are deployed no further than 4 m from the nearest point of vehicle travel. A speed is displayed on the main unit only when a vehicle is identified by both antennas. This only occurs when the vehicle is in the capture area. A speed measurement is held on the display for approximately 1 sec.

If vehicle speeds are to be monitored in the curb lane, the antennas need to be aimed at a point midway between the antennas and over the curbside. If two lanes are to be monitored, the antennas need to be aimed at a point midway between the antennas and in the middle of the two lanes. The unit cannot discriminate the direction of travel of the vehicles.

3.2.4 Traffipax-Vertrieb

Traffipax-Vertrieb of West Germany manufactures multipurpose speed control and traffic surveillance devices. This West German firm is a subsidiary of Robot Foto und Electronic, a company best known for its photographic systems. Le Marquis Audio International of Garden City, New York, is a distributor for them in the United States.

Traffipax-Vertrieb has manufactured several models of speed control devices over the years. The Radar Micro Speed 09 was the model they marketed until recently, when they introduced the Speedophot.

The Speedophot consists of a cross-the-road Doppler radar unit which transmits at a frequency of 24.125 GHz, coupled with a Robot Motor recorder camera, a flash unit and generator, a control unit, and a battery power supply. This device can be mounted in a patrol car (see Figure 3-8a) for either stationary or moving operation or on a tripod (see Figure 3-8b) for stationary operation alongside the roadway.

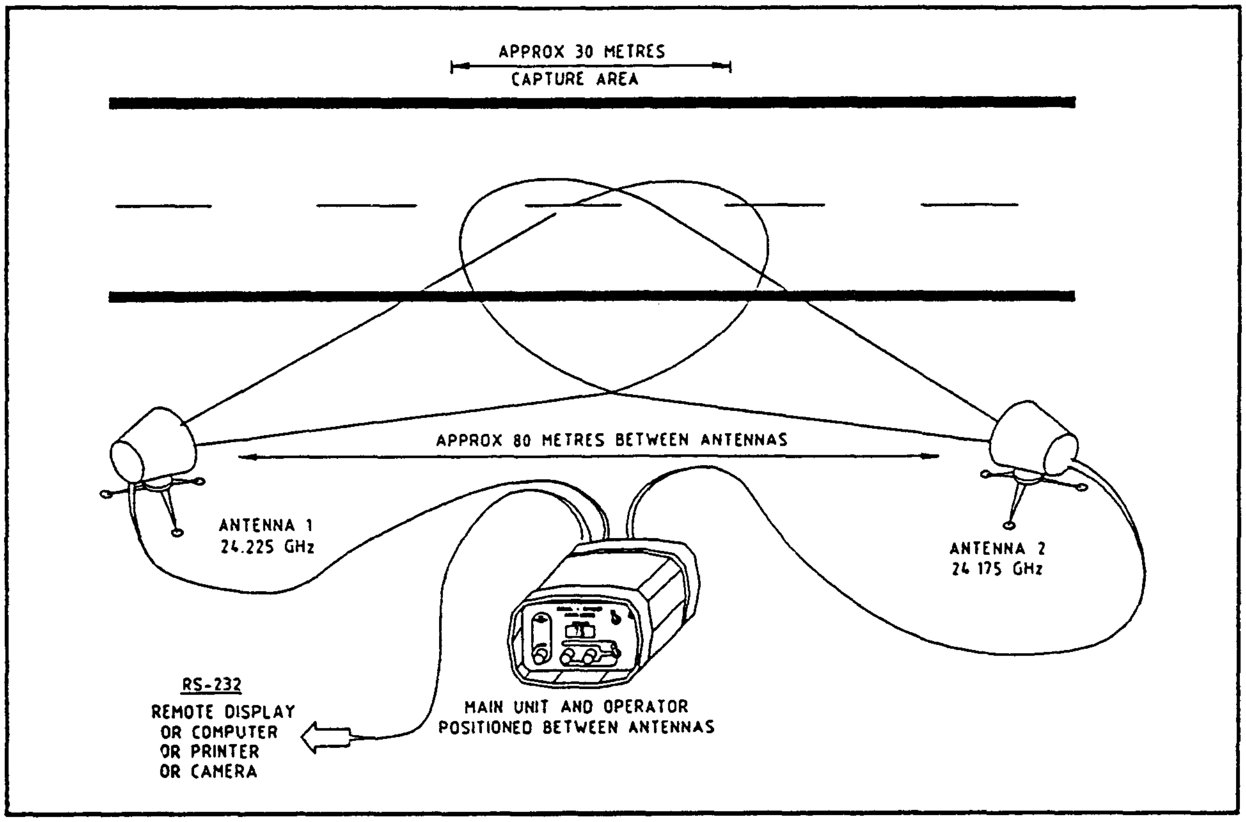


FIGURE 3-7. DEPLOYMENT OF THE PLESSEY DUAL-ANTENNA SPEED MONITOR.

Illustration courtesy of Plessey South Africa Ltd. (Not to scale.)

FIGURE 3-8a. TRAFFIPAX SPEEDOPHOT MOUNTED IN A PATROL CAR.

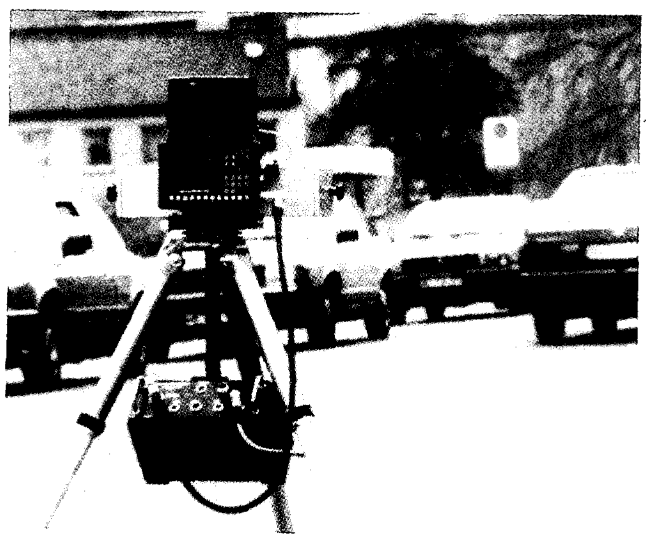


FIGURE 3-8b. TRAFFIPAX SPEEDOPHOT MOUNTED ON A TRIPOD.

Photos courtesy of Traffipax-Vertrieb.

For a vehicle-mounted configuration, the radar antenna can be located behind the grille of the car which should be parked parallel to the roadway. The control unit and flash generator can be installed in the trunk of the car, and only the camera with the integrated control box is attached to the dashboard. For stationary use on a tripod, the radar antenna is positioned at a right angle to the road, and the camera, flash, and control unit are placed in a compact, easily moved arrangement with only the power supply separately attached. For mobile use in moving traffic, the unit switches automatically from stationary radar operation to moving radar or speed detection using following techniques and the vehicle's tachometer output.

The photographic data displayed by the system include the offending vehicle, detected speed, adjusted range of radar, measured traffic direction, time, a seven-digit code, a frame counter, and the mode of operation.

The operating range of the radar extends from one to four lanes and the radar beam has a width 5°. The equipment can be used either manually or automatically. The device can measure departing or approaching traffic with a manual or automatic switchover. For departing traffic, a separate speed limit can be set for passenger cars and for trucks. No details are provided by the manufacturer on how trucks are identified separately from passenger cars. For oncoming traffic, only one speed limit setting can be used for all vehicles. See Figure 3-9 for examples of photographs taken in various modes of operation.

Traffipax-Vertrieb is now including in some of its equipment the technology to transfer all of the data recorded on a fully exposed 30-m roll of film (800 exposures) automatically onto a data medium called a memory card.

The manufacturer states that their speed control and surveillance systems have been used in Europe, Canada, South America, and Asia, including the Soviet Union.

3.2.5 Trafikanalys AB

This small, relatively young Swedish firm started about 2 1/2 yr ago to develop a new-generation ASE device under an agreement with the National Swedish Police Board. The device uses down-the-road radar that is based on military radar techniques. In late summer of 1989, the firm introduced into use two systems: a manned system identified as RC 110 and a fully automatic system identified as ASTRO 110. The manned system can be installed in a patrol car, or it can be mounted on a tripod alongside a patrol car. The ASTRO 110 is usually mounted on a pole alongside the highway or on an overpass where it can monitor traffic passing underneath the overpass. From information provided by the manufacturer, it appears that both systems operate similarly. Consequently, the technical description of the systems' configuration and operation will be given for the RC 110 for convenience.

Picture of approaching traffic with identification of driver

Picture of departing traffic

Picture of speed measuring in moving traffic

Picture of tachometer measuring in moving traffic

FIGURE 3-9. EXAMPLES OF PHOTOGRAPHS TAKEN BY TRAFFIPAX SPEEDOPHOT.

Photos courtesy of Traffipax-Vertrieb.

The RC 110 radar system consists of three main components: a control unit, a radar antenna, and a camera. The lap-held control unit and tripod-mounted radar antenna of the RC 110 are shown in Figure 3-10. The lap-held control unit provides a printout of individual speeds as well as other traffic data. The unit also contains a keyboard and a diagnostic display of codes used and trouble sensed.

The radar operates at a frequency of 10.53 GHz and has an output power of 3 mW only, roughly an order of magnitude less than U.S. systems. The radar does not use the cross-the-road concept; its antenna is aligned along the direction of traffic. The radar provides full tracking of all vehicles between 10 and 75 m away from the radar head. The tracking can be carried out in either direction or both directions simultaneously. Up to three lanes of traffic can be continuously monitored.

The RC 110 operates in two modes. It continually monitors the presence of traffic using rapid pulse transmission. In this standby mode, it sends out a little blip every 0.5 sec to see if anything is moving. If the beam detects something moving, the device automatically switches to a full tracking mode, sending out the beam continuously. In this mode data are collected at a 32-ms rate and are analyzed by digital signal processing (DSP). This method is not new but is a conventional military technique which has now become commercially attractive because of recent developments and access to compact, low-power-consumption DSP processers.

Every vehicle detected in the measurement zone is assigned an identification number and tracked until it exits the zone. Decision-making software controls the tracking and rejects false detections. Once a vehicle is detected exceeding a preset speed limit, its speed and other identifying information are printed on a paper tape. If a camera is used, the offending vehicle is photographed and its speed and other information are optically recorded on the side of the photograph. Two photographs of the offending vehicle are taken 0.5 sec apart. A red-light flash is used to illuminate the vehicle.

The system automatically calibrates itself every 15 min. The calibration procedure can be initiated manually at any time; however, the measurement functions have priority so that real-time operation is maintained.

The device can also be used to collect and record traffic and speed data. These data can be gathered continuously and can be transmitted to a PC or written to a data cassette for later analysis.

Currently the systems are used only in Sweden. The manual system is used in patrol vehicles with two officers in the vehicle and several downstream serving as a stop team. Two installations of the ASTRO 110 system are being evaluated in Stockholm.

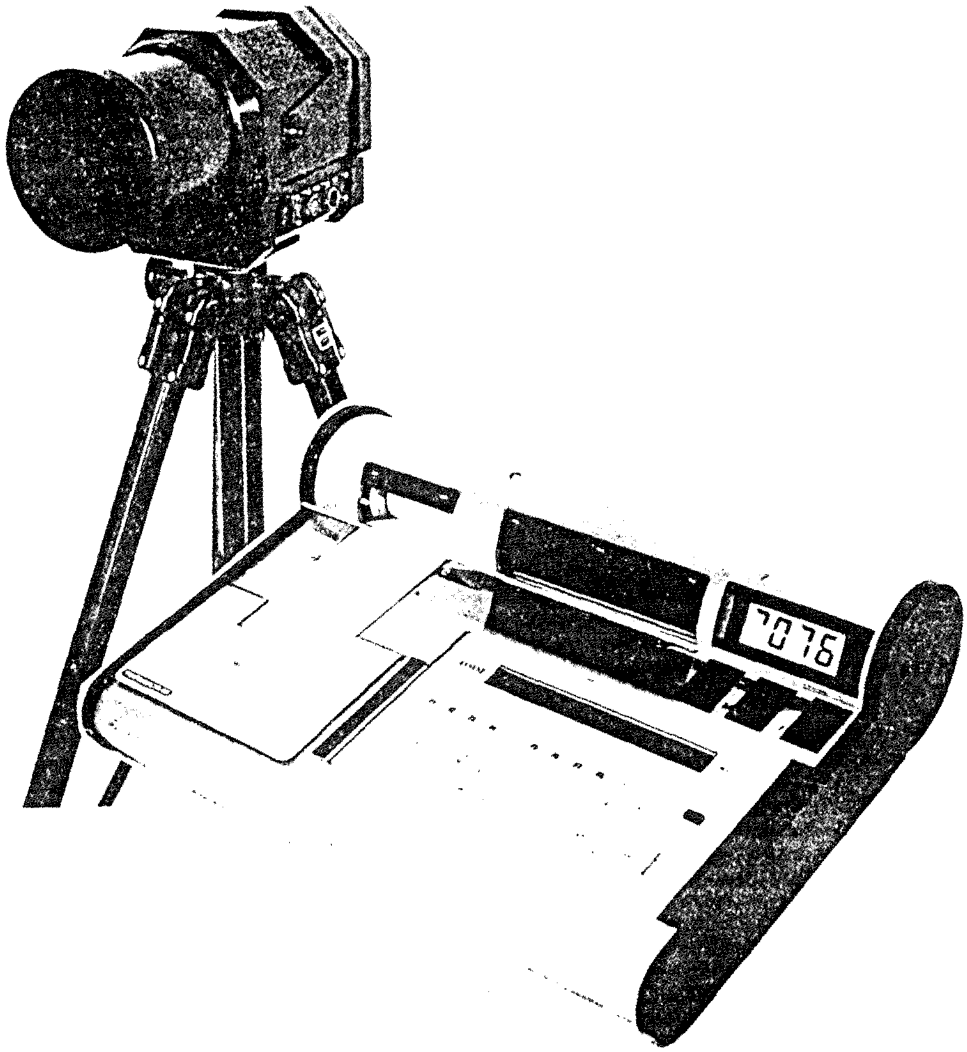


FIGURE 3-10. TRAFIKANALYS RADAR CONTROL MODEL RC 110.

3.2.6 Zellweger Uster AG

Zellweger Uster AG, with headquarters outside of Zurich, Switzerland, is perhaps the most well-known manufacturer of cross-the-road radar systems. These systems have been used by law enforcement agencies in over 30 countries, including the United States, and some of its systems have been in operation for many years. Multanova/RPJ Inc. of Babylon, New York, is a U.S. distributor for the photographic radar and red-light monitoring equipment made by Zellweger Uster AG.

Zellweger Uster AG has produced several speed detection devices over the last 20 years and several were described in our previous report.[7,8] Their latest ASE device is called the Multanova 6F.

The Multanova 6F consists of a cross-the-road Doppler radar unit with a transmission frequency of 34.3 GHz, coupled with either a Jacknau recording camera or a Robot Motor Recorder camera, a flash unit, a control unit, a hand-held operating unit, and a battery power supply. If required, the control unit can be provided with a standard RS232 interface for connection to commercial peripheral equipment such as a printer, mass storage unit, or large display panel. Other sensors can be used instead of the radar antenna, such as light barriers or tacho generators.

The Multanova 6F can be mounted in a patrol car (see Figure 3-11a) for stationary operations or on a tripod (see Figure 3-11b) for operations alongside the roadway. The device can also be mounted in a fixed enclosure on a bridge and overlooking a specific lane of traffic passing underneath the bridge.

The radar signal generated from the approaching or departing vehicle is transferred to the control unit, where it is amplified, filtered, and converted into a series of pulses. The direction of travel of the vehicle is determined immediately such that if the signals are part of the receding traffic, then only signals from the receding traffic are fed into the computer during the remainder of the current measurement. Likewise, if the signal is from the approaching traffic, only signals from the approaching traffic are fed into the computer during the remainder of the current measurement. The computer continuously evaluates the Doppler signal checking for a portion of a vehicle that has a uniform length of at least 10 in. If a uniform section is found, the frequencies are averaged over the section length and converted into a speed value which is displayed on the operating unit. As soon as the speed is determined, a verification process is automatically begun. If verification is successful, the measured speed value is transferred to the photo of the detected vehicle along with the date, time, and a handwritten description of the site. Measurements which cannot be definitely allocated to the vehicle measured are canceled automatically. If several vehicles are recorded on the photograph, a simple photographic grid overlay system permits definite determination of the vehicle measured.

The operating range of the radar extends from one to three lanes and the radar beam has a width of 5°. The equipment can be used either manually or automatically. The device can measure oncoming or departing

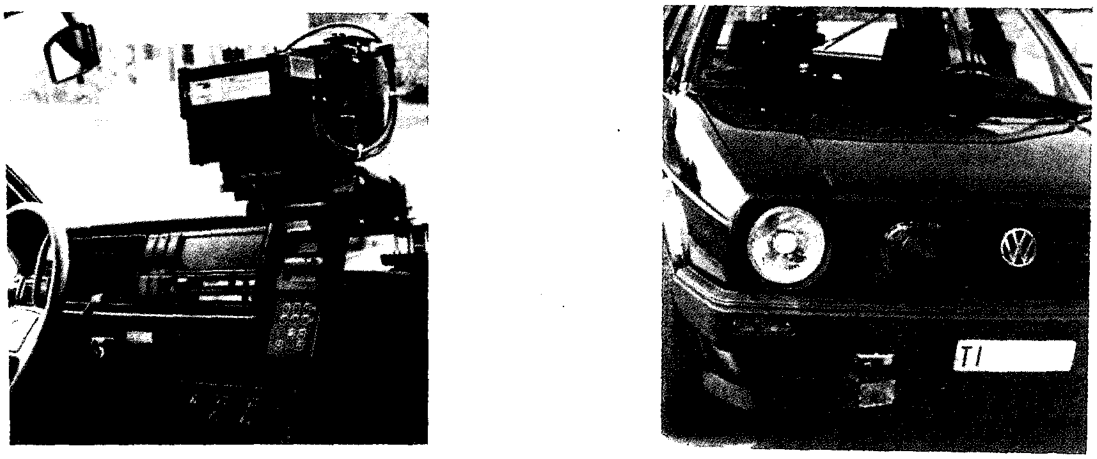


FIGURE 3-11a. MULTANOVA 6F MOUNTED IN A PATROL CAR.

Photos courtesy of Zellweger Uster Ltd.

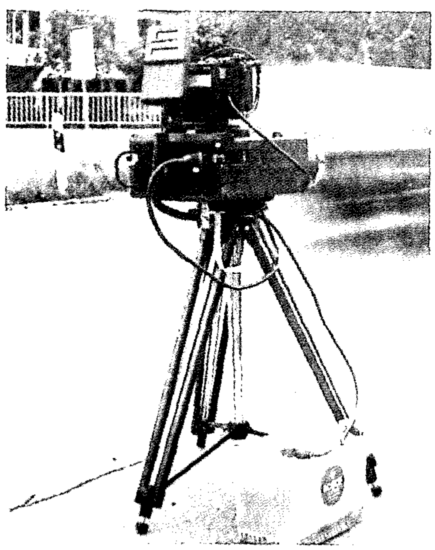


FIGURE 3-11b. MULTANOVA 6F MOUNTED ON A TRIPOD.

Photo courtesy of Zellweger Uster Ltd.

traffic either selectively or simultaneously. For oncoming traffic, only one speed limit setting can be used for all vehicles. However, for departing traffic, a separate speed limit can be set for passenger cars and for trucks. Any vehicle in the near lanes that supplies a consistent return Doppler signal for a time period equivalent to at least 12 m of travel is automatically defined as a truck. It is possible for a car in a lane far removed from the radar unit, where the beam is wider, to produce a consistent return Doppler signal for a long enough time period such that it is evaluated as a truck. In this situation, a review of the photograph would reveal otherwise.

In comparison with older units produced by Zellweger Uster AG, the Multanova 6F represents several innovations. The radar antenna is much smaller than previous antennas and has a good beam concentration. The other components are also much smaller and of lighter weight than before. The radar signals are now tracked and checked by a digital computer in the central control unit. The operation of all of the equipment attached to the central control unit (radar antenna, camera, flash, and printer if necessary) is controlled and displayed on the small hand-held operating unit.

The Multanova 6F system is certified in Switzerland and West Germany.

Traffic Monitoring Technologies of Friendswood, Texas, packages the Multanova 6F in the rear of a four-wheel drive vehicle and leases the detection equipment and vehicle for a service fee. These mobile ASE units are currently being used in Paradise Valley, Arizona, and Pasadena, California.

3.2.7 Eltraff S.r.l.

This Italian firm manufactures a nonradar ASE device called the Velomatic 103A Speed Meter that is used only in Italy under that government's certification. The Velomatic speed detection device has three main components which can be mounted inside a patrol car or externally on a tripod as shown in Figures 3-12 and 3-13, respectively. The three components are a control and calculator unit with built-in printer, a sensor, and a photographic system. Two types of sensors can be used with the device: an optoelectronic sensor or a capacitive sensor. The optoelectronic sensing unit appears to be used basically for speed measurement and is very similar to the one made by Elcos in Vienna, Austria, about 10 years ago.[6,7]

The operating principle of the device is based on measuring the time interval taken by a vehicle to pass over a fixed distance of 1,204 mm between a pair of sensors. The optoelectronic sensors are "aimed" directly across the roadway. Each sensor is entirely passive; no beam of any kind is emitted. Consequently, the unit does not require reflectors on the opposite side of the roadway.

FIGURE 3-12. VELOMATIC 103A MOUNTED IN A PATROL CAR.

Photos courtesy of Eltraff S.r.l.

FIGURE 3-13. VELOMATIC 103A MOUNTED ON A TRIPOD.

Photos courtesy of Eltraff S.r.l.

As a vehicle passes in front of one of the optoelectronic sensors, the amount of light detected by the sensor changes in some fashion. If the second sensor experiences the same pattern of change an instant later, the system logic determines the time lag between them and, hence, the vehicle speed.

Some degree of flexibility is provided the operator of the system during speed enforcement. The operator can select the direction of traffic to monitor without moving the sensor but by simply using a switch. The device can be set up to selectively monitor trucks by training the optoelectronic sensors upward. Also, the sensors can be directed downward so that they detect only vehicles in an adjacent lane.

The Velomatic device is a computer-based system that can be connected to a computer modem. In addition, the device is equipped with a printer to provide instantaneous printouts of detections. The system is powered by a rechargeable battery with a capacity of 20 hr of operation.

The camera that can be used with the Velomatic is set to photograph the rear of offending vehicles when they are 16 m downstream of the camera. The photograph taken shows the date, time of day, location, and speed of the violation (see Figure 3-14). An optional flash is available for nighttime usage.

The Velomatic can also be used to collect vehicle count data and will provide a printed output every 10 min of the number of vehicles passing the sensors plus an accumulated total since the count began. With the aid of a small accessory and either coaxial cables or inductive loops, the Velomatic can be used to detect and photograph red-light violations. This version of the device is described in Section 3.4.

3.2.8 Proof Digitalsystemer A/S

This Danish firm has supplied vehicle-mounted speed measurement devices for more than 10 yr to law enforcement agencies in Denmark, other Scandinavian countries, and Europe. Since 1978 more than 1,500 police vehicles in Europe have been fitted with Proof Digitalsystemer devices.

This company manufactures the ProViDa/PDRS system which was developed in close cooperation with the Danish National Police. "ProViDa" stands for Proof Video Data, and "PDRS" stands for Police Data Recording System. This ASE device is a vehicle-mounted, computerized video/data system and is used to monitor traffic and determine vehicle speeds from time and distance measurements.

The ProViDa/PDRS system consists of five major components: (1) a color video camera, (2) a video/data generator with data/time unit, (3) a PolicePilot speed indicator with data outlet, (4) a ProofSpeed precision speedometer, and (5) a mobile VHS video recorder with a 4 1/2-in color monitor. Several of the system's components are shown in Figure 3-15.

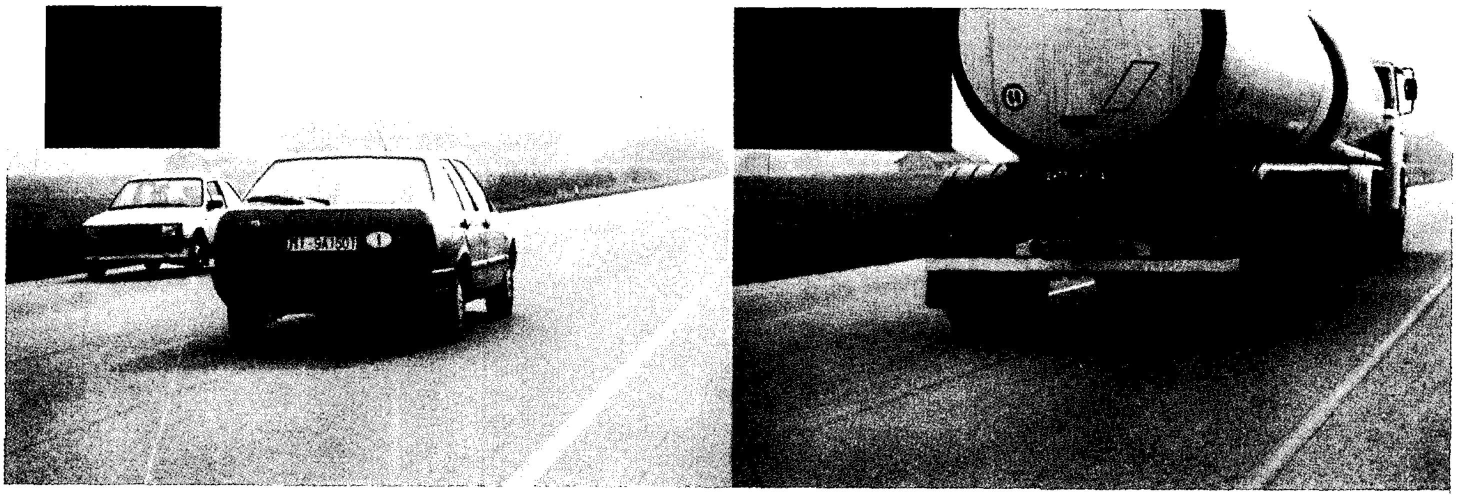


FIGURE 3-14. EXAMPLES OF REAR PHOTOGRAPHS TAKEN WITH THE VELOMATIC 103A SYSTEM.

Photos courtesy of Eltraff S.r.l.

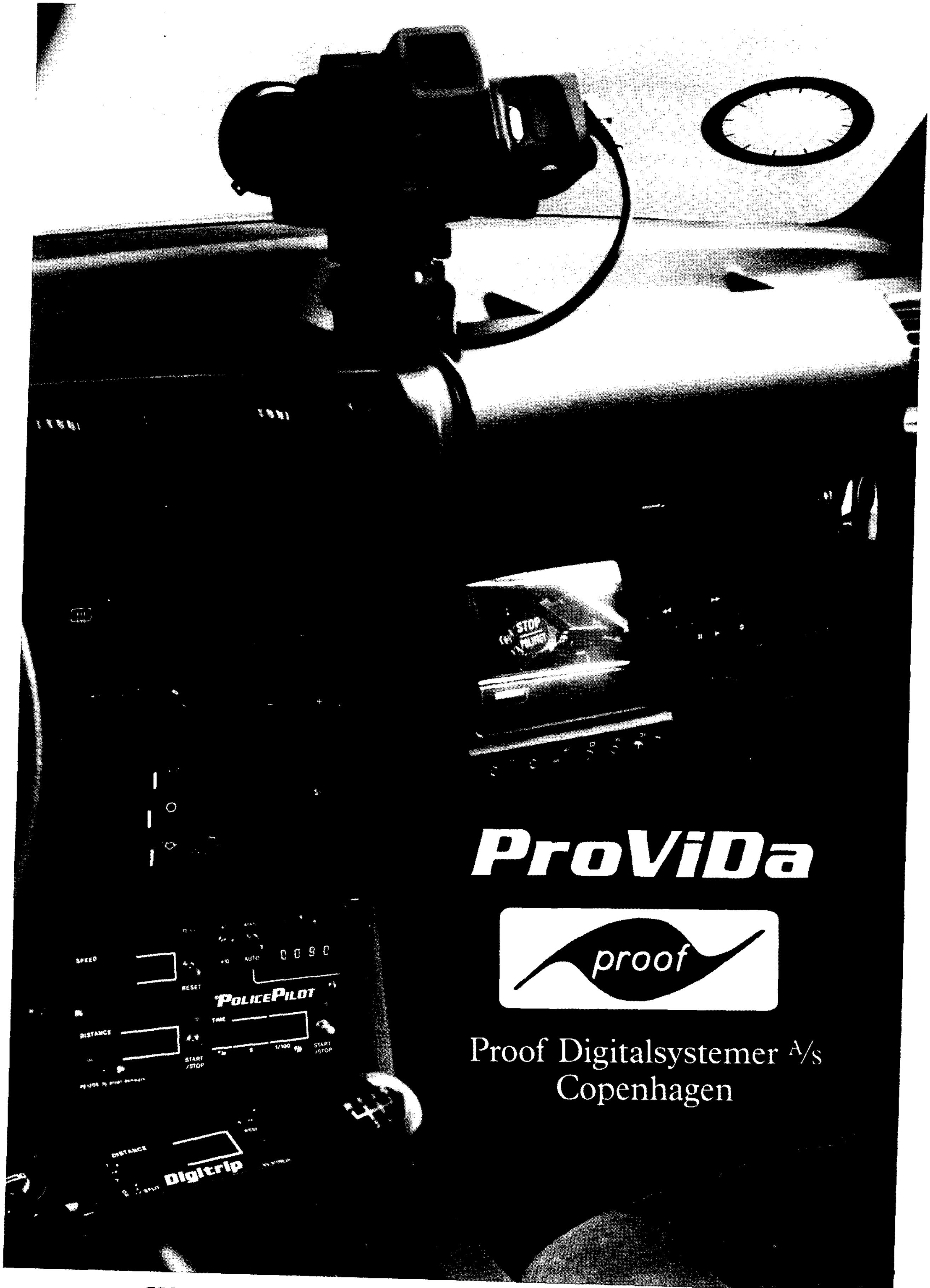


FIGURE 3-15. PROVIDA/PDRS SYSTEM INSTALLED IN A VEHICLE.

Photo courtesy of Proof Digitalsystemer A/S.

The PolicePilot unit contains two stopwatches, two trip counters, two computation circuits, and an additional control circuit. Time and distance are measured by the stopwatches and trip counters, respectively, which are activated by switches on the PolicePilot.

The device is used either in a pacing strategy or when the patrol vehicle is stationary. During a pacing operation, the stopwatches and trip counters are activated by the patrol officer. When the stopwatches and trip counters are stopped, the time and distance data are measured. These data are then transferred automatically to the computer part of the unit, where the speed of the offending vehicle is calculated and the result is transferred to the display area of the PolicePilot and to the video/data generator. The video/data generator transforms these digital signals to video signals which are combined with the video signals from the camera and imported to the video recorder. The speed of the police vehicle, determined by the electronic precision speedometer, is also added to the video recording.

The distance unit has an automatic function into which a premeasured distance can be coded. This enables the operator in a parked car to time passing vehicles. When the timing unit is stopped, the speed of a target vehicle is calculated automatically and sent to the video recorder along with the video signals from the camera.

3.2.9 Trans-Atlantic Equipment Pty. Ltd.

This company in Johannesburg, South Africa, manufactures the Speed-Guard DeLuxe Model 3000 and the Trafficam Speed Camera, which may be combined to form an ASE device. The sensors used by this device are pencil-thin rubber tubes permanently installed 2.5 m apart in any road surface and connected by cable to 6-V DC transducers (see Figure 3-16a). The Speed-Guard apparatus is built into a portable, lightweight, durable, water-resistant aluminum case (see Figure 3-16b) and contains a micro-processor, built-in rechargeable batteries, and a charger. The Trafficam Speed Camera module (see Figure 3-17) used in conjunction with the Speed-Guard sensors record the event of a vehicle traveling in excess of a preset speed limit stored within the Speed-Guard. A rear photograph is taken of the offending vehicle and shows the vehicle's license number, date, time, and the vehicle's speed.

The equipment can be operated automatically in any direction and has been accepted by the Supreme Court of South Africa for use in that country.

3.2.10 Truvelo Manufacturers

This West German firm manufactures the Truvelo M4^2 and the Truvelo Combi systems. The Truvelo M4^2 speed measuring device is a time/distance measurement system that uses two sets of roadway cables placed parallel to each other (two fully independent measuring systems in parallel).

FIGURE 3-16a. ROADWAY SENSORS USED BY SPEED-GUARD.
Photo courtesy of Trans-Atlantic Equipment Pty. Ltd.

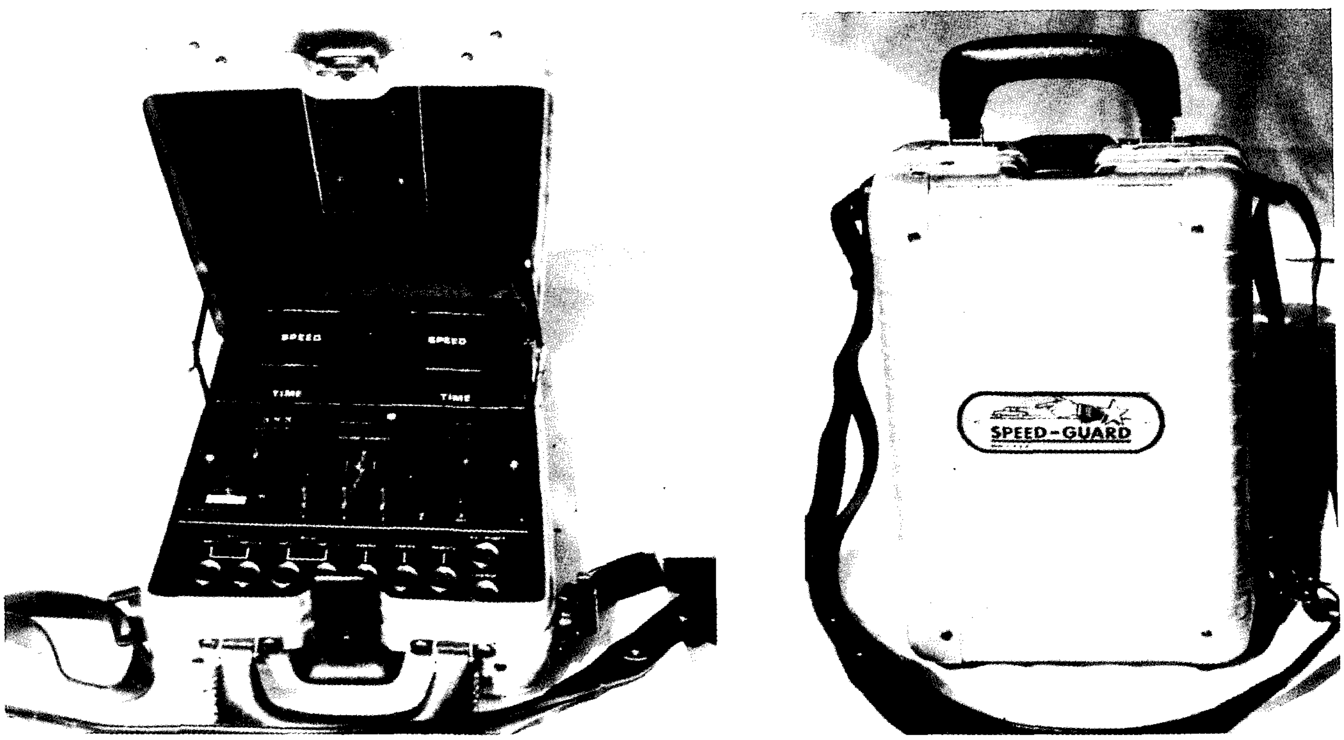


FIGURE 3-16b. SPEED-GUARD CONTROL UNIT.
Photo courtesy of Trans-Atlantic Equipment Pty. Ltd.

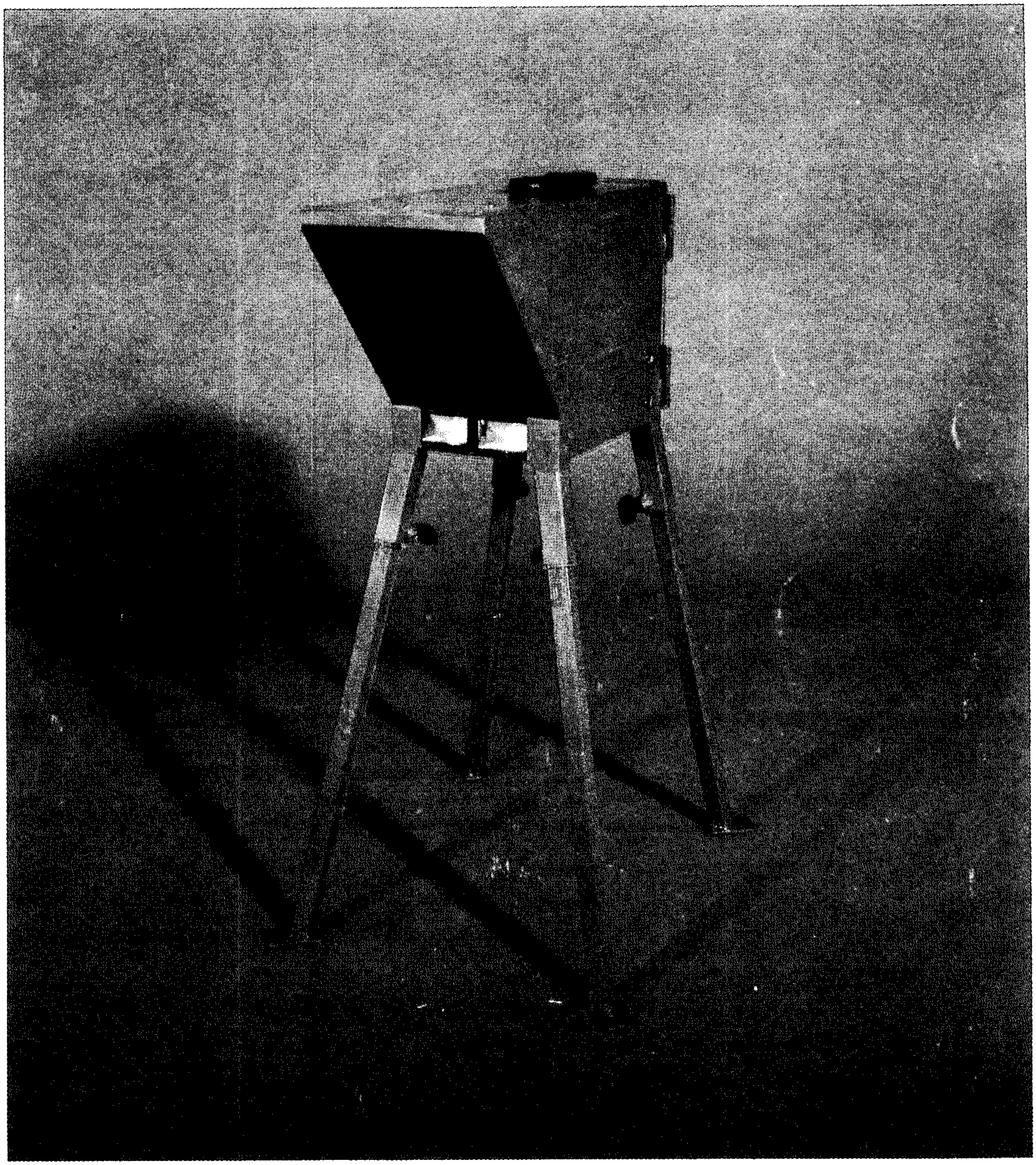


Figure 3-17. TRAFFICAM SPEED CAMERA USED WITH SPEED-GUARD.

Photo courtesy of Trans-Atlantic Equipment Pty. Ltd.

Coaxial microphone cables are used for portable operations where the cables are roadway surface-mounted. Piezoelectric detector cables are installed into the road surface at fixed locations. In both cases the distance between two detectors is kept at 5 ft. The control system of the Truvelo $M4^2$ is housed in a portable attaché case (see Figure 3-18). This unit contains a solid-state microprocessor with a digital display, a warning buzzer for vehicles traveling faster than the preset speed limit, an electronic vehicle counter, built-in rechargeable 12-V DC battery, built-in battery charger, and attachments for connection to the Truvelo camera and flash system and/or a Truvelo remote printer. The Truvelo Combi consists of the $M4^2$ device mounted within the camera housing.

The Truvelo $M4^2$ makes two simultaneous time/distance measurements using the two sets of roadway cables. The measurements are converted into speeds by the microprocessor in the instrument. The speeds are then compared and, if they agree to within 2 km/hr, are accepted and are displayed on the digital readout. Otherwise, they are automatically rejected. The camera and flash system are activated whenever a vehicle is detected traveling faster than the preset speed limit.

The Truvelo camera system permits photographs to be taken from either behind or in front of the vehicle. Frontal photography is accomplished by using the Truvelo red filter flash. The photograph shows the offending vehicle plus data associated with the speed violation which includes the time, date, location code, and two speed values (see Figure 3-19.)

Both systems can be operated totally automatically and can be either tripod-mounted along the roadway or installed in a fixed enclosure.

The Truvelo systems are used, under approval, in West Germany, Austria, South Africa, and in the United Kingdom (without the camera and flash unit).

3.3 OTHER SPEED ENFORCEMENT TECHNOLOGIES

A large number of devices, concepts, and systems for speed enforcement were identified in the study. Table 3-1 is a comprehensive list of all of them except for a few categories that were omitted for various reasons. For example, the list does not include the numerous American down-the-road radars, with one exception. One American down-the-road unit is listed because of its capability to be used also as a time/distance measuring device. The list does not include devices for which all that could be ascertained was a trade name or a manufacturer and those for which, despite our repeated efforts, no technical information could be obtained. Also excluded are systems or devices found to be inapplicable for highway speed enforcement (e.g., systems designed for in-car use such as speed limiters or governors, and systems designed for use by aircraft or trains).

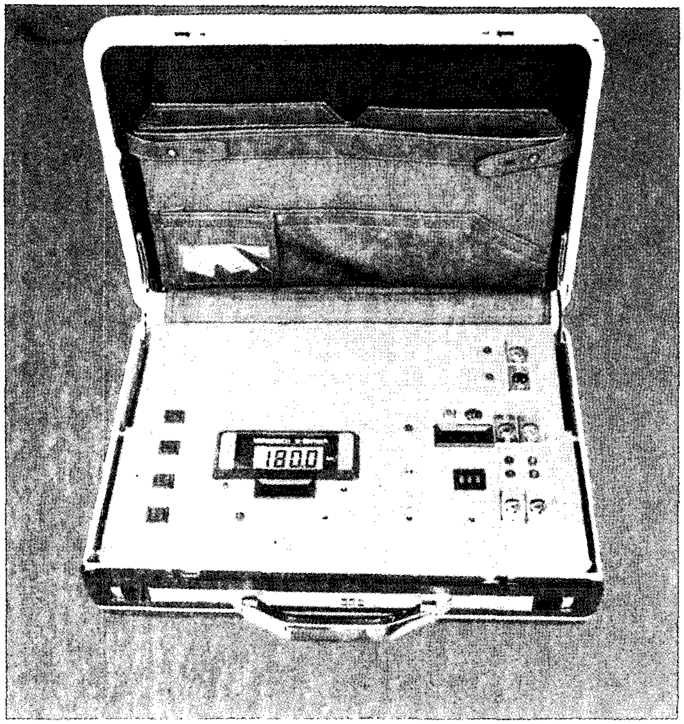


FIGURE 3-18. TRUVELO M4² SPEED MEASURING DEVICE.

Photo courtesy of Truvelo Manufacturers.

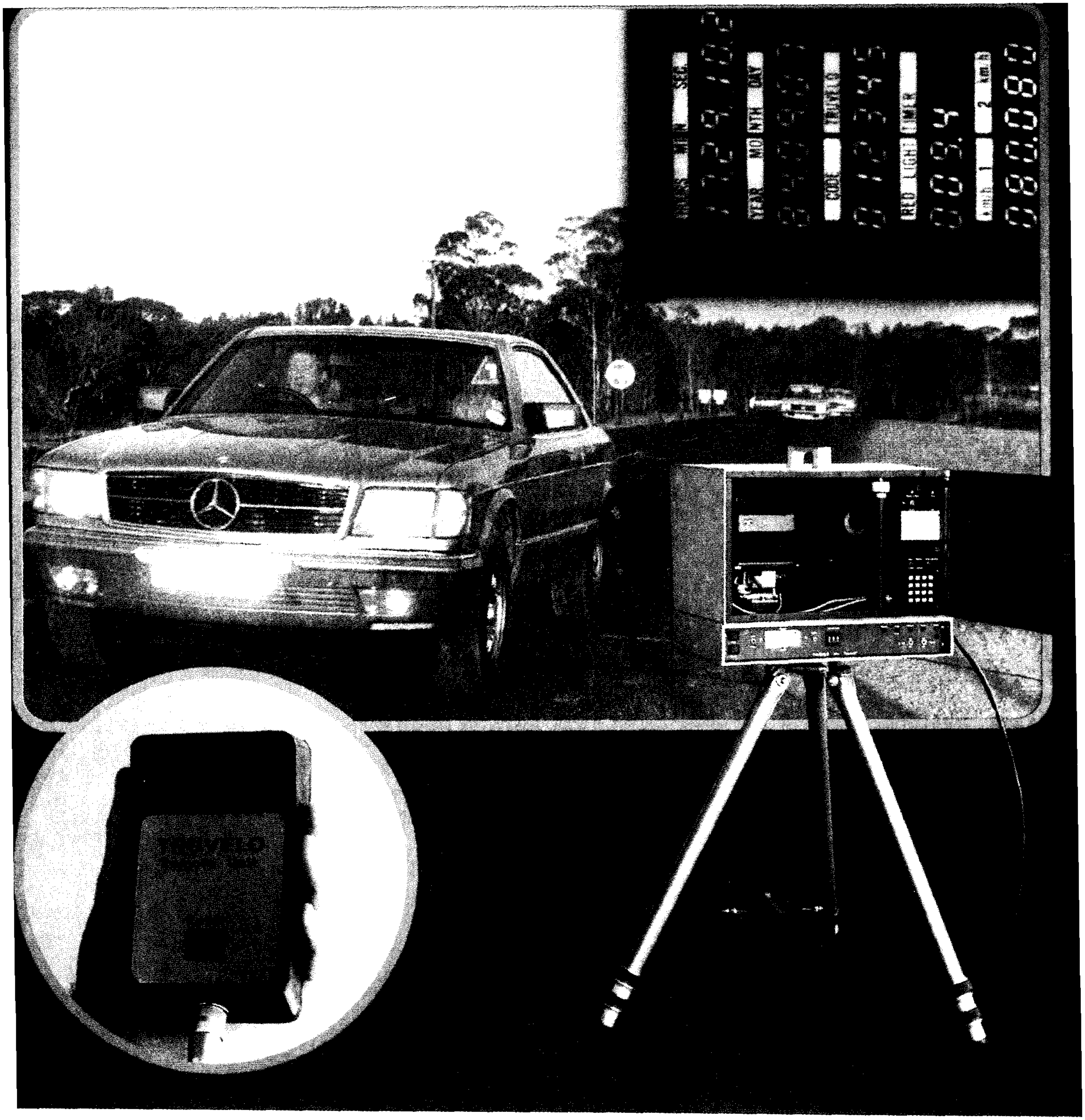


FIGURE 3-19. EXAMPLE OF FRONTAL PHOTOGRAPH TAKEN BY TRUVELO COMBI SYSTEM.

Photo courtesy of Truvelo Manufacturers.

TABLE 3-1. SPEED ENFORCEMENT TECHNOLOGIES

Time/Distance Measuring Concepts

- Eltraff S.r.l., Velomatic 103A (Italy)
- FHWA, Traffic Evaluator System
- Gatsometer B.V., Gatso RLC Type 36ms, and Type 36msg (Holland)
- Kustom Electronics Inc., H.A.W.K. Traffic Safety Radar
- Proof Digitalsystemer A/S, Police Pilot, and ProViDa/PDRS (Denmark)
- Stopwatch
- Systems Innovation Inc., ESP Model TK-100
- Toll Road Tickets
- Traffic Safety Systems Inc., VASCAR-plus
- Trans-Atlantic Equipment Pty. Ltd., Speed Guard De Luxe Model 3000 (South Africa)
- Truvelo Manufacturers, Truvelo M4², and Combi (West Germany)

Doppler Radar--Down the Road

- Plessey South Africa Ltd., Plessey Dual-Antenna Speed Monitor (South Africa)
- Trafikanalys AB, RC110, and ASTRO 110 (Sweden)
- Kustom Electronics, H.A.W.K. (U.S.)

(Other U.S. systems not considered separately in the study)

Billboard-Type Radar

- Kustom Electronics Inc., Giant PR Display
- Mobile Traffic Zone Inc., Mobile Radar Traffic Trailer

Doppler Radar--Across the Road

- AWA Defense Industries Pty. Ltd., Vehicle Speed Radar Model 449 (Australia)
- Gatsometer B.V., Gatso Micro Radar Type 24, and Gatso Micro Radar Type RadCam 24 (Holland)
- Rawar, SRD-77 and DROP (Poland)[a]
- Traffipax-Vertrieb, Micro Speed 09 Radar, and Speedophot (West Germany)
- Zellweger Uster AG, Multanova 6F (Switzerland)

TABLE 3-1 (Concluded)

Photographic Systems With Radar

- AWA Defense Industries Pty. Ltd., Vehicle Speed Radar Model 449 (Australia)
- Gatsometer B.V., Gatso Micro Radar Type 24, and Gatso Micro Radar Type RadCam 24 (Holland)
- Plessey South Africa Ltd., Plessey Dual-Antenna Speed Monitor (South Africa)
- Rawar, SRD-77[a] (Poland)
- Traffipax-Vertrieb, Micro Speed 09 Radar, and Speedophot (West Germany)
- Trafikanalys AB, RC110 and ASTRO 110 (Sweden)
- Zellweger Uster AG, Multanova 6F (Switzerland)

Photographic Systems Other Than Radar Type

- Devlonics Control NV, CCATS (Belgium)
- Eltraff S.r.l., Velomatic 103A (Italy)
- Gatsometer B.V., Gatso RLC Type 36ms, and Type 36msg (Holland)
- Jet Propulsion Laboratory, Wide Area Detection System (WADS)
- Proof Digitalsystemer A/S, ProViDa/PDRS (Denmark)
- Trans-Atlantic Equipment Pty. Ltd., Speed Guard De Luxe Model 3000 (South Africa)
- Truvelo Manufacturers, Truvelo M4² and Combi (West Germany)

Other Detection Systems

- International Measurement and Control Co., Laser Speed Gun

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[a] The Rawar SRD-77 and DROP systems appear to be composed of components manufactured by Traffipax-Vertrieb of West Germany. We have little information on these systems other than a rough translation of a technical description of the equipment.

The ASE devices identified are described in Section 3.2. Most of the other devices are discussed in Section 4. No specific information was available on the Laser Speed Gun because it was in the experimental stage of development.

In addition to the systems that could at least potentially be used for speed enforcement, there are also several systems designed for informing motorists of their speed. These systems are referred to as billboard-type radars. A display of traffic speeds to passing motorists may have a positive impact on lowering speeds, especially when law enforcement personnel or vehicles are nearby.

3.4 DESCRIPTIONS OF RED-LIGHT VIOLATION DETECTION EQUIPMENT

Six manufacturers were identified during the study as producing red-light violation detection systems. The six manufacturers also produce ASE equipment that is described in Section 3.2. (These addresses are included in the Appendix.) The six red-light violation systems (more than six if the various models of each manufacturer are counted) use roadway sensors (inductive loops, cables, or tubes) for vehicle detection and 35-mm cameras to record photographic evidence of the violation. The six systems are discussed below in alphabetical order of the manufacturer's name. In these descriptions the term "red-light violation detection" is abbreviated as RLC (red-light camera).

3.4.1 Eltraff S.r.l.

This Italian firm produces accessories for its Velomatic 103A Speed Meter that convert the unit from an ASE device to one that documents traffic light offenses. The RLC system consists of a control and calculator unit, a photographic unit, including flash, roadway sensors, and a photocell unit. The control and calculator unit and photographic unit are the same as are used in the Speed Meter version of the device. Either a coaxial cable laid on the pavement surface or an inductive loop embedded in the pavement surface is used to detect the passage of traffic relative to the red-light phase of the traffic signal. A coaxial cable is used for mobile operations while the inductive loop is used for fixed installations. The cable or loop is installed downstream of the stop line. A special photocell fixed on the green light of the traffic signal is used to record the state of the traffic lights.

In operation, the camera will photograph the rear of a vehicle detected crossing the roadway sensor whenever the red-light is on. A second rear photograph will be automatically taken 1.5 sec after the first photograph. The information shown on photographs include: a rear view of the vehicle; the traffic light; the time, in tenths of a second, that has elapsed since the traffic light has changed to red; the date; the time; and a hand-written location description. An example of the two photographs taken of a red-light offense is shown in Figure 3-20. The minimum interval between two offending vehicles is 1.3 sec.

FIGURE 3-20. EXAMPLE OF PHOTOGRAPHS TAKEN WITH VELOMATIC 103A RED-LIGHT VIOLATION DETECTION SYSTEM.

Photos courtesy of Eltraff S.r.l.

3.4.2 Gatsometer B.V.

This Dutch firm produces four models of RLC systems designated as RLC Type 36-m, Type 36-4m, Type 36-ms, and Type 36-msg. The four systems differ in their capabilities, but all have the same basic three components: a control unit, a photographic unit (including flash), and a set of roadway sensors (inductive loops). The control and photographic units are installed in a double-walled stainless steel cabinet which is mounted on top of a hinged pole positioned alongside the roadway. The hinged pole allows one person to change the camera's film magazine without the need for a ladder. The inductive loops are installed downstream of the stop line and are connected, along with buried power and signal phase lines from the traffic lights, to the control unit.

The configuration of the roadway sensors is determined by the model type. RLC Type 36-m uses one loop per lane and can monitor red-light violations in either one or two lanes of receding traffic. RLC Type 36-4m uses one loop per lane and can monitor red-light violations in one to four lanes of receding traffic. RLC Type 36-ms uses two loops per lane and can record the speed of every red-light offender detected in either one or two lanes of receding traffic. RLC Type 36-msg also uses two loops per lane and can detect speeding vehicles, independent of the traffic light phase, as well as red-light violations in either one or two lanes of receding traffic.

Two rear photographs are taken of each vehicle detected of a red-light or speeding violation. The time interval between the first and second photograph is adjustable, with the minimum interval being 0.8 sec. The data shown on the first photograph include the time, date, traffic lane, amber light elapse time in tenths of a second, red-light elapse time in tenths of a second, offense number, and location code number. The type of data shown on the second photograph is the same as shown on the first photograph for RLC Types 36-m and 36-4m. With RLC Types 36-ms and 36-msg, the vehicle speed is recorded on the second photograph in the space allocated for the location code number.

The Gatsometer RLC Type 36-ms was field-tested under the general direction of the Nottinghamshire Constabulary in the United Kingdom over an 11-week period, beginning the middle of December 1987.[9] Two intersections in Nottingham were used in the field tests. Vehicles violating the red-light phase were photographed for 7 of the 11 weeks. The first phase of the two phase study was conducted by the Planning and Transportation unit of Nottingham who publicized the use of the detection equipment and monitored the violation rate over the testing period. The second phase was a prosecution period and was operated by the Nottinghamshire Constabulary.

Video tape recordings were taken at both intersections prior to the installation of the equipment. Thirty-nine hours of video recording were used for the analysis of driver behavior prior to the installation of the signal-activated camera. The video taping of the intersections was continued after the activation of the detection camera and was used in the analysis of the RLC system. A 64% drop in the frequency of red-light violations before and after installation was noted at one intersection; and a 57% drop was noted at the other intersection. The police felt that publicizing the presence of the RLC system proved effective in reducing red-light violations.

3.4.3 Traffipax-Vertrieb

This West German firm manufactures a RLC system designated as Traffiphot III. This fully automatic system consists of a control unit, a photographic unit including flash, and roadway sensors (inductive loops). The control and photographic units are installed in a weather-proof enclosure that is mounted on a steel pipe mast positioned alongside the roadway. The control and photographic units can be removed as a single assembly from the enclosure for insertion into other enclosures. This modular design permits the use of a single control and photographic unit for several intersections on a rotational basis. Simultaneous monitoring is possible of up to three lanes of traffic with different red-light phases and varying red-start times.

An automatic aperture control device is provided with the camera. An integrated flash is switched on automatically in bad light conditions. The camera can be adapted to a range of photographic conditions by means of an adjustable flash capacity of 100 to 300 Ws.

The system can be installed to take either rear or frontal photographs. An installation diagram for each operation is given in Figure 3-21.

The system is triggered by a vehicle crossing the induction loop located immediately downstream of the stop line during the red phase. Two photographs are taken of the violation. The time between the two exposures can be set between 0.5 and 5 sec. Digital data are recorded on two lines on the upper margin of both photographs and include the time, date, a code location number, the red-light elapse time to the nearest one-hundreth of a second, the violation number, and either an A or B for the first or second exposures of the sequence.

When frontal photographs are taken, the Traffiphot is equipped with red filters in front of the flash reflector and camera lens. The red flash illuminates the inside of the car without blinding the driver. A red sensitive B/W film has to be used in this case. Also for frontal photographs, the second photograph can be taken independently from the present exposure interval when the vehicle crosses an additional induction loop in the intersection. This optional inductive loop ensures that vehicles are always recorded in a preset position, thus providing a clear identification of the driver.

An option with the equipment is a memory card that preserves automatically all digital data recorded on the film. These data can be analyzed separately and used to select photos from which only the license plate needs to be manually recorded.

TRAFFIPAX

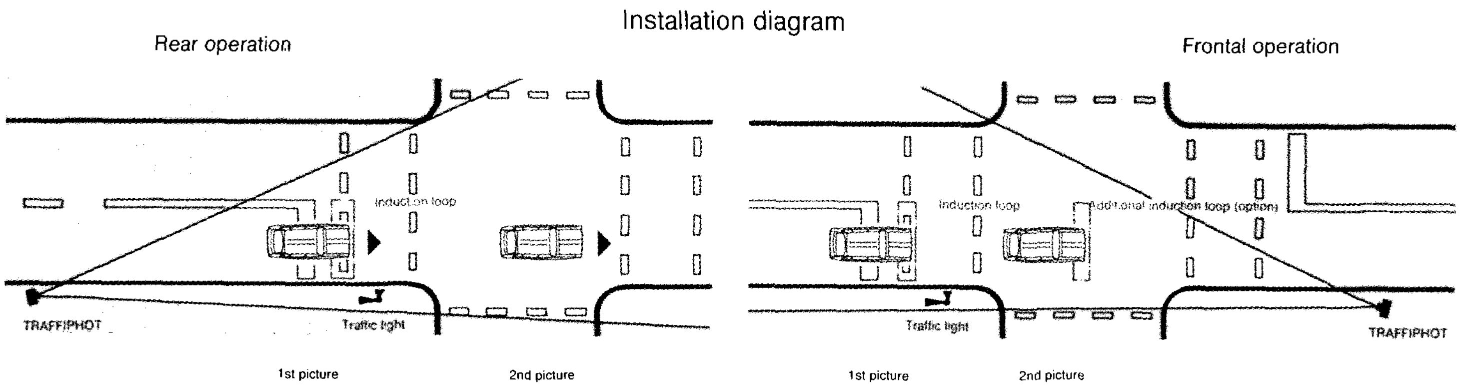

FIGURE 3-21. INSTALLATION DIAGRAM FOR TAKING REAR AND FRONTAL PHOTOGRAPHS WITH THE TRAFFIPHOT III SYSTEM.

Photo courtesy of Traffipax-Vertrieb.

This system was field tested at an intersection in New York City during an RLC demonstration project between January 1988 and early 1989.

3.4.4 Trans-Atlantic Equipment (Pty.) Ltd.

This South African firm manufactures a portable RLC system called the Trafficam. The components of the Trafficam system are: roadway rubber tube sensors, a photographic unit including flash, a control unit, and a rechargeable power supply. The pencil-thin rubber tubes are stretched across the surface of one or two lanes and downstream of a stop line. The tubes are placed 2.5 m apart and are connected to 6 VDC transducers which in turn are connected to the control unit. The control unit and power supply are housed in a portable case that rests on the ground and alongside the roadway. The camera and flash are housed in a cabinet mounted on a pole which is attached to the portable case. The system is connected in an unknown manner to the red-light cycle.

One or two rear photographs are taken of each vehicle detected of a red-light violation. The second photograph, if required, is taken 0.5 sec after the first. The time and date of the offense, the violating vehicle, and the traffic signal are displayed in the photograph(s). The exposure time for the photographs is automatically determined from prevailing light conditions.

3.4.5 Truvelo Manufacturers

This West German firm produces a red-light violation module that can be incorporated into the control unit of the Truvelo Combi system converting it from an ASE to an RLC system. The RLC version of the Combi system can be either tripod mounted alongside the roadway or it can be installed in a weather- and vandal-proof enclosure that is mounted on top of a fixed pole alongside the roadway.

The tripod and fixed installation configurations differ somewhat. For the tripod installation, one piezoelectric cable is placed across the stop line of the intersection and a photocell detector is clipped onto the housing of the red-light. The moment the red-light comes on, the detector cable is activated. A vehicle crossing the stop line (and piezoelectric cable) during the red-light phase will trigger the camera and two photographs will be taken. The second photograph will be used to determine if the vehicle progressed further into the intersection during the red-light phase. For a fixed installation, the control unit is connected to an inductive loop embedded in the roadway surface at the stop line. The red-light status is picked off directly from the traffic light controller at the intersection. The inductive loop and camera activation for the fixed installation is accomplished the same way as for the tripod installation.

The photographs taken of the red-light violation show the offending vehicle and the traffic light plus data which include the time, date, location code, and the red-light elapse time.

3.4.6 Zellweger Uster AG

This Swiss firm manufactures an RLC system called MULTAFOT. This fully automatic system consists of a operating control unit, a photographic unit including flash, and roadway sensors (inductive loops). The control and photographic units are installed in a weather- and vandal-proof cabinet that is mounted on a steel pipe mast positioned alongside the roadway. *The control and photographic units can be moved from one* cabinet to another because of the plug-in type of connections. Special mounting poles are available that provide for the raising and lowering of the cabinet by electric motor for convenience of film changing and equipment maintenance.

The loop detectors are installed in the pavement surface either just upstream or downstream of the stop line depending upon the intersection configuration. A variety of loop configurations can be used so that simultaneous surveillance is possible of up to three separately signalized traffic lanes with different red-light phases and varying red-start times. The loop detectors are connected to the system which in turn is connected to the controller for the signal system.

The RLC system can be installed to take either rear or frontal photographs.

The RLC system is synchronized with the red-light phase(s) of the traffic control system. When a vehicle is detected by the pavement loop during the red-light phase, the camera is activated and two photographs are taken. The first photograph is taken when the camera receives a signal from the loop detector. The second photograph is taken at a preset time interval after the first that can be adjusted between 0.5 and 2 sec in increments of 0.1 sec.

The system will register and provide photographic documentation on any number of successive offenders. If a subsequent red-light violation is detected between the first and second photographs of a preceding violation, the photo-sequence will be extended by a third picture. This sequence can be repeated numerous times.

The camera's aperture and electronic flash are automatically controlled to match the prevailing light conditions. In addition, the electronic flash has two energy levels: 300 and 150 Ws. The flash can automatically switch the power level between photographs. For instance, the higher level is used when the vehicle is furthest away from the camera (first photo for frontal photographs and second photo to rear photographs) and the lowest level is used when the vehicle is closest to the camera.

The photographs show the scene at the intersection and various digital data. These data include the time, date, the red-light elapse time to the nearest tenth of a second for each controlled traffic light(s) (up to three), the number of registered violations, a photograph number, and a location code number. An example of the digital data recorded on a rear photograph is shown in Figure 3-22.

When frontal photographs are taken, the red light is not visible automatically in the photographic sequence as it is for rear photographs. The red light illuminated at the time of the frontal photograph can be captured photographically with a fiber optic element. Light taken directly from the properly illuminated red signal can be captured and routed via a fiber optic line to a position in the picture where its location is in full view of the camera and will not detract from the effort to view the license plates of the offending vehicles.

The system has been field-tested in two U.S. cities. It was tested at an intersection in New York City during an RLC demonstration project between January 1988 and early 1989. The system was also field-tested at two intersections in Pasadena, California, during the first half of 1989.

3.5 TRENDS IN SPEED ENFORCEMENT TECHNOLOGY

About 10 years ago, Midwest Research Institute conducted a multiyear study for NHTSA (Contract No. DOT-HS-8-02030) to identify and examine devices that could be used in the enforcement of speed limit laws. A large number of devices, concepts, and systems were identified in that study. Most of these technologies and devices were not American but had been developed and applied rather extensively throughout the rest of the world. The most widespread technology used outside the United States was manned, across-the-road radar. The most promising technology identified was particularly well suited for automated speed enforcement. That technology used a camera coupled with across-the-road radar to record automatically the license plates of speeding vehicles. The technology was used extensively in Europe and Japan, both in manned and unmanned operations.

Interesting trends in speed enforcement technology have been noted since the first study. Advances have continued to be made in the development of speed detection devices manufactured in the United States. One U.S. company produces a moving radar system that provides complete directional coverage and stopwatch capability. Two firms produce portable billboard-type radar units that provide a digital display to motorists of detected speeds. One Colorado firm is developing a laser speed detection device and hopes to have a working model for law enforcement demonstration sometime in 1990.

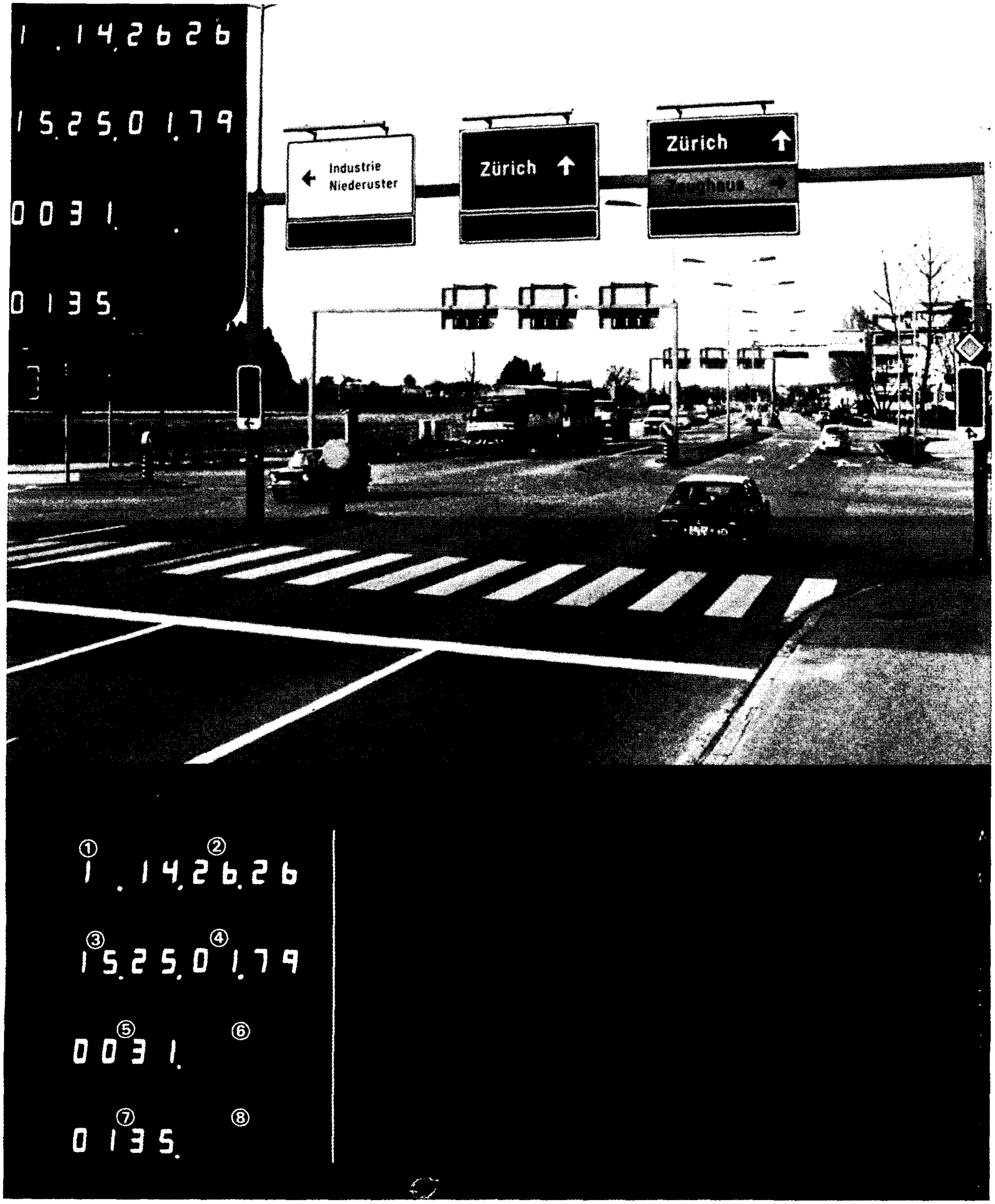

FIGURE 3-22. EXAMPLE OF A REAR PHOTOGRAPH TAKEN WITH MULTAFOT.

Photo courtesy of Zellweger Uster AG.

Advances also have continued to be made in the foreign development of speed detection equipment, with emphasis on automated equipment. These developments are concentrated in European countries, South Africa, and in Australia. Japanese manufacturers identified 10 years ago appear no longer to be involved with the equipment development.

The previously identified major foreign manufacturers of automated speed enforcement devices are still producing equipment, but the equipment appears to be much improved over the models of 10 years ago. The improvements have been achieved by using more current state-of-the-art electronics, and in some cases, lower output power levels. These improvements plus the use of highr radar frequencies have resulted in more compact and lighter weight systems that are more amenable to mobile operations. A variety of speed sensors is used by these systems including cross-the-road radar, down-the-road radar, optoelectronic devices, piezoelectric cables, inductive coils, etc.

New manufacturers of automated speed enforcement equipment have been identified in Sweden, Italy, and Australia. The Swedish system is unique in that its radar unit automatically switches from a standby mode to an active mode when a moving vehicle is detected. In the standby mode, a little blip of energy is emitted at a fixed time interval. A continuous beam of power is emitted in the active mode. The system can detect and measure speeds of multiple vehicles, simultaneously. The Italian device uses an optoelectronic sensor to measure vehicle speeds over a fixed distance between a pair of the sensors. The unit can also be set up to selectively monitor commercial vehicles, as can units produced by three other manufacturers of automated speed enforcement equipment. The Australian system uses an across-the-road radar.

Ten years ago, automated speed enforcement equipment was not used in the United States, although field trials of the equipment had taken place in Texas and New Jersey during the 70s. Now the situation is different. Automated speed enforcement equipment is being used routinely in Paradise Valley, Arizona, and in Pasadena, California, to enforce speed limits in those two communities.

Finally, interest has grown over the last 10 years in detection of red-light violations. Six manufacturers of red-light violation devices, five in Europe and one in Australia, have been identified. These devices are used throughout Europe and in selected areas of Australia and New Zealand. Field trials of two systems have been conducted in the United States--one in New York City and the other in Pasadena, California.

SECTION 4

SUMMARY OF ENFORCEMENT STRATEGIES

This section summarizes the various speed enforcement strategies identified in the study and how speed measurement devices are employed in such strategies. The range of enforcement strategies used is briefly discussed in Section 4.1. A discussion is given in Section 4.2 of various speed enforcement activities at the state and local levels. Section 4.3 provides information on automated red light violation enforcement activities in two U.S. cities. The trends in enforcement strategies over the last 10 years are presented in Section 4.4.

4.1 RANGE OF STRATEGIES USED

In the United States, most speed enforcement is accomplished by one of several conventional techniques. These are:

- Observing traffic from a fixed location (either using a time/distance measuring device or with down-the-road radar) and then pursuing and stopping suspected violators.

- Observing approaching traffic from a fixed location, using down-the-road radar, and then stepping out and directing suspected violators to stop.

- Observing traffic from a moving vehicle (either by pacing or with "moving radar"), and then pursuing and stopping suspected violators.

Many variations of the above can be cited, including the use of teams. The first two enforcement strategies identified above are losing favor with some patrols assigned to 65-mph highways.

Some innovative speed enforcement strategies have been used over the last several years in the United States. These include:

- Unattended radar.
- Portable billboard-type radar.
- Aircraft surveillance.
- Manned automated speed enforcement.

Unattended radar, as a deterrent, has been examined in Kentucky and Virginia. Some law enforcement agencies have experimented with this deterrence idea, attended or unattended, to see if the simple presence of microwave transmissions would slow traffic. Portable billboard-type radar has been used in some areas as an enforcement measure, but mainly as a public relations measure to inform motorists of their speeds in the hope that the speeding motorists would voluntarily reduce their speed. Aircraft surveillance has been, and continues to be, an enforcement strategy for many jurisdictions.

Possibly the most innovative speed enforcement strategy used in the United States is that which makes use of ASE equipment. Even the ASE equipment can be used in a manual mode to accommodate legal constraints surrounding use of photographs or other issues. The ASE equipment used recently in Precinct 8, Galveston County, Texas (July 1986 to July 1987), and presently in Paradise Valley, Arizona (October 1987 to present), and in Pasadena, California (June 1988 to present), has been operated with an officer present who observed approaching traffic from a fixed location. The officers in these three areas made no contact with the violators.

A range of strategies is used in European practice by various law enforcement agencies. They are presented below in order of increasing use of automation, starting with totally manned operations, which are not too dissimilar from U.S. practice, to the use of fully automatic, unmanned equipment:

- Use of stop teams
- Stationary, manned photographic systems
- Moving, manned photographic systems
- Movable, unmanned photographic systems
- Fixed, unmanned, fully automatic operations

The major European manufacturers of ASE equipment are currently producing systems that are designed for installation in a patrol vehicle and used in either a stationary or moving operation. These mobile speed enforcement strategies are becoming more prevalent in Europe. Less emphasis is being placed on the fixed, unmanned, fully automatic operations.

4.2 STATE AND LOCAL SPEED ENFORCEMENT ACTIVITIES

Part of this research study involved collecting information at the state and local levels on speed enforcement strategies and on how speed measurement devices are employed in such strategies. A list was developed of potential law enforcement agencies to be contacted for information relative to their speed enforcement strategies. This list was developed from contacts with several sources. These sources included manufacturers (or distributors) of speed enforcement equipment, law enforcement agencies known for their past interest in innovative speed enforcement technologies, and law enforcement agencies referred to us through preliminary contacts with other police agencies. Preliminary contacts were made with some of the potential agencies in order to develop a final list. Several agencies were excluded from further consideration after the initial contact because their enforcement activities rely heavily on the use of conventional enforcement tactics.

Eleven law enforcement agencies on the state and local levels were selected to be contacted. The sample of agencies selected was representative of the technologies being used. The technologies and associated agencies were:

- Air Surveillance
  - Kansas Highway Patrol
  - Missouri Highway Patrol
- Time/Distance Measuring Concepts
  - Wisconsin State Highway Police)
- Billboard-Type Radar
  - Santa Barbara, California, Police Department
  - Prairie Village, Kansas, Police Department
- ASE
  - Precinct 8 of Galveston County, Texas
  - Paradise Valley, Arizona, City Police
  - Maryland/Virginia State Highway Police
  - Wisconsin State Highway Patrol
  - Minnesota State Highway Patrol
  - Denver Police Department

A brief summary of the agencies' enforcement strategies is given below according to the technologies used.

4.2.1 Air Surveillance

In the past 8 to 10 years, the Kansas Highway Patrol has increased the number of aircraft used for air surveillance from two to five. Surveillance is performed by timing how long it takes a vehicle to travel between two marked points on the highway. The time is then converted into a speed using an equation that includes various operational variables. The speed calculation is performed either by the pilot or an observer in the aircraft. The speed value and descriptive information of the detected vehicle are then radioed to a stop team on the ground. One aircraft can monitor the speeds of vehicles on several roads in an area or in opposing directions of a given highway. Also, several stop teams can be controlled by a single aircraft. The Patrol is pleased with the air surveillance results and plans to continue its use.

The Missouri Highway Patrol uses two aircraft in its air surveillance efforts. The Patrol's experience is very similar to that of the Kansas Highway Patrol.

4.2.2 Time/Distance Measuring Concepts

A contact was made with the Wisconsin Highway Patrol regarding their use of both the HAWK radar and Vascar-Plus. The HAWK radar unit is made by Kustom Electronics Inc. in Lenexa, Kansas. The HAWK unit is both a moving and stationary radar system. It can provide speed readings for target vehicles in the same and opposite lanes, and in front of or behind the patrol vehicle. The HAWK can also be used in a time/distance/speed measurement mode that calculates the target's speed using a predetermined distance and the measured elapsed time taken by the target to cover that distance. The HAWK comes with a hand control unit. The hand control allows the officer to select the lane and direction of traffic to be monitored.

Currently, the Wisconsin Highway Patrol owns 10 HAWK units. Wisconsin was very interested in a device which can be used to monitor traffic in the same or opposite lanes while the patrol vehicle is moving. They have installed five HAWKS in unmarked patrol cars.

The Vascar-Plus speed detection equipment is manufactured by Traffic Safety Systems Inc. in Richmond, Virginia. The Vascar-Plus system is strictly a time/distance measurement system.

The Wisconsin Highway Patrol owns 180 Vascar-Plus units. Wisconsin is extremely pleased with the Vascar system's performance and ease of use. They have all operators of the Vascar system trained annually. The patrol uses the Vascar system in a stationary position on both highways and city streets. The patrol has found the system to be very versatile in where they can use it and how they can use it. They have also found that it is extremely accurate. Based on their studies, Wisconsin believes that if the officer's vehicle is hidden from the traffic, the system is completely undetectable.

4.2.3 Billboard-Type Radar

A site visit was made to the Santa Barbara, California, Police Department to review their use of a Mobile Radar Traffic Trailer. Sergeant Daryl Skare (805-963-3616) is in charge of the deployment and day-to-day operations of the trailer.

The Mobile Radar Traffic Trailer is manufactured by Mobile Traffic Zone Inc. of Woodland, California.* The trailer is intended for city use

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* It is understood that the Woodland, California Police Department had the first unit produced by Mobile Traffic Zone, Inc.

and can be positioned in the curb lane or by the side of any road. The trailer displays the speed of oncoming vehicles on a digital screen below a label of "Your Speed," mounted in turn under a speed limit sign. The trailer contains batteries, circuitry, and a Kustom Falcon radar gun. The unit was initially designed to have the batteries recharged using a built-in solar collector array. This feature has not worked too well, and the unit has since been modified to permit recharging with an external AC source. Typically, the trailer is placed in neighborhoods where the police receive frequent complaints about speeding. The unit is being used currently as a public awareness device and is intended to solicit voluntary compliance with speed laws, thereby promoting a safer community.

No study has been conducted to measure the impact of the trailer's use on levels of speeding. The department thinks the trailer has had some positive impact on speed. However, some drivers have sped past the trailer and were stopped for speeding downstream of the trailer by other police using hand-held radar.

The manufacturer of the Mobile Radar Traffic Trailer has distributed 16 units in the United States: three in North Carolina, four in Nevada, and nine in California. The firm is producing up to two more for use in southern Nevada in a highway construction zone. This will be the first application of their device on a highway. All of their other installations have been in urban locations which have a history of speeding problems. They use Kustom and MPH radar units in their trailers. The system is used as both an educational and an enforcement device. The unit can either be mounted on a trailer, or a smaller display device can be mounted permanently alongside the road. The company is in the process of adding an on-board computer to keep track of all statistics, such as number of cars, speeders, average speeds, etc. They will also be adding an ability to print out all statistics.

A billboard-type radar unit is also used by the Prairie Village, Kansas, Police Department for speed enforcement and public information and education. The unit, called Giant PR Display, is manufactured by Kustom Electronics Inc. of Lenexa, Kansas. The Giant PR Display unit consists of a Falcon radar gun and a Giant PR Display board that provides a digital display of detected speeds to oncoming traffic. The Falcon radar gun is similar to the standard Falcon radar gun, except it is equipped with a special connector for the display. Kustom also sells several attachments with the Giant PR Display such as battery packs, photoelectric cells, tripod stands, and other mounting brackets to connect the Giant Display to an officer's vehicle. The display is weatherproof and requires a 12-V power source. The display is designed so that it only consumes power during the changing of its digits. Kustom indicates that if the display is to be run for no more than 4 to 5 hr, then the battery pack would be sufficient. However, for longer times, Kustom recommends that a power source be connected to the display.

The unit used by the Prairie Village, Kansas, Police Department is designed to be operated either from an array of photoelectric cells mounted on the rear deck of the patrol car or from the vehicle's 12-V power supply. The photoelectric cells do not provide enough power to correctly operate the display, even when solar radiation is directed perpendicular to the cell array. Consequently, the department operates the unit with the patrol vehicle's engine running. The unit is operated during daylight hours and on city streets with 35- or 25-mph posted speed limits and where speeding is known to exist. The department likes the unit and feels it has some impact on vehicle speeds but only in the close vicinity of the unit.

4.2.4 Automated Speed Enforcement Equipment

Interest in ASE equipment by state and local law enforcement agencies has recently increased. The experience and interest of seven agencies are briefly documented below. The resurgence of interest in ASE has arisen from a number of concerns of state and local enforcement agencies, including:

- Raising of speed limits to 65 mph on some facilities.
- Decreased effectiveness of conventional radar due to widespread use of radar detectors. (Several million radar detectors per year are being sold in the United States).
- Difficulty of stopping speeders to issue citations on high-speed facilities.
- High manpower requirements per citation issued for conventional enforcement.

4.2.4.1 Texas Experience With Manned ASE Equipment

Manned ASE equipment was used from about July 1986 to July 1987 in Precinct 8 of Galveston County, Texas. The device used was a Multanova 6F made by Zellweger Uster AG in Switzerland and was rented from a firm in Friendswood, Texas. The system, which included a Robot camera, was mounted in the rear of a four-wheel-drive vehicle, also leased to the constable's office. Frontal photographs were taken of speeding vehicles detected. An auxiliary, manually operated camera was used to photograph the rear of the vehicle if the vehicle had no front license plate. The speed enforcement was confined to a portion of interstate highway running between Houston and Galveston and outside of incorporated areas.

The firm providing the equipment and vehicle also provided the film, film processing, film review for identification of the license plate number, printing of the citations (including second mailings as a follow-up), and mailing of the citations (using the county stationery). For this service, the firm charged the Constable's Office $20 for each fine collected.

Between 4,000 and 5,000 citations were issued over the one-year period resulting in about $70,000 in fines collected. Between 40% and 48% of the vehicle owners responded with payment to the first letter. The follow-up letter said those refusing to pay would be arrested, and some were. Owners of commercial vehicles and out-of-state vehicles were difficult, if not impossible, to track and punish.

Sixteen of the speeding cases went to jury trial. The prosecution won all of the cases. Four speeding convictions were appealed to the County Court of Appeals where the convictions were overturned. The County Attorney then decided not to prosecute any more of these cases.

The operation was stopped by the District Attorney's office in July 1987. Also at the time, public opinion developed against the use of the equipment, and some irate motorists were even detected throwing rocks at the enforcement vehicle to knock out the flash, which was claimed to be blinding the motorists.

At the time the ASE equipment was used in Texas, there was no provision in the law to permit vehicle owners to be charged for speed violations committed by any driver of the vehicle. The ASE equipment was used because no law prohibited its use. A bill (House Bill 830) was introduced in early 1987 in the Texas legislature to provide the proper legal environment in Texas for use of ASE equipment. However, the bill was never released from the subcommittee of the House Transportation Committee.

The citations issued are under judicial review, and it is possible that the $70,000 in fines collected may have to be refunded. Thus, it appears unlikely that ASE will be used again in Texas in the near future.

The same equipment was also pilot-tested by the city police of La Marque, Texas, for a 90-day period during early 1987. The problems in Precinct 8 impacted the equipment's use in La Marque, and several city officials reportedly lost their jobs over the pilot tests.

The Texas experience presents a strong case for laying proper groundwork before ASE is employed in U.S. law enforcement activities.

4.2.4.2 Paradise Valley, Arizona, Experience With Manned ASE Equipment

A site visit was made to the Paradise Valley, Arizona, Police Department to review their use of ASE equipment. Mr. Onno Primsze, Director, Support Services Division (602-948-7418), is in charge of the deployment of the ASE equipment and is assisted in the day-to-day operations by Sergeant Ron Warner.

In October 1987, the Paradise Valley, Arizona, Police Department began using manned ASE equipment to enforce speed limits at approximately 60 locations within this community of about 13,600 inhabitants. The city is located on the northeast edge of Phoenix and contains a number of heavily traveled north-south and east-west routes that connect adjacent communities.

The equipment used is the Multanova 6F made by Zellweger Uster AG. The department has only one of the units, and it is mounted in the rear of a four-wheel-drive vehicle. The detection equipment and vehicle are leased from Traffic Monitoring Technologies (TMT) in Friendswood, Texas. Frontal photographs are taken with a Robot camera mounted in the vehicle, and an additional camera is located a short distance upstream of the enforcement vehicle to take a rear photograph of the speeding vehicle at about the same time the frontal photo is taken.

The "Photo Radar" unit is deployed at various times of the day and night and is used about 25 to 30 h/week. A diamond-shaped warning sign with the message "Photo Radar in Use" is deployed upstream of the enforcement vehicle to notify motorists of the operation.

All 18 officers on the force that are assigned to patrol have been trained in the use of the equipment by TMT. However, only 3 of the 18 officers are assigned full-time for speed enforcement.

The legal environment for use of an ASE device in Paradise Valley is somewhat unique. Two years ago, the state changed its statutes regarding speeding penalties. Prior to the law change, a speeding offense was a misdemeanor, regardless of the speed level. Now, drivers caught speeding more than 20 mph over the posted speed limit are charged with a misdemeanor (a criminal traffic offense). Drivers caught speeding 20 mph or less over the posted speed limit are charged with a civil infraction. In August 1987, the City Council passed an ordinance stating that registered owners of vehicles are presumed responsible for certain violations involving the vehicle, including speeding. The owner of the vehicle cited with a speeding violation has four options: if not the driver at the time of the violation, identify the driver (or the new owner if the vehicle had changed ownership); pay the fine; attend the defensive driving class; or contest the violation by appearing in court (see Figure 4-1). If the owner fails to respond to a civil infraction citation, a second notice will be sent and the owner's driver's license will be suspended until the fine is paid. If the owner fails to respond to a criminal traffic offense, the owner's driver's license will be suspended and a warrant will be issued for his/her arrest.

The Texas firm providing the equipment and vehicle also provides the film, film processing, film review for identification of the license plate number, printing of the citations (including second mailings as a follow-up), and mailing of the citations. Much of this operation is handled in the local office of TMT. The city pays the firm a fee of $20 for each paid ticket or owner attending a defensive driving course.

The Paradise Valley Police like the Swiss-made Multanova system and claim very few problems with the equipment, the courts, or adverse public opinion. During the first year of operation, about 11,000 speeding citations were issued. (The department now claims to be generating about

ALBERT FITCH
63543 BUFFALO SPEEDWAY
APARTMENT 765
TUCSON, AZ 87654

EXAMPLE

IN THE TOWN MAGISTRATE'S COURT
IN AND FOR THE TOWN OF PARADISE VALLEY, ARIZONA

STATE OF ARIZONA,
PLANTIFF,
V.

ALBERT FITCH
DEFENDANT

SUMMONS

NO. PVPD - 00987631

A CIVIL traffic violation has been filed in this Court against you ALBERT FITCH charging that, in the Town of Paradise Valley, Maricopa County, Arizona, on or about Oct 20, 1987 AT 11:48:08 AM you violated the laws of the State of Arizona by speeding.

YOU ARE HEREBY SUMMONED to appear before this Court located at 6401 East Lincoln Drive (Southeast corner of Lincoln and Invergordon), Paradise Valley, Arizona on NOVEMBER 19, 1987 at 08:30:00 AM

IF YOU FAIL TO APPEAR AS REQUIRED HEREIN,
THE CHARGE MAY BE DEEMED ADMITTED.

DATE 30-Oct-1987

JOHN SMITH (SIGNATURE ON FILE)
Judge of Paradise Valley Town Magistrate's Court

COMPLAINT NO. PVPD - 00987631	SOC. SEC. NO.	AGENCY USE	MILITARY Yes No
COMPLAINT DEFENDANT'S COPY	DRIVER'S LICENSE NO.	STATE	CLASS ☐ OPER ☐ CHAUF.
STATE OF ARIZONA VS. DEFENDANT	FIRST ALBERT FITCH	MIDDLE	LAST NAME

☒ CIVIL TRAFFIC
☐ CRIMINAL TRAFFIC
COMPLAINT

IN THE PARADISE VALLEY MAGISTRATE'S COURT MARICOPA COUNTY, AZ.
The undersigned says
The defendant did:

TOWN OF PARADISE VALLEY
MARICOPA COUNTY
STATE OF ARIZONA
ARIZONA TRAFFIC TICKET AND COMPLAINT

ADDRESS (RESIDENCE) 63543 BUFFALO SPEEDWAY			TOWN TUCSON,	STATE AZ 87654		ZIP	
SEX	WEIGHT	HEIGHT	EYES	HAIR	ORIGIN	BIRTH DATE	
BUSINESS ADDRESS			TOWN	STATE		ZIP	
VEH	COLOR	YEAR	MAKE	TYPE	LICENSE NO. 123456	STATE AZ	EXPIRATION

ON MONTH Oct	DAY 20	YEAR 1987	TIME 11:48:08 AM
AT SOUTH BOUND AT 8600 NORTH EVERGORDON			PARADISE VALLEY, ARIZONA
COMMIT A ☐ MISDEMEANOR X CIVIL TRAFFIC VIOLATION			X RADAR
IN VIOLATION OF SECTION: ARS 28-701A			APPROX. SPEED 46
AS FOLLOWS: SPEED PAST THE POSTED LIMIT			LAWFUL SPEED 35

NOTICE TO APPEAR
MAGISTRATE'S COURT - 6401 E. LINCOLN DRIVE
TOWN OF PARADISE VALLEY, AZ

Your court date and time is on NOVEMBER 19, 1987 at 08:30:00 AM

☐ Without admitting guilt, I promise to appear as directed hereon.
☐ Without admitting responsibility, I acknowledge the receipt of this complaint.

SIGNATURE X________________

I certify that upon reasonable grounds I believe the defendant committed the act described contrary to law and I have caused a copy of this complaint to be served upon the defendant.

COMPLAINANT: DON C. FANNING NO. 0061

DEFENDANT IS ADVISED TO READ INSTRUCTIONS ON REVERSE SIDE AND BRING THIS COPY TO COURT

Complaint Type: CIVIL Complaint No.: PVPD - 00987631 Fine / Sanction: $60.00

In the interest of protecting the lives and property of our citizens, an automated speed monitoring system is being used by The Town of Paradise Valley to observe traffic and photographically record those drivers exceeding the speed limits.

The system, operated by an officer of the Paradise Valley Police Department, photographed a vehicle registered in your name. The photograph is available for viewing at the Paradise Valley Magistrate's Court, 6401 East Lincoln Drive, Paradise Valley, AZ.

You are required to respond no later than your arraignment date, by doing one of the following:

OPTION I. a. If you did not own the vehicle at the time of the violation you are required to identify the new owner in the space provided below, sign this form and mail it in the enclosed self-addressed envelope before your arraignment date.

b. If you were not the driver of this vehicle at the time indicated in the complaint you are required to identify the driver in the space provided below, sign this form and mail it in the attached self-addressed envelope before your arraignment date.

— New Owner NAME ________________
STREET ADDRESS ________________ ________________
— Driver CITY, STATE, ZIP ________________ Your Signature

OPTION II. Pay the fine or sanction for this offense. You may pay in person at The Town of Paradise Valley Magistrate's Court, 6401 East Lincoln Drive, Paradise Valley AZ or

If you wish to pay your fine or sanction by mail for the citation you have just received, you may do so by following steps 1 thru 6 below.

1. Your fine or sanction for this offense is shown on the upper right hand corner of this form.
2. If your complaint is checked "criminal traffic" in the upper right hand portion, sign the following statement and provide the driver's license number of the driver.

I hereby post $____________as bail and intend to forfeit, and do not want a trial.
Sign Here for Criminal Traffic________________ Driver's License No.____________ State________

(CONTINUES ON REVERSE SIDE)

FIGURE 4-1. EXAMPLE OF SPEEDING CITATIONS USED BY PARADISE VALLEY, ARIZONA, POLICE DEPARTMENT.

IMPORTANT NOTICE

The reverse side hereof contains a true copy of the offense described in the Complaint that will be filed in the designated Court.

The offense for which you have been cited is either a CIVIL TRAFFIC VIOLATION or a CRIMINAL TRAFFIC OFFENSE. Each citation may be different. To determine which notice applies to you on this citation look at the box which is checked in the upper right hand portion of this citation.

If the "CIVIL TRAFFIC" box is checked, pursuant to ARS 28-1058-B-2 notice is hereby given that IF YOU FAIL TO APPEAR AS DIRECTED IN THIS COMPLAINT ON A CIVIL TRAFFIC VIOLATION A DEFAULT JUDGMENT WILL BE ENTERED AGAINST YOU. A CIVIL SANCTION WILL BE IMPOSED AND YOUR LICENSE WILL BE SUSPENDED. YOUR DRIVER'S LICENSE WILL REMAIN SUSPENDED UNTIL THE CIVIL SANCTION IS PAID.

If the "CRIMINAL TRAFFIC" box is checked, pursuant to ARS 28-1058-B-1 notice is hereby given that IF YOU FAIL TO APPEAR ON A CRIMINAL CHARGE, A WARRANT WILL BE ISSUED FOR YOUR ARREST AND YOUR LICENSE WILL BE SUSPENDED.

3. If your complaint is checked "civil traffic" in the upper right hand portion, sign the following statement and provide the driver's license number of the driver.

   I hereby admit responsibility for the civil traffic violation alleged and submit $__________ as the civil sanction for such violation.

   Sign Here For Civil Traffic ____________________ Driver's License No. _______________ State ______

4. Sign complaint form.
5. Mail this form, the signed complaint form with .. . heck or money order payable to The Town of Paradise Valley Magistrate's Court in the enclosed self addressed envelope before your court date. (NO CASH - PLEASE)
6. If you pay the fine/sanction by mail, you will not be required to appear in court, but you must mail the fine/sanction before your court date or else personally appear. In the event you fail to comply and the complaint alleges a "criminal traffic" offense, a warrant may be issued for your arrest. If the complaint alleges a "civil traffic" violation, your operator's or chauffeur's license may be suspended.

OPTION III. Attend Traffic Safety Option Class—*if you are eligible.* You are eligible if you have not attended this traffic safety class within two (2) years. This class is conducted by the Arizona Consortium for Traffic Safety, Inc. (ACTS). The six (6) hour Basic Adult Defensive Driving Class deals with attitudes, skills and knowledge special to driving in Arizona.

To sign up for the Traffic Safety Option Class you must:

1. Come to court on the day and time shown on your citation.
2. Bring your copy of the citation.
3. Bring sixty ($60.00) dollars in cash—**No Personal Checks.**

You must pay for the class at the time you sign up. When you have completed the Traffic Safety Option Class, your citation will be dismissed and NO POINTS will be placed on your driving record.

OPTION IV. If you wish to contest the violation, you must appear in court on the date and time shown on the summons.

FIGURE 4-1. (Concluded)

24 citations per hour of deployment.) Approximately 68% of the owners sent the speeding citations either pay the fine or agree to attend the defensive driving school. Owners of commercial vehicles and out-of-state vehicle owners are difficult to track and punish. However, some recent progress has been made in citing owners of commercial vehicles, and several rental car agencies have agreed to cooperate in identifying who was renting the car at the time of the speeding violation.

Seven court case convictions have been appealed to the County Superior Court. The speeding convictions on six of the seven cases were upheld. A ruling on the seventh case was made in favor of the plaintiff (driver) because of mistaken identity, which had nothing to do with the operation of the ASE device. A special case was brought before the Arizona Supreme Court by the American Civil Liberties Union to enable appealed cases to be brought directly to that high court rather than going through the lower appellate courts. The Arizona Supreme Court refused to accept jurisdiction over the appellate courts in these cases.

The city police believe the use of the equipment has contributed to a 43% reduction in citywide accidents compared to the same period prior to implementation. The success with the system in Paradise Valley has prompted several other Arizona cities to consider using the equipment in their areas. The Phoenix suburbs of Scottsdale and Glendale are very interested in the equipment. The city council of Peoria, Arizona (another Phoenix suburb), recently approved the use of the equipment in this community of about 5,000 people.

4.2.4.3 Pasadena, California, Experience With Manned ASE Equipment

A site visit was made to the Pasadena, California, Police Department to discuss the department's use of the "Photo Radar" unit. Lieutenant Robert Huff in the Field Services Division (818-405-4620) is in charge of the deployment of the ASE equipment, as well as the field trials with the red-light violation equipment described in Section 4.3.

The Pasadena, California, Police Department used a manned ASE device during a pilot study in December 1987. Warnings were issued during the test period to 1,420 drivers. The pilot study was deemed to be so successful with the public, judges, and law enforcement officers that a decision was made to begin speed enforcement with the device on non-freeways within this community of about 135,000 inhabitants on June 1, 1988. A press release (see Figure 4-2) concerning the operation was distributed on May 17, 1988. A news conference involving radio, TV, and newspaper coverage was held on June 2 to further explain the operation and safety benefits of the equipment.

The equipment used during the pilot test and now during the speed enforcement phase is the Multanova 6F photo radar system. The department leases one of the units, mounted in the rear of a four-wheel- drive vehicle, from Traffic Monitoring Technologies (TMT) in Friendswood, Texas. Frontal photographs are taken with a Robot camera mounted in the

NEWS RELEASE

FFICE OF THE CHIEF
MES M. ROBENSON

PASADENA POLICE DEPARTMENT
142 NORTH ARROYO PARKWAY
PASADENA, CALIFORNIA 91103

PRESS RELEASE

MAY 17, 1988

THE PASADENA POLICE DEPARTMENT, PASADENA, CALIFORNIA, WILL BEGIN ITS OPERATION OF THE PHOTOGRAPHIC RADAR SYSTEM ON JUNE 1, 1988. PHOTO-RADAR IS THE LATEST TECHNOLOGY IN TRAFFIC SPEED LAW ENFORCEMENT.

PHOTO-RADAR HAS BEEN USED FOR SEVERAL YEARS IN EUROPE AND VARIOUS COUNTRIES AROUND THE WORLD. IT HAS PROVEN TO BE HIGHLY EFFICIENT EQUIPMENT WHICH IS ALSO VERY EFFECTIVE IN CONTROLLING SPEEDING AND ACCIDENTAL DEATH AND INJURY.

THE PASADENA POLICE DEPARTMENT TESTED THE PHOTO-RADAR SYSTEM FOR 30 DAYS IN DECEMBER, 1987. "WARNINGS" WERE ISSUED DURING THE TEST PERIOD TO 1420 DRIVERS. ADDITIONALLY, A SURVEY FORM ACCOMPANIED THE "WARNING." THE MAJORITY OF THOSE SURVEYS RETURNED WERE IN FAVOR OF THE USE OF PHOTO-RADAR, A PROVEN DETERENT IN ACCIDENTAL DEATH AND INJURY.

IN APRIL OF 1988, THE PASADENA CITY BOARD OF DIRECTORS MADE THE DECISION TO ENTER INTO A CONTRACT WITH TRAFFIC MONITORING TECHNOLOGIES OF FRIENDSWOOD, TEXAS, TO PURCHASE THE PHOTOGRAPHIC RADAR SYSTEM.

PASADENA IS PROUD TO BECOME THE FIRST MAJOR CITY IN THE UNITED STATES TO INITIATE A PROGRAM THAT HAS SUCH A GREAT POTENTIAL TO PREVENT ACCIDENTS AND REDUCE INJURIES AND FATALITIES.

FOR FURTHER INFORMATION CONTACT LIEUTENANT BOB HUFF AT (818) 405-4620.

FIGURE 4-2. PASADENA, CALIFORNIA, PRESS RELEASE.

vehicle. An additional camera is used by the enforcement officer to manually take a rear photograph of the speeding vehicles that do not have front license plates. In California, vehicles are required by law to have both front and rear license plates, but in fact many vehicles do not have front license plates.

The "Photo Radar" unit is deployed at various locations on weekdays between 6:30 a.m. and 8 p.m. and is used now about 16 h/week. A rectangular-shaped sign with the message "You Have Just Passed Through Photo Radar (You May Be Notified By Mail)" is deployed downstream of the enforcement vehicle to notify motorists of the operation. Informational signs are also posted at the city limits of Pasadena to alert motorists that the speed limit is enforced with photo radar.

The department has 12 officers assigned to traffic patrol. Ten of the 12 officers have been trained in the use of the equipment by TMT. The arrangements with TMT are the same as in Paradise Valley. They provide film, film processing, printing of the citations, and mailing of the citations. Much of this operation is handled in the local office of TMT which receives a fee of $20 for each paid ticket.

The Pasadena police like the Swiss-made Multanova system and claim very few problems with the equipment, the courts, or adverse public opinion. During the first three months of operation, about 7.4% of the motorists passing the enforcement locations were "speeding" (exceeding the speed limit by a predetermined amount). Seventeen months after the operation began, the percentage of vehicles detected as speeding dropped to 5%. During the first seven months of operation, 4,082 speeding citations were issued out of 9,728 violations detected from 160,354 vehicle passages. Citations were issued in only those cases where the photograph was clear enough to see the violator's face and the license number could be identified. Seventeen months after the operation began, a total of 14,733 had been issued.

About 84% of the owners sent the speeding citations either paid the fine or identified who was driving at the time of the offense. Out of the 14,733 citations issued during the first 17 months of operation, 283 cases were heard in Pasadena's Municipal Court. None of the court cases have been lost by the city, and none of the decisions have been appealed.

4.2.4.4 Maryland/Virginia State Police's Interest in Manned ASE Equipment

The Maryland State Police (MSP) has long shown interest in new enforcement technology and ASE equipment. The MSP was one of the three state police agencies that took part about 10 years ago in the field evaluation of four ASE devices.[7] Between August 24 and October 15, 1987, the Special Enforcement Unit field-tested the Traffipax Photographic Radar System to determine its usefulness for a study of truck speeds and violations. The Unit was impressed with the operation of the latest system, but no further action was taken to purchase the system.

The Maryland State Police have joined the Virginia State Police to form a task force under contract with NHTSA to conduct a pilot study of using ASE equipment on the Capitol Beltway. The Virginia State Police will actually be the lead group under this contract. The project will include an evaluation of the applicability of using such equipment to deter speeding under a variety of operating conditions. The pilot study will be limited to the mailing of warning letters to speeders; no arrests will be made.

The Maryland State Police also has an interest in the laser speed gun being developed by International Measurement and Control Company in Littleton, Colorado. A committee has been set up in the department to review and evaluate the laser gun when it becomes available.

4.2.4.5 Wisconsin Department of Transportation/State Highway Patrol Interest in Manned ASE Equipment

In 1987 the Wisconsin State Highway Patrol, at the direction of the Secretary of the Wisconsin Department of Transportation (WisDOT), performed an in-house study of the possible use of manned ASE equipment in Wisconsin. The main emphasis behind the requested study was to see if some of the Patrol's force could be freed from enforcing speed limits on certain interstate highways and used to enforce speed limits and drunk driving violations on other facilities.

The Patrol's study recognized that the use of ASE is a very sensitive topic, and that before ASE was used in Wisconsin, certain statutory changes would be needed as well as the support of the criminal justice system, the legislature, and the public. The Patrol's preliminary conclusions were:

- ASE would be best used on medium to heavy traffic volume highways where a substantial number of speeding violations and accidents occur.
- ASE could possibly increase voluntary speed compliance if used on certain highway facilities.
- The use of ASE must be for enhanced highway safety, or it will not be acceptable to the public.
- If WisDOT decides to pursue the ASE issue, it would be wise to begin with a demonstration, or pilot test, project.

In response to these conditions, the Highway Patrol developed a recommended implementation plan for WisDOT's approach to the integration of ASE technology into Wisconsin traffic law enforcement. The detailed plan covered activities that would take place over about a two-year period.

The implementation plan has been placed on hold until ways can be found to make use of state data to identify highway segments with high traffic volumes and where substantial speeding and accidents occur.

4.2.4.6 Minnesota Governor's Office for Highway Safety/State Highway Patrol's Interest in Manned ASE Equipment

The Director of Traffic Safety in the Minnesota Governor's Office for Highway Safety is pushing very hard to get automated speed enforcement into use in Minnesota. The office has plans for two separate programs in FY1990, possibly starting in the spring.

One program would involve the state DOT working in cooperation with the State Highway Patrol to install photo radar in highway construction work zones. The proposed project would be publicized and probably involve only the issuance of warning letters to identified owners of detected speeding vehicles. The project would be state-funded.

The second program, using NHTSA 402 funds, would employ a photo radar system on selected dangerous urban routes. The prime candidate at present is an arterial in St. Paul that carries very heavy traffic, has a high accident rate, has a high incidence of speeding, and is difficult to patrol. The arterial is a fairly narrow roadway, two lanes in places, with a river on one side and bluffs on the other. The roadway has no place to pull cars over for issuance of speeding citations. The state intends to highly publicize the program, emphasizing that they are trying to identify only the very high-speed, hazardous offenders. Initial plans are to use frontal photos and warning letters. The state does not yet have legislation to make arrests using photoradar evidence, although that may be a reality in a few years.

4.2.4.7 Colorado's Office for Highway Safety/Denver Police Department's Interest in Manned ASE Equipment

The Colorado Office for Highway Safety is in favor of automated speed enforcement technology being implemented in that state. The office has developed a three-year highway safety plan that includes, as one objective, the encouragement of the use of photo radar in the state to improve highway safety. The Denver Police Department is very interested in the use of automated speed enforcement (ASE) equipment to enforce speed limits on the interstate facilities within the city limits. Statutory changes in the state law would be needed before the equipment could be used. Consideration is being given to approach the Colorado Association of District Attorneys to have that group sponsor legislation that would permit the use of ASE equipment under certain conditions in Colorado.

4.3 U.S. EXPERIENCE WITH AUTOMATED RED-LIGHT VIOLATION ENFORCEMENT

Two U.S. cities (Pasadena, California, and New York City) have conducted pilot tests of automated red-light violation equipment, including sensors and photographic capabilities. These tests are reviewed briefly here.

4.3.1 Pasadena, California

During the Pasadena site visit to review ASE usage, MRI also inspected a Multafot automated red light surveillance system. This installation was part of a demonstration project supported jointly by the City and Multanova. The system was installed at the intersection of Fair Oaks Boulevard and Union Avenue in Pasadena and observes traffic traveling northbound on Fair Oaks Boulevard. The system's purpose was to photograph northbound vehicles that violate the red phase of the traffic signal. Some operational problems were experienced with the system. About 95% of the photographs taken were of nonviolating vehicles, partly because of the location at which the vehicle sensors were initially installed and a tendency of many drivers to encroach or creep past the stop bar and into the crosswalk area during the red phase. The system was relocated to another intersection shortly and further evaluated. No decision has been made by the department to purchase the system.

4.3.2 New York City

New York State has, for several years, been attempting to put in place in New York City an automatic system to enforce red traffic signal violations. The technology, and the legal political framework, is very close to that used in Europe for speed enforcement.

Two demonstrations of red-light violation detection equipment have taken place in New York City. The first demonstration was conducted from June 1985 through March 1986 at the intersection of Third Avenue and 86th Street in Manhattan. The device used was the Traffiphot unit. LeMarquis International, the U.S. distributor of the equipment, was responsible for the placement, setup, and monitoring of the device. During the 44 days of full operation, approximately 4,000 red-light offenses (an average of 90 violations per day) were clearly detected and recorded on film. No citations were issued during the demonstration.

The second demonstration took place from January 1988 through early 1989 and involved three intersections: Third Avenue and 86th Street in Manhattan, Jewell Avenue and Kissena Boulevard in Queens, and Fourth Avenue and Ninth Street in Brooklyn. During the second demonstration, the Traffiphot system was again used at the Manhattan intersection, the Multafot made by Zellweger Uster was used at the intersection in Queens, and a system made by Alex Jacknau Filmaufrahme was used at the intersection in Brooklyn. The operation at the first two intersections ended during the summer of 1988.

Photographs of red-light violations were obtained from the first two intersections during the second demonstration. No film was ever obtained from the Brooklyn site. At the Manhattan location (Traffiphot), a maximum of 40% of the photographs taken recorded a red-light violation in which the license plate number was readable. At the Queens site (Multafot), a maximum of 56% of the photographs taken recorded a readable red-light violation. Summonses were not issued for the detected violations.

The findings from the second demonstration were:

- The two devices that worked produced usable results, although significant fine-tuning and calibration were necessary.
- Site selection and design must be carefully executed to ensure the best results.
- Methods for reviewing the film and identifying violators must be devised to maximize the cost-effectiveness of the system.
- Some elements of the operations, such as maintenance, require highly skilled personnel.

While both studies were being performed in New York, there was no legislative approval to issue tickets based on photographic evidence. However, during the second study, a bill was submitted to the New York Legislature which would authorize New York City to photograph vehicles and to mail summonses to the registered owners of the vehicles. On July 7, 1989, the New York Legislature passed this bill, thus allowing photographs as evidence and summonses to be mailed to the registered owners.

The New York City Department of Transportation now has plans for installing red-light violation detection equipment at 25 intersections in that city. Citations for red-light violations will be issued through the mail to the registered owners of the vehicles identified. A two- to three-month delay in the start of the installation has occurred because of fiscal problems. It is anticipated that program will start in January 1990, at the earliest.

4.4 TRENDS IN SPEED ENFORCEMENT STRATEGIES

A range of speed enforcement strategies is used in European practice by various law enforcement agencies. The use of ASE equipment in these strategies was identified 10 years ago and has remained strong over that period. Developments over the last 10 years are reviewed here.

Several innovative speed enforcement strategies have been tried in the United States over the last decade to improve compliance with speed limit laws. Possibly the most innovative speed enforcement strategy used in the United States is that which makes use of ASE equipment. Over the last three years there has been growing interest by city, county, and state law enforcement agencies in the use of manned, automated speed enforcement technology that has been imported from European manufacturers. The interest at the city and county levels has turned into practical experience. Manned automatic speed enforcement equipment installed in a vehicle and employing across-the-road radar in connection with a camera was used for speed enforcement in Precinct 8 of Galveston County, Texas, from about July 1986 to July 1987. The same type of equipment has been used continuously from October 1987 in Paradise Valley, Arizona, and from June 1, 1988, in Pasadena, California, for speed enforcement on nonfreeway facilities in these two communities. Other city law enforcement agencies in Arizona and California are watching with interest the developments in Paradise Valley and Pasadena. The State Police of Maryland and Virginia have teamed together concerning a pilot study of using automated speed enforcement equipment on the Capitol Beltway.

Ten years ago, there was some emphasis, particularly in West Germany, Switzerland, and Japan, on the use of fixed, unmanned, fully automatic operations for selected portions of expressways. No indication has been found of the use of unmanned, fully automated speed enforcement equipment in areas where it did not exist before. Perhaps one reason for this is the development of highly mobile and compact equipment that did not exist 10 years ago.

Ten years ago, the use of automatic speed detection equipment by law enforcement agencies in Australia and the United Kingdom was not considered. In March 1986, the Victoria, Australia, police began using manned automated speed enforcement equipment (automated equipment for detection of red-light violations has been used in Victoria since August 1983). In the next few years, it is believed that automated equipment for the enforcement of traffic violations will be used in the United Kingdom. Such equipment is currently under discussion and, in some cases, trial.

The Saudi-Arabian Traffic Police Department is currently considering the installation of automatic speed detection equipment on the entire Makkah/Jeddah Expressway that covers a distance of 60 km between the two cities.

SECTION 5

TRENDS IN LEGAL ISSUES ASSOCIATED WITH AUTOMATED SPEED ENFORCEMENT

In a study[6,7] for NHTSA conducted about 10 years ago, several legal issues were examined regarding the potential employment of automated speed enforcement devices in the United States, especially when they involved photography. The issues examined included the individual's rights to privacy, equal protection, admissibility of photographic testimony into evidence without corroborative testimony of a human being, and vicarious liability. Most of the concerns examined were found not to present formidable legal barriers to the employment of automated speed detection devices in the United States. The one exception was the vicarious liability problem as it applied to speed-law statutes. This concerned the legal issues that might be encountered with the imposition of criminal or civil liabilities on the owners of vehicles observed in violation of speed laws, in the absence of information about the identity of the actual drivers. In using the automated speed detection devices, the vehicle owner can be identified as the offender (through the license plate), but may not be the driver at the time of the offense. A suggested solution to this legal issue was the creation of civil vicarious liability statutes for traffic offenses, including speeding violations. The civil statutes designed to impose vicarious liability on the owners of vehicles observed in violation of speed laws would eliminate many of the objections imposed by criminal statutes.

It was noted 10 years ago that the most common vicarious liability vehicular offense was a parking violation. In some states, minor traffic offenses were being decriminalized. This situation presented a legal environment for passage of vicarious liability (civil) statutes for other traffic offenses including speeding and red-light violations.

In 1987 Arizona changed its statutes regarding speeding penalties. Drivers caught speeding more than 20 mph over the posted speed limit are charged with a criminal misdemeanor. Drivers caught speeding 20 mph or less over the posted speed limit are charged with a civil infraction. In August 1987 the City Council of Paradise Valley, Arizona, passed an ordinance stating that registered owners of vehicles are presumed responsible for certain violations involving the vehicle, including speeding. This legal environment set the stage for what appears to be a relatively successful usage of manned automated speed enforcement equipment in that community since October 1987.

The usage of manned automated speed enforcement equipment was stopped after about one year of usage in Precinct 8 of Galveston County, Texas because of public opinion. At the time the manned automatic speed enforcement equipment was used in Texas, there was no provision in the law to permit vehicle owners to be charged for speed violations committed by any driver of the vehicle. In fact, a bill was introduced in early 1987 in the Texas Legislature to provide the proper legal environment in Texas for use of ASE equipment. However, the bill was never released from the subcommittee of the House Transportation Committee. This defeat augmented the legal and public opposition to further use of the ASE equipment in Texas.

The use of manned automated speed enforcement in Pasadena, California, since June 1988 was preceded by news media coverage, public information and education, instructions for city prosecutors and local judges, and consultations with various attorneys to encourage state legislators to consider a modification to the state statutes concerning speeding offenses.

On July 7, 1989, the New York Legislature passed a bill that would authorize New York City to photograph vehicles committing red-light violations at up to 25 intersections and to mail summonses to the registered owners of the identified vehicles. The act took effect on July 20, 1989, and will remain in full force for three years. At that time the amendments and provisions made by the act shall be repealed unless extended by another act of the legislature. The law could, with little modification, apply equally well to speed violations detected by automated systems. Equipment manufacturers consider New York to be the pilot state in the United States as far as passing (model) enabling legislation.

The photographic evidence collected or planned to be collected by automated enforcement equipment in four U.S. locations has one thing in common. Both frontal and rear photographs of the offending vehicles were taken or are planned to be taken. Currently the frontal photograph does not have the perceived opposition it had about 10 years ago. It provides the prosecution a means for the positive identification of the driver in those cases in which the driver or owner wants to challenge the citation in court.

In March 1986, legislation was passed in Victoria, Australia, that was intended to improve police operations in relation to the use of red-light cameras and, subsequently, speed cameras. This legislation, the Motor Car (Photographic Detection Devices) Act (1986) or "owner-onus legislation," placed the responsibility for red-light violations and speeding offenses detected by cameras onto the owner of the vehicle rather than the driver. The results of this legislation have had beneficial effects on police costs and efficiency.

It is anticipated that within the next few years, automated systems will be introduced in the United Kingdom for enforcement of a number of types of traffic violations. Such equipment is currently under discussion and, in some cases, trial. These steps are being taken in the wake of recent U.K. government proposals for a reform of road traffic law (Road Traffic Law Review Report, HMSO, London 1988).

SECTION 6

COMPARISON OF SELECTED ASE DEVICES AND RED-LIGHT VIOLATION DETECTION DEVICES

This section brings together information and data obtained during the study for the purpose of comparing various systems. These comparisons are based on manufacturer specifications and the reported experiences of U.S. and European users. The technical information on the enforcement equipment was obtained mainly through correspondence with the manufacturers and during telephone conversations with the manufacturers' representatives in the United States. It was possible, in one instance, to talk directly with the manufacturer of one of the ASE devices during a demonstration of the device in the United States.

The system specifications and comparisons of selected ASE devices are presented in Section 6.1. The system specifications and comparisons of selected red-light violation detection systems are given in Section 6.2. The comparative data in both sections are given in tabular format.

6.1 SYSTEM SPECIFICATIONS AND COMPARISONS OF SELECTED ASE DEVICES

The major automated speed enforcement systems of 10 manufacturers are listed in Table 6-1, together with their primary components and other information. All of these systems are capable of operation using photographic evidence, although many can be used without that feature.

Of the 10 manufacturers listed, six use Doppler radar. However, four of the six systems operate in the cross-the-road mode. In addition, three of the cross-the-road radar systems also include a provision for recording speed of the offending vehicle during pacing operations using a digital tachometer. The four nonradar systems listed in Table 6-1 use various types of sensors including passive optical sensing (Velomatic 103A); roadway sensors; and, in the case of the ProViDa/PDRS, stopwatches and distance counters or a tachometer.

All but one of the system manufacturers produce their own sensing components. The Speedophot device made by Traffipax-Vertrieb is the one exception. This system uses a radar unit made by Gatsometer and a tachometer made by Robot.

Eight of the manufacturers offer cameras with their systems; some offer a choice of cameras. Most are 35-mm systems, designed for data

TABLE 6-1. SPEED ENFORCEMENT SYSTEMS CAPABLE OF PROVIDING PHOTOGRAPHIC EVIDENCE

Company	Country	Device	Sensor type[a]	Sensor mfg.	Camera	Flash	Electronics technology	Cost[b]
AWA Defense Industries Pty. Ltd.	Australia	Vehicle Speed Radar Model 449	Doppler Radar	AWA Defense Industries	Canon F1	Bowen Ltd.	Microprocessor	$25,000
Gatsometer B.V.	Holland	Gatso Micro Radar Type 24	Doppler Radar and Tachometer	Gatsometer B.V.	Robot	Gatsometer B.V.	Microprocessor	$19,000
	Holland	Gatso Micro Radar Type RadCam 24	Doppler Radar and Tachometr	Gatsometer B.V.	Single Lens Reflex Camera (Canon F1, Pentax SRL)	Gatsometer B.V.	Microprocessor	$23,000
Plessey South Africa Ltd.	South Africa	Plessey Dual-Antenna Speed Monitor	Doppler Radar	Plessey South Africa	N.S.	N.S.	Microprocessor	$13,000 SA Rands
Traffipax-Vertrieb	West Germany	Speedophot	Doppler Radar and Tachometer	Doppler Radar by Gatsometer Tachometer by Robot	Robot	Bosch	Microprocessor	$40,000
Trafikanalys AB	Sweden	RC110 ASTRO 110	Doppler Radar	Trafikanalys AB	Hasselblad	N.S.	Microprocessor and Digital Signal Processing	$31,000
Zellweger Uster AG	Switzerland	Multanova 6F	Doppler Radar and Tachometer	Zellweger Uster AG	Jacknau Robot	Zellweger Uster AG	Microprocessor	$38,000
Eltraff S.r.L.	Italy	Velomatic 103A	Optoelectronic and Capacitive	Eltraff S.r.L.	Fujica FTIF	N.S.	Microprocessor	$13,000
Proof Digitalsystemer A/S	Denmark	ProViDa/PDRS	Stop Watches, Trip Counters, and Tachometer	Proof Digital-systemer	Color Video	-	Microprocessor	N.S.
Trans-Atlantic Equipment Pty. Ltd.	South Africa	Speed Guard De Luxe Model 3000	Roadway rubber tubes	Trans-Atlantic Equipment	N.S.	N.S.	Microprocessor	N.S.
Truvelo Manufacturers	West Germany	Truvelo M4[2] and Combi	Piezoelectric and Coaxial Cables	Truvelo Manufacturers	Robot	Truvelo Manufacturers	Microprocessor	$30,000

[a] All Doppler radars, except the ones used by Plessey and Trafikanalys, are of the cross-the-road type.

[b] Approximate, for single unit including camera but exclusive of permanent enclosures, installation, customs, taxes, etc. Costs are not firm quotes, but are shown only for rough, comparative purposes.

N.S.: Not stated.

recording. The West German Robot or the Japanese Canon F1 are used by five of the manufacturers. The Pentax SRL, Jacknau, and Fujica FTIF are other 35-mm cameras used. The Trafikanalys RC110 and ASTRO 110 systems use a Hasselblad camera with 70-mm film. The ProViDa/PDRS device made by Proof Digitalsystemer uses a color video camera instead of a film camera.

Flash units, either for night use or to enhance daylight photography, are available for the Vehicle Speed Radar, Gatso Micro Radar, Speedophot, Multanova 6F, and Truvelo systems. The availability of flash units is uncertain for the Plessey, Trafikanalys, Eltraff, and Trans-Atlantic Equipment devices. The ProViDa/PDRS device does not use a flash unit.

All of the systems use sophisticated electronics in conjunction with their signal-processing logic. All make use of integrated circuits and microprocessor technology. One manufacturer, Trafikanalys, uses advanced digital signal processing (DSP) to continually monitor the presence of all vehicles in the measurement zone. This method is a conventional military technique which has now become commercially attractive because of recent developments and access to compact, low power consumption DSP processers.

Finally, just for illustrative purposes, rough cost figures are given. It should be noted that none of these systems, except the Multanova 6F, are currently being sold in the United States. It is likely, however, that if a substantial U.S. market develops, there will be significant cost reductions from those shown in Table 6-1.

Each manufacturer listed in Table 6-1 was requested to provide an estimate of the training required in the use of equipment and the manufacturer's cost for that training. Estimated annual maintenance costs for the equipment were also requested. The responses to these inquiries are presented in Table 6-2. The period of training offered by the manufacturers in the general operation of the equipment ranged generally from one to two days for all but the Vehicle Speed Radar system. Gatsometer offers a full week of technical training for a skilled technician in the maintenance of the equipment. The manufacturer's estimate of training time and requirements are based upon European user experience. It is possible the estimates are unrealistic (low) for U.S. needs and would have to be supplemented by department or state training in speed enforcement.

The specifications for the speed sensors used by the 10 manufacturers are shown in Table 6-3. Six use Doppler radar units as explained above. The cross-the-road concept is used by four of the six Doppler radar systems. The radar beam of these four systems is aimed diagonally at between 20 and 25 degrees from the direction of travel. The logic used in these four systems corrects for this angle. The beam alignment for the Trafikanalys systems and the Plessey system is much smaller: 0 to 10 degrees and ~ 11 degrees, respectively.

TABLE 6-2. ESTIMATED TRAINING DURATION, ASSOCIATED TRAINING COSTS, AND ANNUAL MAINTENANCE COST FOR ASE EQUIPMENT IDENTIFIED

Company	Device	Training duration (days)	Cost of training	Annual maintenance cost
AWA Defense Industries Pty. Ltd.	Vehicle Speed Radar Model 449	3-4	$7,800[a]	$600
Gatsometer B.V.	Gatso Micro Radar Type 24	1-5	Included in cost of equipment	$250-500
	Gatso Micro Radar Type RadCam 24	1-5	Included in cost of equipment	$250-500
Plessey South Africa Ltd.	Plessey Dual-Antenna Speed Monitor	1	N.S.	N.S.
Traffipax-Vertrieb	Speedophot	1	N.S.	Included in maintenance contract
Trafikanalys AB	RC110 ASTRO 110	N.S.	N.S.	N.S.
Zellweger Uster AG	Multanova 6F	1	Billed on hourly basis plus expenses	N.S.
Eltraff S.r.L.	Velomatic 103A	2	$400[b]	$1,300
Proof Digitalsystemer A/S	ProViDa/PDRS	N.S.	N.S.	N.S.
Trans-Atlantic Equipment Pty. Ltd.	Speed Guard DeLuxe Model 3000	N.S.	N.S.	N.S.
Truvelo Manufacturers	Truvelo M4^2 and Combi	1	Included in cost of equipment	$500

[a] Training conducted at user's facility.
[b] Training conducted at manufacturer's facility.
N.S.: Not stated.

TABLE 6-3. SENSOR SPECIFICATIONS

Company	Device	Beam alignment[a] (degrees)	Radar frequency (GHz)	Radar beam width[b] (degrees)	Radar beam power (mw)	Power consumption (Watts)	Effective lateral range (lanes)	Direction discrimination[c]	Speed measurement range (mph)	Accuracy (mph)	Measuring interval (sec)	Temperature range (°F)
AWA Defense Industries Pty. Ltd.	Vehicle Speed Radar Model 449	25	24.15	4	10	4.8	4	Yes	12-158	±1	0.75	32 to 122
Gatsometer B.V.	Gatso Micro Radar Type 24	20	24.125	5	15	10	1-4	Yes	12-160	±1[d]	0.5	-4 to 140
	Gatso Micro Radar Type RadCam 24	20	24.125	5	25	N.S.	1-4	Yes	12-160	±1[d]	0.5	-4 to 140
Plessey South Africa Ltd.	Plessey Dual-Antenna Speed Monitor	11	24.225 and 24.175	10	2.5	N.S.	2	No	6-124	±2%	0.12	32 to 122
Traffipax-Vertrieb	Speedophot	20	24.125	5	20	6	1-4	Yes	12-155	±1	0.5	14 to 140
Trafikanalys AB	RC110	0-10	10.53	12	3	9.5	3	Yes	12-155	±0.5[e]	0.192	-22 to 140
	ASTRO 110	0-10	10.53	12	3	9.5	3	Yes	12-155	±0.5[e]	0.192	-22 to 140
Zellweger Uster AG	Multanova 6F	22	34.30	5	0.5	26	3	Yes	15-155	±2	0.5	32 to 113
Eltraff S.r.L.	Velomatic 103A	90	-	-	-	0.34 Optoelectronic Sensor 0.06 Capacitive Sensor	3	Yes	2-620	±1%	1.3	14 to 122
Proof Digitalsystemer A/S	ProViDa/PDRS	-	-	-	-	N.S.	2	Yes	0-299	0.05%	Manually Dependent	N.S.
Trans-Atlantic Equipment Pty. Ltd.	Speed Guard De Luxe Model 3000	90	-	-	-	0.6	2	Yes	N.S.	N.S.	N.S.	-4 to 167
Truvelo Manufacturers	Truvelo M4[2] and Combi	90	-	-	-	17	Unlimited[g]	Yes[g]	6-186	±1[h]	0.7	23 to 149

[a] Angle between centerline of beam and direction of travel.
[b] Total width (horizontal) between half-power points (-3 db).
[c] Unit can discriminate direction of vehicle travel.
[d] ±2% for speeds over 62 mph.
[e] ±1% for speeds over 62 mph.
[f] ±3% for speeds over 62 mph.
[g] Dependent on detection cable installation.
[h] ±2% for speeds over 62 mph.

The four remaining systems in Table 6-3 use the time/distance concept to determine speed. The Velomatic, Speed Guard DeLuxe, and Truvelo look directly across the road, perpendicular to the direction of travel, and measure the time required for a vehicle to pass between two points. The Velomatic senses this by means of two passive optical sensors or a set of capacitive sensors; the other two systems utilize a set of roadway tubes or cables. The fourth nonradar system uses manually activated stopwatches and distance counters to compute vehicle speeds.

The radar units use various microwave frequencies, ranging from 10.53 GHz to 34.30 GHz. Many of the radar units operate near to the "K-band" (24.15 GHz). The higher frequency bands used by all but the Trafikanalys systems have resulted in smaller and lighter systems than the models of 10 years ago.

With the exception of the "down-the-road" Trafikanalys and Plessey systems, all the other radars have very narrow beam widths, in the 4- to 5-degree range. The beam widths for the Trafikanalys and Plessey radars are 12 and 10 degrees, respectively.

The down-the-road radars emit an RF signal with lower power (2.5 to 3 mW) than American radars. The other radars have a beam power of between 0.5 and 25 mW.

The sensing systems have average power consumption during normal operations between 0.06 and 26 W,* and all operate from standard 12 V DC car batteries. The manufacturers recommend using AC power and converters for permanent (fixed) installations.

All but the Plessey, Proof Digitalsystemer, and Trans-Atlantic Equipment systems claim to be effective across at least three lanes of traffic. The Gatso Micro Radar and Speedophot systems claim to detect vehicles across at least four lanes of traffic. The Truvelo systems are not limited in effective lateral range, practically, because the range depends only on the length of cable installed.

All systems, except the Plessey, can detect either approaching or receding traffic. With most systems, the user selects the direction of interest and the system will ignore signals from vehicles traveling the other way. The Truvelo systems' rejection capability depends on the cable installation configuration.

Most systems are stated to be capable of measuring speeds up to at least 124 mph with reasonable accuracy, assuming the equipment is set up and aimed properly. With the exception of the Proof Digitalsystemer and Trans-Atlantic Equipment devices, the various logics used by the systems in the automatic mode would be capable of identifying and recording the speeds of vehicles with time headways between them as short as 0.12 to

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* Does not include consumption of camera, flash, or other accessories, which tend to be of short duration and represent peak loads.

1.3 sec. These values are generally comparable to the times required to advance the film to a new frame and to recharge the flash unit, if any.

Operations under extreme temperatures are reflected in the last column of Table 6-3. The values shown are those quoted by the manufacturers and which define the guaranteed range of validity for the stated accuracies. The smallest range of operating temperatures is noted for the Vehicle Speed Radar device, the Plessey system, and the Multanova 6F system. The lower operating temperature for these three systems is 32°F. One temperature problem, which has been partially resolved by a user, concerns the maximum operating temperature, 113°F, for the Multanova 6F. Overheating problems have been experienced for the Multanova 6F when operated in a vehicle during the summer months in Paradise Valley, Arizona. The problem was partially resolved by ducting chilled air to the unit from the vehicle's air conditioner. This required adding a partition, duct work, and a heavy-duty fan mounted in front of the vehicle's radiator.

The photographic capabilities of each ASE system are displayed in Table 6-4. The systems utilize one of seven cameras: the Canon F1, the Robot Motor Recorder 36 BET, the Pentax SRL, the Hasselblad, the Jacknau FT/6FJ, the Fujica FTIF, and a color video camera model ProViDa. All but two are 35-mm cameras, using a standard format of 24 x 36 mm. The Hasselblad uses 70-mm film and produces a negative format of 45 x 60 mm. For the 35-mm cameras used in all but the Truvelo systems, the relatively high-speed 400 ASA black and white film is generally recommended. A 200 ASA film is recommended for the Truvelo systems. The standard configuration(s) of each camera system is given in Table 6-4.

A wide range of lenses is used with the cameras. The shortest lens, 50 mm, is used by the Velomatic 103A device. This size of lens was a standard length about 10 years ago. It has since been replaced by either a 75- or 90-mm f3.8 lens. A previous study[8] suggested the lens should be 135 mm in length so that state identification and expiration date on the license plate could be read. It appears that three manufacturers have adopted the focal length recommendations. The cameras used with the Multanova 6F can be fitted with either a 135-mm f1.2 or a 150-mm f3.8 lens, depending on the camera used. The Trafikanalys systems use a 150-mm lens, and the Gatso Micro Radar Type RadCam 24 can use a 60- to 120-mm zoom lens.

The shutter speeds of the cameras range from 1/500 sec up to 1/2000 sec, with 1/1000 sec the most commonly used. All camera systems, excluding the video camera, include a power winder capable of at least one photograph every 1.5 sec, but more commonly, one every 0.5 sec.

All of the devices, except the Gatso Micro Radar Type RadCam 24, come with automatic exposure control as a standard accessory.

Most of the cameras can be fitted with any of several sizes of backs or magazines, to handle different lengths of film. The only exceptions to this are the Trafikanalys systems and the Trans-Atlantic Equipment

TABLE 6-4. PHOTOGRAPHIC SPECIFICATIONS

Company/System	Camera	Film size (mm)	Film (ASA)	Lens (mm)	Largest aperture	Max. shutter speed (sec)	Power winder	Repetition rate (sec)	Automatic exposure control	Magazine size (exp)	Automatic display	Written display	Operating temp. (°F)
AWA Defense Industries Pty. Ltd./ Vehicle Speed Radar Model 449	Canon F1	35	400	85	1.4	1/1000	Yes	1.5	Yes	36, $\geq$ 90	Time, Date, Speed, Location, Direction	-	41 to 122
Gatsometer B.V./ Gatso Micro Radar Type 24	Robot	35	400	75 or 90	3.8	1/1000	Yes	0.5	Yes	36, 800	Time, Date, Speed, Direction, Location Code	Location Description	-4 to 140
Gatso Micro Radar Type RadCam 24	Canon F1 or Pentax SRL	35	400	60 to 120	2.8	1/2000	Yes	0.5	No	36, 100	Time, Date, Speed, Direction, Location Code	-	-4 to 140
Plessey South Africa Ltd./ Plessey Dual-Antenna Speed Monitor	Camera system not available yet												
Traffipax-Vertrieb/ Speedophot	Robot	35	400	75 or 90	3.8	1/1000	Yes	0.5	Yes	36, 800	Speed, Range of Radar, Traffic Direction, Time, Date, Code, Frame Counter, Mode of Operation	-	14 to 140
Trafikanalys AB/ RC 110 ASTRO 110	Hasselblad	70	N.S.	150	3.5	1/500	Yes	0.5	N.S.	400	Speed, Distance to Vehicle, Direction of Traffic, Time, Date, Site Code, Speed Limit	-	-22 to 140

TABLE 6-4. (Continued)

Company/System	Camera	Film size (mm)	Film (ASA)	Lens (mm)	Largest aperture	Max. shutter speed (sec)	Power winder	Repetition rate (sec)	Automatic exposure control	Magazine size (exp)	Automatic display	Written display	Operating temp. (°F)
Zellweger Uster AG/ Multanova 6F	Jacknau FT/6FJ	35	400	85, 135	1.2	1/500	Yes	0.5	Yes	36, 400	Date, Time, Speed, Direction	Location Description	14 to 122
	Robot	35	400	75, 150	3.8	1/750	Yes	0.5	Yes	36, 800			
Eltraff S.r.L./ Velomatic 103A	Fujica FTIF	35	400	50	N.S.	1/1000	Yes	1.3	Yes	20, 36, 72	Date, Time, Speed	Location Description	14 to 122
Proof Digitalsystemer A/S/ ProViDa/PDRS	Color Video Camera Model ProViDa	-	-	N.S.	N.S.	N.S.	-	Manually Dependent	Yes	-	Speed, Time, Distance, Date	-	N.S.
Trans-Atlantic Equipment Pty. Ltd./ Speed Guard De Luxe Model 3000	N.S.	35	N.S.	N.S.	N.S.	1/2000	Yes	0.5	Yes	36	Speed, Time, Date	N.S.	-4 to 167
Truvelo Manufacturers/ Truvelo M4[2] and Combi	Robot	35	200	75,90	3.8	1/1000	Yes	1.0	Yes	36, 300, 800	Date, Time, Speed, Location Code	-	23 to 149

N.S.: Not stated.

system, which accept 400- and 36-exposure magazines, respectively. For attended operations of relatively short duration, the standard 20- or 36-exposure magazine is recommended. However, for unattended, automatic operation a larger magazine is used. The Gatso Micro Radar Type 24, Speedophot, Multanova 6F, and Truvelo systems use an 800-exposure magazine for unattended operations. All of these larger magazines use bulk-loaded film, which may require purchase of loading apparatus and spare cassettes.

One of the biggest differences among the camera systems is in the data chambers. All are specially designed by the speed detection system manufacturer. The purpose of the data chamber is to display (superimpose) pertinent data on the photograph of the speeding vehicle. The data are gathered from various sources into the data chamber, put into a display, illuminated, and reflected through an opening in the back of the camera onto a designated location on the frame of film.

The items normally displayed include the date, time of day, speed of photographed vehicle, direction, sequence number, and a location code. Written information, such as a location description, can be added to the data display area of some models.

The operating temperature range is given in the last column of Table 6-4. The statements concerning the temperature problems with the sensors apply equally to the camera systems.

6.2 SYSTEM SPECIFICATIONS AND COMPARISONS OF SELECTED RED-LIGHT VIOLATION DETECTION SYSTEMS

The major red-light violation detection systems of six manufacturers are listed in Table 6-5, together with their primary components and other information. All of the systems provide photographic evidence of the violations detected. The six manufacturers also produce ASE equipment described in preceding sections. The red-light camera (RLC) systems use various types of roadway sensors including inductive loops, coaxial cables, piezoelectric cables, and rubber tubes.

Gatsometer is the only manufacturer of the six listed to produce more than one RLC system. This firm produces four models of RLC systems which vary in the number of traffic lanes monitored. In addition, two of the four models also record the speeds of vehicles detected.

All but one of the RLC system manufacturers make their own roadway sensors. The Traffiphot III is the one exception; its roadway sensors are manufactured by the 3M Company.

The systems utilize one of three cameras: the Fujica FTIF, the Robot Motor Recorder 36 BET, and the Jacknau. All are 35-mm cameras, using a standard format of 24 x 36 mm. Any 35-mm film may be used, but 400 ASA black and white is generally recommended, especially when rear photographs are taken. Flash units, either for night use or to enhance daylight photography, are available for all the systems. When frontal photographs are taken, the RLC system is usually equipped with red filters in front of the flash reflector and camera lens. The flash illuminates the inside of the car without blinding the driver. A red sensitive black-and-white film has to be used in this case.

A variety of lens lengths are available for use with the RLC systems. The lens lengths range from 35 to 105 mm, depending on the camera used.

The shutter speeds of the cameras range from 1/500 sec up to 1/2000 sec. All cameras have a power winder and come with automatic exposure control.

Three of the camera systems can be fitted with several sizes of magazines, to handle different lengths of film. The Velomatic 103A system uses up to 72-exposure magazines, the Traffiphot III system uses up to 1200-exposure magazines, and the Truvelo system uses up to 800-exposure magazines. The Gatso systems, the Trans-Atlantic Equipment system, and the Multafot system use 800-exposure, 36-exposure, and 400-exposure magazines, respectively.

A variety of data items are displayed on the photographs including the date, time of day, location code, sequence number, and the red-light elapse time.

All of the systems make use of integrated circuits and microprocessor technology.

Finally, rough cost figures are given in Table 6-5 for comparative purposes. These figures include camera, sensors, and enclosures but exclude costs for installation, customs, taxes, etc.

TABLE 6-5. RED-LIGHT ENFORCEMENT SYSTEMS CAPABLE OF PROVIDING PHOTOGRAPHIC EVIDENCE

Company	Country	Device	Sensor type	Sensor mfg.	Camera	Flash	Electronic technology	Cost
Eltraff S.r.L.	Italy	Velomatic 103A	Inductive Loops or Coaxial Cables	Eltraff S.r.L.	Fujica FTIF	N.S.	Microprocessor	$13,000
Gatsometer B.V.	Holland	Gatso Traffic Light Camera (RLC 36)	Inductive Loops	Gatsometer B.V.	Robot	Gatsometer B.V.	Microprocessor	$21,000
Traffipax-Vertrieb	West Germany	Traffiphot III	Inductive Loops	3M	Robot	Bosch	Microprocessor	$30,000 to $60,000
Trans-Atlantic Equipment Pty. Ltd.	South Africa	Trafficam Red Light Camera (RLC)	Roadway Rubber Tubes	Trans-Atlantic Equipment	N.S.	N.S.	Microprocessor	N.S.
Truvelo Manufacturers	West Germany	Truvelo Combi	Piezoelectric Cables	Truvelo	Robot	Truvelo Red Filter System	Microprocessor	$30,000
Zellweger Uster AG	Switzerland	Multafot	Inductive Loops	Zellweger Uster AG	Jacknau	Zellweger Uster AG	Microprocessor	$40,000

SECTION 7

CONCLUSIONS

The subject of enforcement technology, and more specifically automated speed enforcement, is of widespread interest--not just to the federal government, but to the numerous law enforcement agencies in the United States as well. This report contains much information with which most such agencies are probably not familiar. The following are the major conclusions that have been developed, in consideration of all the information obtained during the study.

- Speed limit compliance in the United States has decreased in recent years and is of national concern.

- Achieving better compliance with speed limits in general has been very difficult in the United States.

- Innovative approaches to speed enforcement have been tried in the United States with limited or mixed success.

- Applied technology, especially the foreign-developed automated speed enforcement (ASE) equipment, is important to the future of law enforcement and provides an approach for improving compliance with speed laws.

- All ASE devices have one feature in common--they have the capability of being coupled with a camera system to obtain photographic evidence of speeding violations. The detection portions of the devices employ various methods for making speed measurements, but the most common is cross-the-road Doppler radar.

- The cross-the-road radar systems are more sophisticated (and costly) than American systems and are more commonly used in Europe and elsewhere than are the American systems.

- Advantages of the cross-the-road radar systems are their greater selectivity, superior capability to detect speeding in heavier traffic, ability to identify speeding vehicles, freedom from human error, and effective indetectability by radar detectors.

- A new development in ASE equipment makes use of short-range down-the-road Doppler radar and digital signal processing (DSP). This electronic processing enables the system to track several vehicles simultaneously.

- Some of the major manufacturers of ASE devices identified 10 years ago are still producing devices, some manufacturers appear to have stopped producing the units, and new manufacturers have emerged.

- Improvements in current ASE devices have been achieved by using more current state-of-the-art electronics, and in some instances, lower output power levels. These improvements plus the use of higher microwave frequencies have resulted in more compact and lighter weight systems more amenable to mobile operations.

- A wide range of lenses is available with the cameras used in the ASE devices. Longer focal length lenses are now available than were used 10 years ago. The longer focal length lenses should help in the identification of small features (state identification and expiration date) on the photographs of U.S. license plates.

- Many of the ASE devices are versatile in that they can be deployed in a variety of enforcement strategies, including moving operations.

- Some of the ASE devices can be used to selectively enforce speed limits for trucks and passenger cars.

- Over the last three years there has been growing interest by U.S. city, county, and state law enforcement agencies in the use of manned, ASE devices.

- Several manufacturers of red-light violation detection systems were identified.

- Red-light violation detection systems are used in Europe and elsewhere (outside the United States). Some of these systems have been demonstrated in the United States.

- Some political subdivisions in the United States have enacted legislation enabling the use of photographic evidence of traffic violations.

SECTION 8

RECOMMENDATIONS

A number of recommendations have been developed based upon the findings of the study. These recommendations are presented below.

- Selected current ASE devices should undergo engineering field evaluations to determine the appropriateness of the current configurations for use in the United States.

- Selected current ASE devices should be field-tested in an operational setting in which the systems are actually employed to issue warnings and, eventually, citations for speeding.

- In support of the operational field-testing activity, public information strategies need to be developed that can make the affected public aware of the general concept of ASE devices and associated deployment strategies.

- Model legislation should be developed that will assist jurisdictions in implementing the required legislation to permit field testing of a citation-oriented ASE strategy.

- Comparative data need to be acquired to determine the effectiveness of ASE devices to deter speeding in the United States.

- Use of ASE devices in the United States should be accomplished with careful planning and under proper legal and public acceptance conditions.

SECTION 9

REFERENCES

1. Public Law No. 93-239, Section 2, 87 Stat. 1046-1048.

2. Public Law No. 93-643, Section 107, 114, 88 Stat. 2281, 2284, 2286.

3. Public Law No. 95-599, Section 205, 92 Stat. 2689.

4. U.S. DOT, FHWA, Highway Statistics Division.

5. "Police Traffic Radar: Is It Reliable," prepared by the National Bureau of Standards, published by the National Highway Traffic Safety Administration, DOT/HS-805254, February 1980.

6. Glauz, W. D., and R. R. Blackburn, "Technology for Use in 'Automated' Speed Enforcement," Midwest Research Institute, Interim Report on Contract No. DOT-HS-8-02030, June 1980 (Publication DOT-HS-805454).

7. Blackburn, R. R., and W. D. Glauz, "Pilot Tests of Automated Speed Enforcement Devices and Procedures," Final Report on Contract No. DOT-HS-8-02030, February 1984 (Publication DOT-HS-806573).

8. Pierce, R., and R. P. Milliken, "Evaluation of the Gatso Mobile Radar Speed Detection Device," Nottinghamshire Constabulary, October 1987.

9. Nottinghamshire Constabulary, "Gatso Traffic Light Camera," 1988.

APPENDIX

MANUFACTURERS/DISTRIBUTORS OF AUTOMATED SPEED ENFORCEMENT SYSTEMS

RADAR SYSTEMS

Manufacturer	Comments
Mr. Keith Puyenbrock AWA Defense Industries Pty. Ltd. 2-6 Ardtornish Street Holden Hill, Adelaide South Australia 5088 Tel: 6182660666 FAX: 0116182660667	Uses cross-the-road radar for speed sensing
Mr. Warren Baker US Business Development Manager AWA Defense Industries Pty. Ltd. Suite 203 2 Research Drive Stratford, Connecticut 06497 Tel: 203-377-1252 FAX: 203-386-1395	Confirmed U.S. Representative for AQA Defense Industries, Pty. Ltd.
Mr. Gatsonides Gatsometer B.V. M. Gatsonides & Sons P.O. Box 9 2050 AA Overveen Holland Tel: 023255050 FAX: 023276961	Uses cross-the-road radar for speed sensing
Mr. Michael Solow GTEL 2000 Kentmere Parkway Wilmington, Delaware 19806 Tel: 302-652-4835	Unconfirmed U.S. Representative for Gatsometer B.V.
Mr. Willie Gibbens Plessey South Africa Ltd. 64/74 White Road Retreat 7945 P.O. Box 23 PLUMSTEAD 7800 Republic of South Africa Tel: 021725110 FAX: 021720008	Uses two intersecting radar beams directed down-the-road for speed sensing

Manufacturer	Comments
Mr. Klaus T. Krause Traffipax-Vertrieb Hildener Strasse 57 Postfach 13 07 24 4000 Dusseldorf-Benrath West Germany Tel: 02117110502 FAX: 02117110569	Uses cross-the-road radar for speed sensing
Mr. Gernd Rind, President LeMarquis International, Inc. 550 Stewart Avenue Garden City, New York 11530 Tel: 516-227-2217 FAX: 516-227-1986	U.S. distributor for Traffipax-Vertrieb
Mr. Lars-Yngve Felth GEFLE TRAFIKANALYS AB Box 965 S-80133 GAVLE Sweden Tel: 4626172305 FAX: 4626172307	Uses down-the-road radar and digital signal processing for speed sensing
Mr. Simon Goede Zellweger Uster AG Traffic Electronics CH-8610 Uster Switzerland Tel: 019406711 FAX: 019404530	Uses cross-the-road radar for speed sensing
Mr. Peter A. Umbdenstock Multanova/RPJ, Inc. 25 Trade Zone Court Ronkonkoma, New York 11779 Tel: 800-237-6713 FAX: 516-981-5858	U.S. Representative for Zellweger Uster

NONRADAR SYSTEMS

Manufacturer	Comments
Eltraff S.r.l. Via Massironi 20 20049 Concorezzo Milano Italy Tel: 039640268 FAX: 039691282	Nonradar; uses optoelectronic and capacitive sensors for speed detection
Proof Digitalsystemer A/S Sandbackvej 5 DK-2610 Roedovre DENMARK Tel: 452913344 FAX: 452913402	Nonradar; uses time/distance measurement for speed determination
Trans-Atlantic Equipment Pty. Ltd. P.O. Box 11449 Johannesburg 2000 Republic of South Africa Tel: 6181558/9 FAX: 6143929	Nonradar; uses roadway rubber tubes for speed determination
Mr. F. J. Gebert Managing Director Truvelo Manufacturers Unter den Ulmen 16 4100 Duisburg 12 (Meiderich) West Germany Tel: 0203442363 FAX: 01149203448300	Nonradar, uses piezoelectric and coaxial cables for speed determination