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FHWA Study Tour for Speed Management and Enforcement Technology

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Summary Report of the

FHWA Study Tour for Speed Management and Enforcement Technology

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Executive Summary

This report documents the findings of a study team from the United States (U.S.) which conducted a scanning tour in the Netherlands, Germany, Sweden, and Australia during the period April 21 through May 5, 1995. The purpose of the tour was to obtain firsthand knowledge about the practices and policies concerning speed management and enforcement technology.

Federal, State, and local government agencies can apply much of what the Speed Management and Enforcement Technology Team found in its scanning review. A summary of the team's findings is given below. Additional information on specific speed management strategies can be found in the country summaries.

Speed Management

General Framework for a Speed Management Program

For any jurisdiction to be successful in addressing speed-related problems, there must be a clear vision of how speed will be managed. This vision must be shared by all participants. The public, road users, police, the courts, traffic safety specialists, road engineers, and others must know their role and responsibilities as they relate to the jurisdiction's vision of speed management.

For a speed management program to be successful, the following components are essential:

- The speed-related safety problem must be clearly identified and effectively communicated to everyone involved, especially the public. Quantitative goals for the program should be established and revised as needed.

- The strategy or methods selected for implementation must have the potential for solving the problem.

- Engineering, enforcement, and educational speed management techniques must be integrated and coordinated. No single technique can effectively accomplish the goals of the program.

- The plan must be fair and reasonable to the majority of road users, e.g., speed limits should be viewed as reasonable to the majority of drivers and be consistent for similar roadway and traffic conditions.

- Implementation must be augmented with a continuous ongoing evaluation program to monitor and determine the effectiveness of the management techniques.

- The plan must be flexible and change when safety conditions merit.

- The road safety community must work with legislators to insure that the necessary legislation is enacted and revised, as needed, to accomplish the speed management goals.

- Through each phase of the program, all participants must be kept informed and involved, especially the public.

From initiation, the speed management plan should emphasize unity of purpose and objective and foster coordination and cooperation. In particular, a coordinated approach to tactical planning of enforcement operations within an overall deterrence strategy appears to offer the greatest potential for achieving one of the key objectives of any speed management plan: a reduction in inappropriate speeds and speed-related crashes.

Borrowing from Australia's highly successful approach to strategic planning of speed management, any strategy selected should be based upon a general deterrence approach to behavior modification through a program involving public education, attitude change, special visible enforcement, and targeted promotion. This approach should be accompanied by continued development of appropriate engineering and legislative actions.

The strategy must be consistent, using proven highway safety methods and technology. The major components of the plan should include:

- **Long-term framework**—Public education through extensive advertising to address beliefs and attitudes and provide a rational basis to encourage that change is essential. Continuous monitoring of knowledge and attitudes is important.

- **Medium-term reviews**—Examination and rationalization of the process, procedures and practices, i.e, appropriateness of speed limits, engineering, penalties, etc., must be conducted to improve speed management efforts.

- **Short-term initiatives**—Special targeted enforcement activity, with appropriate warnings and action and associated publicity, is necessary to reinforce particular safety issues. Monitoring and evaluation of program effects are imperative.

Specific Speed Management Methods

Specific speed management methods that can be incorporated into a comprehensive speed management program are given below. The findings related to enforcement technology are given in the next section of this summary.

Realistic Speed Limits

A prerequisite to developing any effective speed management program is to establish realistic speed limits to match roadway design and area characteristics. The relationship between speed limits and the roadway environment must be credible and consistent. If speed limits are viewed as unrealistic for prevailing conditions by the majority of road users, the plan is doomed to failure. A knowledge-based expert system such as the VLIMITS or NLIMITS developed in Australia would assist engineers in selecting realistic speed limits. Modification and application of the system in the United States should be considered.

Variable Speed Limits

Flexible speed limits and warning displays that can be varied to match traffic and environmental conditions, including fog, have been in use for over 30 years. Experiences with variable speed limits on motorways in the Netherlands and on autobahns in Germany indicate that traffic flow can be improved, e.g., a 5 to 15 percent reduction in travel time has been reported. Accident reductions of 25 to 50 percent have also been achieved with these systems.

In view of the substantial traffic flow and safety benefits, the study team considered that the concept could be transferred to the United States and implemented. Because variable speed limit systems cost between $0.4 and $1 million US per km, the system should be implemented in areas where environmental and/or traffic conditions result in significant fluctuations in the desired speed.

Differential Speed Limits by Vehicle Type

Differential limits for cars and trucks are used in most countries. For example, general speed limits of 110 and 120 km/h for light vehicles were used in the countries visited, except for German autobahns, which have no posted limits. General speed limits for heavy vehicles are typically 80 km/h.

Differential speed limits can lead to large differences in speed, which may have adverse safety effects. No studies have been conducted in the countries visited to determine if the effects are real or imagined. There is not enough evidence at this time to suggest application of differential speed limits by vehicle type in the United States.

Speed Governors on Heavy Vehicles

As of January 1995, the European Union countries have required speed limiters on all heavy vehicles. It is too early to tell if speed differences between heavy vehicles and other road users will lead to safety problems. This technology could be implemented on heavy vehicles in the United States. It is likely that there would be little political resistance if top speeds for heavy vehicles were limited to 113 km/h (70 mi/h).

Traffic Calming Techniques

Speed humps, roundabouts, lane narrowing, and other traffic calming methods were employed to reduce vehicle speeds in residential areas in the countries visited. These measures may be applicable for many areas in the United States. Some localities such as Howard County, Maryland, have already implemented residential traffic calming.

Although experience indicates that traffic calming techniques are effective in reducing vehicle speeds, there are concerns with using these methods. Plowing difficulties may be encountered in heavy snow areas due to the raised curbs and humps. Also, the majority of residents in the area must be informed about and agree to the implementation. Because the calming techniques physically reduce vehicle speed, response times by emergency medical and fire vehicles may be reduced. In addition, the narrow lanes and curbs are fixed objects, which may invoke legal liability concerns in some communities. Finally, funding may be a problem if a number of communities within a jurisdiction elect to install traffic calming. Road agencies with limited funding may have to install the methods on a priority basis.

Speed Limits Based on Driver Perception

Perceptual techniques, i.e., road narrowing through pavement markings, tactile strips, etc., give the driver visual indications that the roadway is intended for lower speed operations. Experience in the Netherlands on rural roads indicates that these methods can reduce vehicle speeds by 5 to 10 km/h and reduce accidents by 35 percent.

The major problem envisioned with using these methods in the United States is liability. Throughout most of the road building history in the United States, the practice has been to design and construct highways with wide lanes, recovery areas, and clear zones to improve safety. The use of perceptual techniques tends to run counter to current design and safety standards. Further research is suggested before implementation of perceptual techniques can be recommended.

Public Education and Information

The importance of educating and communicating information to the public regarding speeds, accidents, and speed management measures cannot be overemphasized. Several innovative education and information techniques were found in the countries visited. For example, in the Netherlands, Germany, and Australia, specific safety messages are conveyed to high-risk groups (based on their accident involvement) through rather unconventional methods, e.g., music and sports figures were used to relay safety concepts to teenagers. In New South Wales, traffic safety curriculums have been developed and introduced into all grade levels in secondary schools. Safety materials are presented by the teachers along with other subjects such as mathematics and science. In Victoria, multi-million dollar advertising campaigns are used to convey safety messages to the public and to measure attitudes.

Consideration should be given to employing, wherever possible, these educational techniques in the United States.

Enforcement Technology

The Europeans and Australians appear to make more use of enforcement technology in comparison to jurisdictions in the United States, particularly photo radar and red light cameras. Law enforcement personnel in both Europe and Australia have been trying to find more efficient ways of using existing technology without increasing personnel.

In the European countries visited, enforcement of traffic laws appears to be secondary to deterrence, as voluntary compliance is promoted through heavy educational campaigns. Education is also a major component of the Australian approach to speed management, but it is done in concert with legislation and enforcement. While all countries visited attempted to change attitudes and behaviors through education, the Australians also place strong emphasis on enforcement to deter inappropriate speeding behavior.

Using existing enforcement technology more effectively without increasing personnel has important implications in the United States. Specific enforcement technology and deployment methodologies that may be applicable in the United States are summarized below:

VASCAR (Visual Average Speed Computer and Recorder)

VASCAR was used to differing degrees in all countries visited. Based on conversations with officials during the scanning review, it appears that VASCAR is deployed in the same manner in which it is used in the United States. In the enforcement district surrounding Gothenburg, Sweden, VASCAR is the primary enforcement tool. All new police vehicles in Gothenburg are equipped with VASCAR.

Radar (RAdio Distance And Ranging)

Moving and stationary radar was used in all countries visited in a manner similar to how it is used in the United States. In New South Wales, Australia, radar is the primary enforcement tool. It is interesting to note that all radar in the state is mounted outside the police vehicle to eliminate the potential of injury to the officer in case of an accident, and to eliminate unnecessary exposure of the officer to radar microwaves, believed by some to cause cancer.

Lidar (LIght Distance And Ranging)

Lidar, often referred to as laser, is used or being reviewed in each country visited. For example, the enforcement area surrounding Gothenburg, Sweden, had four laser units available for approximately 100 traffic officers. Contingent upon funding, New South Wales, Australia, plans to purchase as many lasers as they can for use by their 1,000 traffic officers. The lasers being used and those under consideration for use are all made by American companies.

Photo Radar

Photo radar is used in some manner in all countries visited. In the Netherlands and in New South Wales, Australia, photo radar was used as an enforcement tool. In Victoria, Australia, widespread use of photo radar is employed as a general deterrent. Because photo radar substantially increases police visibility without the need for additional personnel, this technology should be considered for use in the United States.

Although photo radar can be deployed without human intervention, in all countries visited it was used with an officer present. The reason for this deployment strategy is to remove the impression that it is used only to generate revenue. In addition, an officer witnessing the infraction provides additional evidence for prosecutors.

Photo radar was successfully and extensively used in the Netherlands and in Australia primarily because legislation was enacted that permitted issuing citations to the vehicle owner and not to the driver. Photo radar was not successful in Germany and Sweden because their laws require that tickets be issued to the driver. Current photo radar technology does not consistently and reliably identify drivers.

It is important to stress that photo radar must be used in conjunction with a comprehensive and coordinated speed management program such as the one outlined above. For additional details on successful implementation of photo radar, the reader is encouraged to examine the summaries on the Netherlands and Australia.

Red Light Camera

Although not directly related to speed management, red light cameras were used in the countries visited to improve safety at signalized intersections. Typically, the cameras were installed at high-accident intersections or at locations where drivers were disobeying traffic signals. Experience with red light camera installations in the Netherlands and in Australia indicate that this technology can reduce incidents of running the red light by 35 to 60 percent. Furthermore, reductions in right-angle accidents of 32 percent have been reported.

In order to effectively use red light cameras, it is necessary to have legislation that permits issuing tickets for infractions to vehicle owners.

Due to the beneficial safety effects of red light cameras, the United States Department of Transportation has initiated a red light program for local governments. Additional application of available technology is recommended.

1. Introduction

1.1 Background

Speed management consists of employing engineering, enforcement, and educational methods for the purpose of reducing speed-related crashes and promoting the orderly movement of road users.

Speeding, defined as driving at a speed unsafe for conditions or exceeding the posted speed limit, is cited as one of the most prevalent factors that contribute to crashes. In 1994, speeding was cited as a contributing factor in 12 percent of all police-reported accidents in the United States (U.S.).[1] Speeding was also listed as a factor in 31 percent of all fatal crashes.[2] The economic cost to society of speed-related crashes is currently estimated to be $24 billion annually.

While considerable attention and debate has been focused on speed limits on the Nation's high-speed roadways, speed-related crashes occur on all types of rural and urban roads. In fact, 90 percent of speed-related fatalities occurred on non-Interstate highways. Of the fatal crashes reported on urban roads, 30 percent were speed-related. On rural roads, 36 percent of all fatal crashes were speed-related. Speed was cited as a contributing factor in 39 percent of the fatalities reported on local roads.

Because the energy dissipated in a crash is equal to the mass of the vehicle and its occupants times the speed squared, excessive speed exponentially increases the severity of a crash. Other consequences of excessive speed include greater distances traveled during driver reaction time, increased stopping distances, reduced effectiveness of occupant protection devices, and less time to perceive and react to traffic and roadway conditions.

In spite of the enormous societal costs and pain and suffering associated with speed-related crashes, the public generally does not view speeding as a serious safety problem. Compliance with existing speed limits is very poor. Roads with similar design and traffic characteristics often have different posted speed limits. Enforcement officials have limited resources to devote to speeding issues, and the public frequently suggests that these resources be devoted to more serious crimes. Officers are required to use considerable discretion in arresting speeders as the courts have often concluded that some speed limits are not reasonable. Public attention to speeding issues is typically limited to an occasional news story about a serious injury crash involving excessive speed. The public is often left with the belief that if only the speed limit were lower, the accident would not have occurred. In addition, speed management efforts may not be coordinated to fully utilize the limited available resources. Many gaps exist in our current knowledge of the underlying relationships and the effectiveness of various speed management strategies.

Management of speed is essential to improving road safety. The results of research studies indicate that a driver's choice of speed can be influenced by engineering measures such as roadway design and traffic control devices, by enforcement of reasonable speed regulations and conviction of violators, and through education of all road users. Nevertheless, there does not appear to be a simple solution to the problem. Speeding involves a wide range of complex factors including public attitudes, driver behavior and training, vehicle performance, roadway and environmental characteristics, speed zoning practices, enforcement strategies, and court sanctions.

Speed management techniques used in other countries, such as variable speed limits, traffic calming, and automated enforcement, have received some attention in the United States; however, there is little general knowledge concerning what, why, when, where, and how these measures work, and if they are applicable to U.S. roads.

1.2 Purpose and Scope

The scanning tour was conducted to identify and obtain first-hand information about the development, implementation, and evaluation of speed management programs. Of particular interest were programs, concepts, and technologies that could be transferred to the United States. Specific emphasis was placed on techniques used to identify speed-related problems, efforts to manage speed based on objective engineering data, police and judicial involvement and coordination, educational methods used to communicate the problem to the public, and procedures for involving the community. As enforcement is a major factor in managing vehicle speeds, special attention was placed on the application of automated enforcement technologies and their effect on traffic safety.

Due to the limited time afforded to the study team during visits to the host countries, it is important to note that this report may not include all of the speed management techniques used in the countries and jurisdictions visited. The report intentionally focuses on the programs and technologies that the study team felt had the greatest potential benefit for further consideration and/or implementation in the United States.

1.3 Methodology

The Transportation Technology Evaluation Center (TTEC) of Loyola College in Maryland planned and coordinated the study tour. The study team, consisting of 11 members, represented a cross section of Federal, State, and local highway agencies, enforcement officials, and researchers involved in speed management. A list of team members appears in Section 1.5, and a biographical sketch of each appears in Appendix C.

Prior to conducting the scanning tour, the team prepared a comprehensive list of questions concerning speed management and enforcement technologies. The questionnaire, shown in Appendix A, was sent by TTEC to coordinators in each country to aid in planning meetings and site visits.

During the period from April 21 through May 5, 1995, the scanning team visited the Netherlands, Germany, Sweden, and Australia. In each country, meetings were held with agencies and persons involved in speed management. The team met with Federal, regional, and local transportation officials; law enforcement officers; researchers; communications experts; educators; consultants; and contractors. A list of the individuals who met with the study team in each country is shown in Appendix B.

Formal presentations describing speed management programs and enforcement efforts were made by the officials in each country. Due to the size of the study team and the limited time available at each meeting, two study team members were preselected in each country to ask specific questions and to obtain clarification of material presented. The team also made field trips to locations where speed management techniques and/or automated enforcement technologies were implemented. Whenever possible, research reports, brochures, educational materials, and video tapes were obtained to supplement the information presented. Often, informal discussions with individuals during breaks and after hours provided valuable insights and a better understanding of the practices and problems encountered.

1.4 Overview of Report

This document is a summary report which provides a preview of the speed management techniques and enforcement technologies reviewed by the study team in the Netherlands, Germany, Sweden, and Australia. In the following sections, a brief overview of the speed management and enforcement policies, as well as individual speed-related projects that were reviewed by the study team, are presented for each country visited. The material was taken from the formal presentations, as well as from reports and other information given to the team. At the conclusion of each country summary is a brief discussion of the findings and their transferability to the United States. The discussion is based on the opinions of the study team and is only intended to reflect the team's perceived transferability of the methods to the United States.

The major findings of the study team are outlined in the final section of the report and are repeated in the executive summary. Finally, published materials that are referred to and video tapes are listed in the sections indicated.

1.5 Study Team Members

The Speed Management and Enforcement Technology study team consisted of the following Federal, State, local government, university, and private industry representatives.

Janet A. Coleman Team Leader	FHWA, Office of Highway Safety Washington, DC
Major Raymond D. Cotton	Commander, Commercial Vehicle Enforcement/ Automotive Safety Enforcement Division Maryland State Police, Annapolis, MD
Lt. Col. Rodney Covey	Assistant Director Arizona Department of Public Safety Phoenix, AZ
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Hernan E. Peña, Jr.	Assistant Director Department of Traffic and Transportation City of Charleston, SC
Michael L. Robinson	State Traffic Engineer Minnesota Department of Transportation Roseville, MN
William C. Taylor	Professor of Transportation Engineering Department of Civil Engineering Michigan State University, East Lansing, MI

1.6 Comparison of Country Demographics

Shown in Table 1 are selected demographics for each of the countries visited by the study team as compared to the United States.

Table 1. Selected Demographics of Countries Visited.

Category	The Netherlands	Germany	Sweden	Australia	United States
Area (km^2)	41,200	357,039	449,750	7,686,844	9,363,353
Population (millions)	15	81	9	17	258
Population Density (per km^2)	364	227	20	2	28
Number of Motor Vehicles x 1,000	6,700	45,400	4,300	10,200	194,400
Fatalities (1993 data)	1,252	9,949	632	1,946	40,115
Accident Rate (Accidents per vehicle km x 10^6)	0.38	0.67	N/A	0.15	0.63
General Speed Limits (km/h)					
Freeway	120	No limit	110	110	105
Rural Road	80	100	80	100-110	89
Urban Area	50	50	50	60	40-56

Source: BASt, based on International Road Traffic and Accident Database, January 1995.

2. Summary Report on The Netherlands

2.1 Introduction

The study team conducted a scanning review in the Netherlands on April 24 and 25, 1995. The review involved formal meetings with and presentations by safety officials at the Rijkswaterstaat (the Ministry of Transport), the National and Regional Traffic Police, the Amsterdam City Police, and road safety consultants. The team also made field visits to inspect automated enforcement methods, a red light camera and speeding program, a fog detection system, a speed management system on a rural road, and traffic control and signaling systems on Dutch motorways.

2.2 Overview of Speed Management

The Road Safety Department of the Ministry of Transport is responsible for developing the safety management program on the national level. Similar to speed management programs in other countries, speed management in the Netherlands is an essential element in their comprehensive safety management plan.

The basic objective of the Third Multiyear Plan on Safety, which was established in 1991, is to achieve 25 percent fewer deaths by the year 2000 than in 1985.[3,4] Furthermore, based on 1985 statistics, the plan calls for reducing fatalities by 50 percent and injuries by 40 percent by the year 2010. An additional national goal is to have the 90th percentile speed at or below the posted speed limit on all roads by the year 2000. The program also calls for a 20 percent decrease in fuel consumption and reductions in emission levels by the year 2010.

To achieve the safety objectives, a Spearhead Policy was developed which specifically targets identified safety problems. The policy addresses the following major accident problems:

- Drinking and driving.
- Speeding.
- Safety device usage, e.g., increase the use of seat belts in the back seat.
- Accident black spots, e.g., identify accident locations with emphasis on more route- and area-oriented approaches as opposed to spot locations.
- Bicyclists and pedacyclists, e.g., educate young and inexperienced riders.
- Heavy vehicles.

With regard to speeding, the main spearheads are to reduce excessive speeding, especially on secondary rural 80 km/h roads, and to require speed limiters on all heavy vehicles. In October 1993, speed limiters became compulsory for trucks over 12 metric tons. Experiments utilizing engineering, enforcement, and education measures on 80 km/h roads are discussed later in this section.

A key element of the Dutch safety program is the Sustainable Road Safety Policy. The Policy is based on the concept of removing the main causal factors in the driver-vehicle-highway system. The primary features of the Policy include examining human capabilities and limitations, conducting safety audits, i.e., design review, field review, etc., and evaluating the effectiveness of the policies. The construction of a separate bicycle path along a main road is an example of a sustainable safety infrastructure.

One of the most important features of implementing the national safety policy is seeking and obtaining cooperation and coordination among all the organizations involved in traffic safety. For example, the safety policy requires cooperation among the national governmental organizations, the 12 provinces, local and other ministries such as the judicial system, private organizations, trade, industry, and safety groups such as the Dutch Road Safety Association and the Dutch Cyclists Association. The trend has been to turn management of systems and programs to the provincial governments, who have the responsibility for implementing and institutionalizing safety into society. Ninety percent of the national safety budget has been turned over to the provincial governments. Execution of the road safety policy is conducted primarily by regional committees of traffic safety. The committees consist of local councils, provinces, police and the public prosecutor in the region, companies, and other partners.

Generally, the Dutch approach to the speed problem is preventative rather than repressive (such as imposing fines and punishment). Preventative measures include traffic education, communication, insurance incentives, road design, intelligent cruise control, traffic enforcement, and speed control for trucks. Specific elements of the national speed strategy include:

- Electronic traffic enforcement designed to reduce the labor-intensive effort of stopping each vehicle and to increase driver perception of enforcement.

- Flexible speed limits on motorways where speed limits can be lowered through changeable message signs to encourage motorists to adapt to prevailing traffic and environmental conditions.

- Lane restrictions for trucks.

The national government supports regional and local authorities in implementing the speed policy by passing on knowledge and financial support wherever possible. For example, assistance from the national government is provided for problem identification, data collection, analysis, and evaluation.

Experience in the Netherlands indicates that it takes a long time and much cooperation and compromise to develop, implement, and maintain a speed management program. The speed policy, which was adopted in 1988, is expected to take a long time to implement. Through questionnaires and communication, which includes enforcement, the government is attempting to make the public view speeding as socially unacceptable.

2.3 Speeding and Speed Limits

Although traffic volumes have increased dramatically in recent years, fatalities continue to decline in the Netherlands. In the 1970s, there were 3,600 fatalities per year, as compared to 1,252 in 1993. It was estimated that approximately 50,000 persons were injured in accidents in 1993.[4] The estimated societal cost of these crashes is 9 billion NLG ($6 billion US). Speeding was cited as a factor in 70 percent of the crashes in the Netherlands.

General speed limits for various roadway types are established by national law. The speed limit on motorways for light vehicles is 120 km/h. Motorways with a lower design or with heavy traffic flow have a limit of 100 km/h. On rural roads, the general limit is 80 km/h. Urban roads have a general limit of 50 km/h, and the limit in residential areas is 30 km/h. General speed limits are usually not posted along the roadside.

On urban multilane streets, limits can be raised from 50 to 70 km/h. Speed limits are not normally reduced less than the general limits unless accident statistics and other data provide compelling evidence that the limit should be lower. The ultimate approval of the posted speed limit is given by the police.

The maximum speed limit for trucks is 80 km/h. Speed limiters, now mandatory on trucks over 12 metric tons, limit the maximum speed to 90 km/h.

Mean and 85th percentile speeds for private cars on different road types are summarized in Table 2. Of particular concern to the policy makers are the high speeds on the 80 km/h main roads. Approximately 50 percent of the fatal crashes reported on 80 km/h roads involve drivers exceeding the speed limit.[3]

2.4 Enforcement

Much of the communication of speed policies to motorists comes from police officials. Fines for speeding and other traffic offenses are established by the provinces. Monies from traffic fines are deposited into the general fund. The Netherlands has 16 courts in 12 provinces, which have 62 local judicial entities. Violators of traffic regulations are not assessed with penalty points on their driving record. Judges generally feel that road safety is not a high priority compared to criminal activity. Drivers fined for exceeding the speed limit by 30 km/h or less simply pay the fine. Drivers traveling in excess of 30 km/h over the limit must pay the fine and go to court. A judge can revoke a driver's license if the driver exceeds the speed limit by more than 50 km/h.

Table 2. Private Car Speeds on Different Roadway Types in The Netherlands.

Road Type	Speed Limit km/h	Mean Speed km/h		85th Percentile Speeds km/h	
		1992	1994	1992	1994
Motorways	120	112	111.9	126.5	126.6
Motorways	100	105.3	104.1	119.2	117.6
Main Roads	100	90	85	104	98
Main Roads	80	81	77	94	89
Urban Roads	50	N/A	49*	N/A	59*

* Speeds measured in three major cities.

Police enforcement in the Netherlands involves a variety of techniques, including stationary, mobile, non-automatic, and automatic methods.

Radar detectors are not prohibited in the Netherlands; however, law enforcement officials believe radar detectors are detrimental to their effort and often change radar frequencies to reduce the effectiveness of detectors.

While an enforcement tolerance is left to the discretion of the officers and varies from one province to another, typical tolerances range from 7 to 15 km/h over the speed limit.

To increase enforcement efforts without increasing personnel, electronic traffic enforcement has been implemented. One of the most important factors in successfully implementing electronic traffic enforcement in the Netherlands was enabling legislation that permits sending tickets to the owner of the vehicle. Previously, the police could issue violations only to the driver. Additional details of the Dutch use of electronic traffic enforcement is given in the section on Enforcement Measures.

2.5 Summary of Speed Management Techniques Reviewed by the Study Team

During the scanning tour of the Netherlands, the team visited sites to obtain first-hand information about specific speed management techniques. A brief summary of the engineering, enforcement, and educational methods examined is given in the following sections.

2.5.1 Engineering Measures

Fog Advisory System on the A16 Motorway

In November 1990, 8 persons were killed and over 100 vehicles were involved in collisions during fog on the A16 motorway near Breda. As a result of the crash history, a fog advisory system was installed on a 12-km section of the motorway which has a posted speed limit of 100 km/h. Traffic volumes on the section range from 60,000 to 70,000 vehicles per day. Approximately 20 percent of the volume is heavy vehicles.

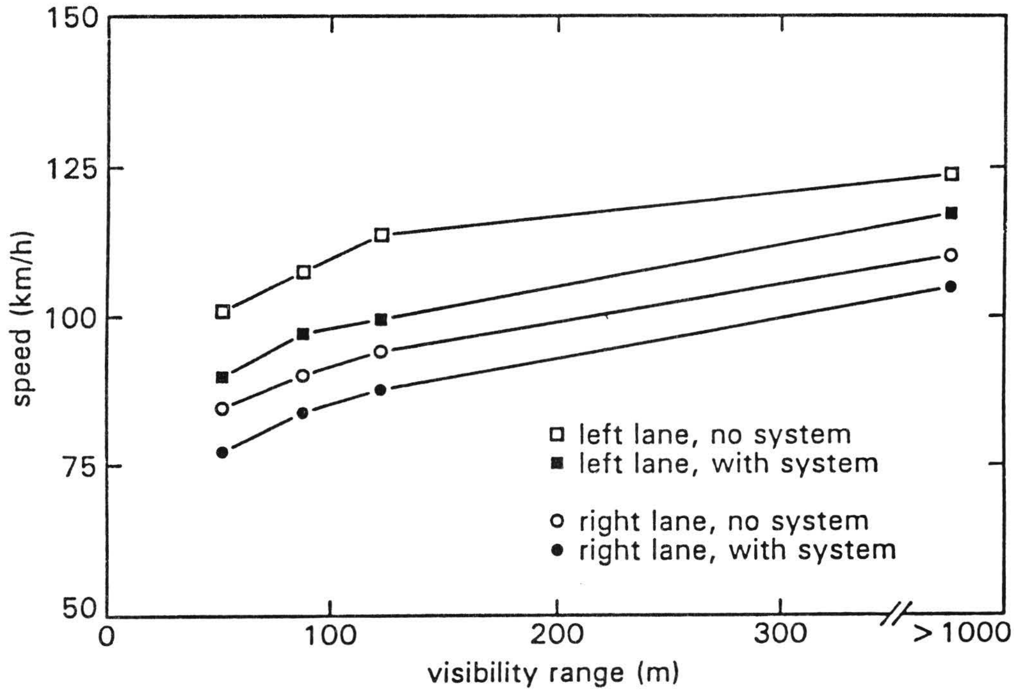
The fog advisory system consists of gantries with matrix signs installed at intervals of 700 to 800 m. Currently, 20 visibility sensors measure the visibility distance each minute and transmit the information to a central computer. When fog conditions exist, a speed limit of 60 km/h is displayed if the visibility is less than 70 m. When the visibility is greater than 70 m and less than 140 m, 80 km/h is displayed. Along with each speed, a general warning symbol and the word "MIST" is displayed. When the visibility is above 140 m, the general speed limit of 100 km/h applies. Although the fog advisory system was initially installed as a stand-alone unit, in November 1992, it was incorporated into the Motorway Signaling System.

The objective of the system is to encourage lower travel speeds during fog and to reduce speed variance. An evaluation of the system was conducted to examine changes in speeds and headways during fog conditions.[5] As shown in Figure 1, mean speeds at all of the monitoring stations were reduced by 8 to 10 km/h during fog conditions after the system was installed. Mean speeds were still higher than displayed speeds. A small reduction in the standard deviation of speeds was also found. There was a small, but significant, decrease in the percentage of vehicles with headways less than one second.

In extremely dense fog, with visibility less than 35 m, the system appears to have an adverse effect on speed, i.e., the mean speeds are lower than the posted limit of 60 km/h. Overall, the researchers concluded that the system has positive effects on driver behavior during fog.

Motorway Signaling System

A Motorway Signaling System is being installed in the Netherlands.[6,7] Implementation began in 1981 and the system now covers approximately 200 km. Plans are for the system to encompass 900 km of motorways by the year 2000. The objectives of the system are to reduce congestion and queues that produce secondary accidents.



Source: Hogema and van der Horst, "Evaluation of the A16 Fog Signaling System With Respect to Driving Behavior," 1994.[5]

Figure 1. Changes in Mean Speed During Fog on the A16 Motorway.

The system consists of gantries placed approximately 500 m apart. Inductive loops monitor traffic flow and send the data to outstations linked to a central computer. Signs mounted on the gantries are capable of displaying different speed limits, depending on traffic and weather conditions. Various messages, such as lane closure symbols for construction and maintenance zones, can also be displayed. Shown in Figure 2 are the speed and warning displays advising of a lane closure ahead. However, as illustrated in Figure 3, no messages are displayed during good weather and favorable traffic conditions.

While the system is primarily designed to manage congestion and to safely close a lane for road repairs or emergency incidents, evaluations indicate an approximately 50 percent reduction in secondary accidents. A general increase in traffic flow with 5 to 15 percent less travel time lost has also been reported. Costs of the system are estimated to be between 1 and 1.5 million NLG ($0.7 and $1 million US) per km.

The Motorway Signaling System is part of the Motorway Traffic Management System. In an effort to utilize existing infrastructure more safely and efficiently, the traffic management system will incorporate Intelligent Transportation System (ITS) concepts such as dynamic route information, improved incident management, etc.

Figure 2. Motorway Signaling System with Variable Speed Limit Displays.

Figure 3. Motorway Signals Are Not Displayed During Good Weather and Traffic Conditions.

Perceptual Speed Management Treatments on 80 km/h Roadways

Due to speeding and excessive crash experiences on 80 km/h roads, research was undertaken to identify the problem and to develop countermeasures. The research discovered that most motorists did not obey the speed limit because they did not recognize the roadway as an 80 km/h highway.

A multidisciplinary team consisting of central (or federal), regional, and provincial transportation officials, the regional police, a traffic psychologist, a graphic design consultant, a driver comfort physiologist, an opinion researcher, and several private safety organizations began the project in 1991. The team concentrated on developing measures consisting of physical and visual speed restrictions. The goal of the project was to reduce driving speed by 5 km/h and reduce accidents by 35 percent.

Following extensive laboratory tests and a pilot road test, it was decided to create physical and visual measures that would encourage drivers to obey the 80 km/h limit. The measures included limiting the effective width of the driving lane, replacing the roadside markings with tactile strips, narrowing the driving lane by widening the centerline markings, and using different roadside marking posts.

Speed measurements taken for 2 years on 4 trial roads with the speed management measures and 4 control roads without the measures, indicate that speed reductions of 5 to 10 km/h can be achieved with these devices. A 36 percent reduction in accidents was reported on the trial roads, while accidents increased by 17 percent on the control roads.

Other Engineering Methods

While in the Netherlands, the study team observed a number of other infrastructure and speed management methods that have not been mentioned. For example, traffic calming techniques such as speed humps, raised crosswalks, road narrowing, etc., are used in residential areas to reduce vehicle speeds to the posted 30 km/h limit. In some urban areas, there are car-free zones, especially in high-density areas. As approximately one-third of the traffic in the Netherlands consists of bicyclists, the basic philosophy appears to be to reduce vehicle speeds or to eliminate vehicles to safely accommodate bicycle traffic.

2.5.2 Enforcement Measures

Automated Enforcement on Motorways

As shown in Figure 4, speed cameras are used in the Netherlands to enforce speed limits and provide motorists with the perception that speeding is unacceptable.

Figure 4. Speed Camera in Operation on the A2 Motorway.

Speed cameras are primarily used by the Dutch as a preventative measure to increase a driver's perception of apprehension as opposed to a repressive measure, i.e., generating revenue through fines.

Shown in Table 3 is a summary of the speed enforcement effort devoted to motorways in 1992.[8] Formerly, 95 percent of patrol officers' hours that were devoted to speed detection identified only 30 percent of speeders. With the speed camera, only 5 percent of the person hours are needed to produce 70 percent of the violations. Clearly, automated enforcement greatly increases effective use of personnel without increasing staff.

It was estimated that 80 to 90 percent of the violators detected by speed cameras pay fines without going to court. When photo radar is used, the enforcement tolerance is generally 7 km/h over the speed limit.

A preliminary study of the effectiveness of automated speed enforcement on motorways in the Netherlands has been conducted by Oei.[9] In 1994, a short-term evaluation of intensified automated enforcement on the A2 Motorway showed no reduction in the percentage of speeders or average speed. The enforcement effort was increased from 100 hours per month before the campaign to 300 hours of speed enforcement per month during the study. The researcher felt that the absence of publicity by the media may have led to the finding of no speed effect.

Table 3. Speed Enforcement on Dutch Motorways in 1992.

Enforcement Method	Person Hours	Detected Speeders
Radar and Camera	4,300 (5%)	210,000 (70%)
Radar, Surveillance Vehicle Stopped	81,700 (95%)	90,000 (30%)
Total	86,000	300,000

Automated Enforcement on 80 km/h Roadways

Speed measurements on two-lane roads indicate that 40 to 60 percent of the passenger cars exceed the 80 km/h speed limit. As there is a disproportionately higher number of fatalities on these roadways, a series of speed management experiments have been conducted. The experiments involved several speed control techniques including infrastructure improvements, warning systems, police enforcement, and information campaigns.[8] The objectives of the tests were to increase the attention level of drivers, improve driver compliance with speed limits, and reduce the accident rate.

In one experiment, the speed management measures consisted of a fixed warning sign at the beginning of the section, followed by an automated speed warning sign that flashed when the vehicle exceeded the speed limit. Further downstream, a speed camera was installed. Prior to beginning the experiment, an information campaign was conducted to advise motorists about the dangers of speeding. In the first phase, automated warning signs were used to encourage driving speeds between 60 and 80 km/h. In the second phase, speed cameras were installed to detect motorists who traveled above 90 km/h.

The results of the experiment indicated a reduction in speeds of 3 to 8 km/h. The percentage of speeders reduced from 38.2 to 11.4 percent. There was a slight increase in speeds slower than 60 km/h. No consistent change in speed was found on the control roads. A 35 percent decrease in accidents on the experimental roads occurred; however, the sample size was quite small.

An automated speed warning sign has also been used on the approach of an intersection.[8] When combined with occasional police presence at the intersection, the 85th percentile speeds decreased from 95 to 70 km/h.

Red Light and Speed Cameras

The PROject against Red light violations Or Speeding (PROROS-Project) is a comprehensive effort utilizing engineering, enforcement, and education to reduce red light offenses and speeding. Accident, speed, and other data were used to identify problem locations in Amsterdam. Based on follow-up studies, engineering improvements such as intersection modifications, signing and signalization changes, etc., were made where appropriate. In addition, two traffic light cameras and five cabinets were installed on major crossroads, and five more cabinets will be purchased in 1995.

In September, October, and November of 1993, selective enforcement was undertaken at 12 locations using a variety of methods including marked police motorbikes, unmarked motorcycles with video equipment, unmarked police cars, radar speed checks with marked police cars, unmarked speed checks with cameras, etc. During the period, publicity included posters, leaflets, and stickers, in addition to press coverage in the newspapers and on television stations.

Education of drivers to change their attitudes is also an important part of the project. A music video was developed to educate 18- to 24-year-olds concerning the dangers of speeding on mopeds. A module was also prepared for driving schools to distribute the message to a wider audience.

The PROROS-Project is an ongoing effort. While final conclusions are not available at this time, some preliminary findings have been reported. During the three months of checks in 1993, 3,550 people were observed speeding and 121 ran the red light. At several locations, speeding was reduced by 40 percent; however, at other locations, there was no measurable effect. It is felt that speeds and accidents will be reduced by continuing the program.

2.5.3 Educational Measures

Aktiecentrum (Action Center Observance of Speed Limits)

Aktiecentrum is an innovative marketing and communication plan to stimulate speed limit observance by communication of police enforcement to the public. The basic strategy is to improve enforcement credibility by visibility. The project was initiated in October of 1992 to provide general communication about speed limits and police control. The activities are conducted by communications experts working with the police. The basic goal was to improve the effectiveness of existing police efforts. The first objective was to increase public interest in speed limits, which was accomplished by communicating speed limits news items as being unusual, unexpected, and unpredicted. The second objective was to increase the perception that a driver would be fined for exceeding the speed limit. This objective was accomplished by using signs along the roadway and news media releases describing planned police activities.

After one year of communication efforts, there was an increase (from 10 percent before to 16 percent after) in public perception that a driver could be fined for exceeding the speed limit. The percentage of drivers who felt that the police did not do enough enforcement was reduced from 52 to 43 percent. A special traffic surveillance project is also underway to determine if communication efforts have an effect on speeding behavior. After five months, preliminary results indicate that less than 5 percent of the motorists are speeding. Continuing communication efforts are planned.

2.6 General Observations and Conclusions

The comprehensive safety and speed management program used in the Netherlands appears to be having positive safety effects; however, speed violations remain unacceptably high.

One important finding is that cooperation and consensus of all of the involved agencies must begin early and continue throughout the program. It is imperative to get everyone involved in the speed management process.

Automated speed cameras significantly increase enforcement efforts without increasing personnel.

One of the primary reasons automated speed enforcement is working in the Netherlands is because legislation was passed to make the vehicle owner responsible for the speeding violation.

Variable speed limits, such as the signaling systems used on Dutch motorways, can reduce accidents and increase traffic flow. However, the systems are expensive and are only used in high-volume locations and at sites with adverse environmental conditions.

The concept of using physical and visual measures to create the effect of a low-speed roadway appears to be promising; however, further research is necessary. Of particular concern to the team are liability issues associated with narrowing the pavement.

The team expressed concern about the truck-car differential (80 v 120 km/h) on motorways, as this speed variance may lead to an increase in accidents. This issue will be studied in the Netherlands. Several presenters indicated that they did not feel it was a problem, as it encourages trucks to stay in the right lane.

3. Summary Report on Germany

3.1 Introduction

On April 26 and 27, 1995, the study team conducted a scanning review in Germany. The review consisted of formal meetings with and presentations by transportation officials, researchers, and an enforcement officer at the Federal Ministry of Transport in Bonn and at the Federal Highway Research Institute (BASt). Field trips were also made to a traffic management test facility near Köln and a fully operational traffic management center in Rheinland.

3.2 Overview of Speed Management

Since reunification in October 1990, the Federal Republic of Germany includes 16 Laender States. The Federal Government, the States, and local communities and associations participate in safety management development and planning.[10] Specifically, the safety efforts include:

- Influencing the behavior of road users.
- Improving the technical safety of vehicles.
- Improving highway design to eliminate accident black spots.
- Improving rescue services.

Unlike other countries visited by the study team, speed management is not a high priority at the federal level in Germany. In fact, managing speeds through engineering, enforcement, or public education is not conducted at the federal level. Currently, BASt is not involved in any speed-related investigations or evaluations. Speed management activities, such as traffic calming, enforcement, and education, etc., are conducted at the local level.

The general absence of a formal speed management program in Germany is perhaps driven by the public perception that one should drive at a speed appropriate for conditions, and this speed should not be determined by the government. The officials and researchers who met with the study team also shared this view. It is believed that road safety can be enhanced by alerting drivers to dangerous spots or stretches, rather than imposing a specific limit, thereby increasing the acceptance ratio. Local maximum posted limits reflect the need to warn motorists and support them in their duty to drive at a speed appropriate for conditions.

In a major study entitled "Social Attitudes to Road Traffic Risks in Europe" (SARTRE), a public opinion poll concerning speed and other traffic issues was conducted. This particular opinion poll revealed some interesting items concerning German motorists' attitudes towards speed.[11] Eighty-eight percent of the East Germans and 79 percent of the West Germans polled felt that driving too fast was a cause of accidents. However, 30 percent of the West Germans favored no speed limit on autobahns. To achieve harmonization in the European Union, approximately 90 percent of the Germans favored a 50 km/h speed limit in urban areas. However, a harmonized speed limit of 120 km/h on the autobahns was supported by only 34 percent of the Germans.

3.3 Speeding and Speed Limits

Shown in Figure 5 are the road fatalities for the years 1953 through 1992. Between 1970 and the reunification in 1990, there was a general decline in fatal accidents in West Germany. In the year following reunification, road fatalities increased. However, following a public information campaign, the death toll continued to decline.

Although the German autobahns consist of only 2 percent of the roadway network, they carry almost 30 percent of the vehicle travel. Fatal accident rates on the autobahns are 7 per billion vehicle km compared to 15 in urban areas and 24 on rural roads. Accidents involving unadapted speed, defined as inappropriate speed for conditions and exceeding the speed limit, are shown in Table 4.[12] In 1993, unadapted speed was a contributing factor in 26 percent of the injury accidents and 49 percent of the fatal accidents.

Although there are no general speed limits on autobahns, there are posted speed limits of 80, 100, and 120 km/h on about one third of the autobahn network. The general speed limit on rural roads is 100 km/h. On roadways in built-up areas, the general speed limit is 50 km/h. In residential areas, the general limit is 30 km/h and 10 km/h in historical areas. It was estimated that the average speed on German motorways is increasing by 1 km/h annually.

In general, speed limits are established by highway code. Administration regulations set the standards on how speed limits should be established. Roadside development and commercial vehicles are considered as factors in establishing speed limits; design speed is not.

3.4 Enforcement

Speed enforcement in Germany operates in a less obtrusive manner than elsewhere. Police intervention seems to be an exception. Generally, they do not stop a motorist, but ascertain the facts primarily by means of radar devices, ensuring due prosecution. In built-up areas, imposition of limits is guaranteed by local authorities that post cameras, working in conjunction with the police. As indicated in Figures 6 and 7, there is considerable commercial vehicle travel on German roads. Special speed enforcement programs are targeted toward trucks because the injuries are more severe when they are involved in accidents. Other than commercial vehicles, no special segments of the vehicle population are subjected to antispeeding campaigns.

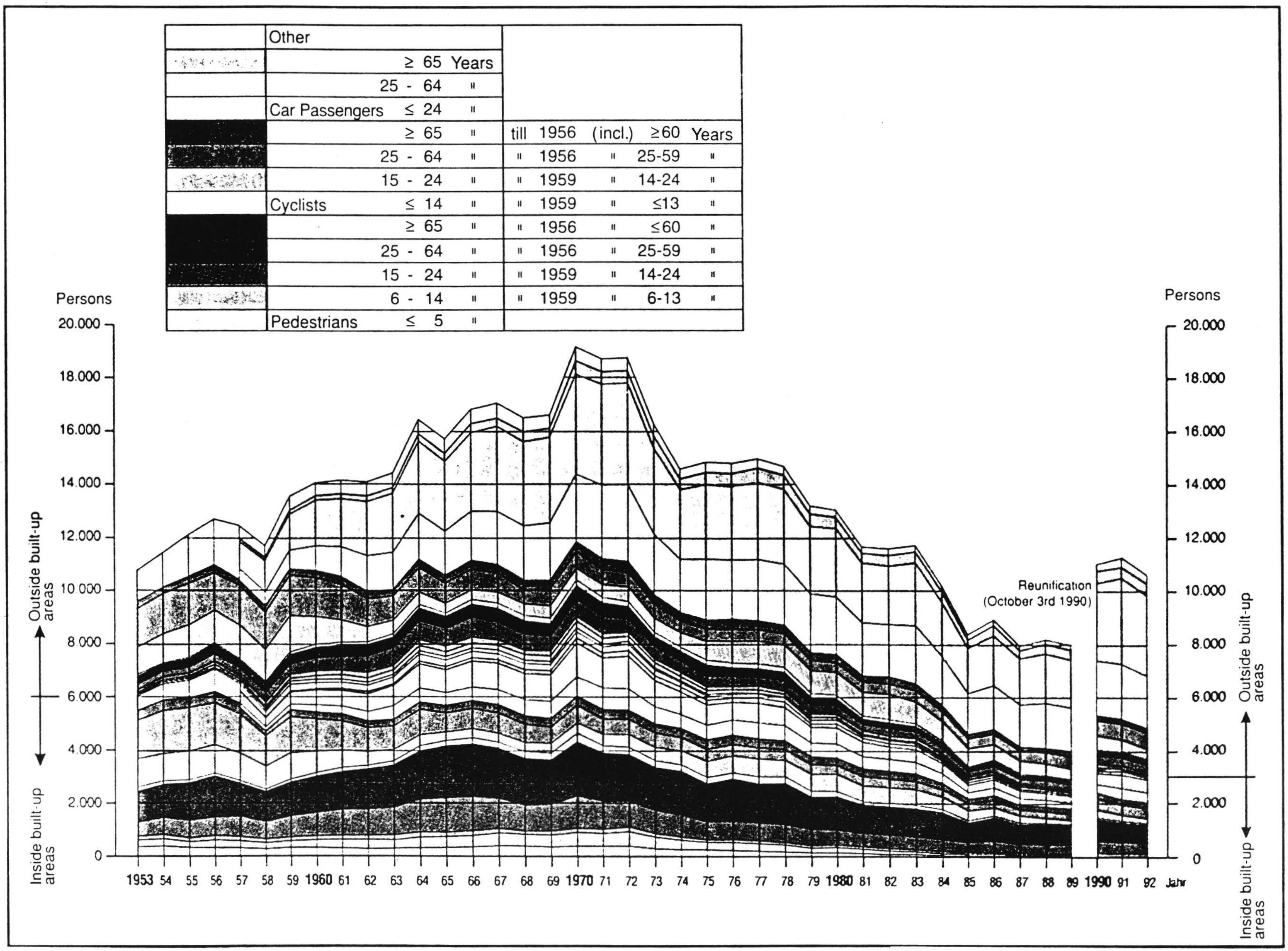


Figure 5. German Highway Fatalities.

Table 4. German Accidents Involving Unadapted Speed.

Year	Total			Unadapted Speed		
	Injury Accidents	Persons Injured	Persons Killed	Injury Accidents	Persons Injured	Persons Killed
1991	358,147	516,835	11,300	101,855 (26.4%)	150,187 (29.1%)	5,356 (47.4%)
1992	395,462	527,428	10,631	99,618 (25.2%)	146,057 (27.7%)	4,979 (46.8%)
1993	385,384	515,540	9,949	101,907 (26.4%)	149,515 (29.0%)	4,871 (49.0%)

Fines for speeding range from $29 US for exceeding the speed limit by 10 km/h or less to $290 US for 50 km or more over the limit.[13]

On the local level, there is some experimentation with photo radar to determine its impact on vehicle speeds. Speed cameras have not been widely used because German law requires positive identification of the driver for a traffic infraction. Current speed camera technology does not consistently and reliably identify drivers. There is a technical tolerance of 3 km/h to account for measurement error and an additional so-called "opportunity tolerance" of another 3 km/h. The threshold from which speeding is detected by cameras varies according to local conditions. Police indicate they are moving away from photo radar in favor of a laser-video camera interface installed in the police vehicle. The primary reason for this change is to provide the courts with additional evidence of a driver violation, and to eliminate the problems associated with identifying the driver with photo radar.

Based on a review of the literature, a long-term investigation of automatic radar devices was conducted at Elzer Mountain on the A3 autobahn.[14] To reduce accidents and accident severity, a speed limit of 100 km/h was posted and speed cameras were placed above each lane. Passenger cars exceeding 110 km/h and trucks exceeding 45 km/h were photographed. Tickets were sent to the vehicle owners by mail. In addition to speed cameras, police patrols were used, especially on weekends, to cite drivers for speeding. Immediately after this 100 km/h speed limit was imposed, a 30 km/h reduction in mean speed was noted. Following installation of the speed cameras, an additional 20 km/h reduction in speed occurred. The combined effects of the speed limit and speed cameras produced a 91 percent reduction in accidents on that stretch of autobahn.

Based on discussions with officials, there appears to be little interaction between the courts and police or between courts and transportation officials concerning speed management. No special effort or program has been established to encourage interaction or relationships.

Figure 6. German Police Enforce Commercial Vehicle Regulations.

Figure 7. Truck Lane Restrictions on a German Road.

3.5 Summary of Speed Management Techniques Reviewed by the Study Team

The scanning team visited a traffic management testing facility near Köln and an operational traffic center in Rheinland. A brief summary of the methods examined is given below.

Traffic Management Research Facility

The Germans have long been a world leader in advanced traffic management technology. Some of the projects reviewed by the team included an automated toll collection system, advanced route guidance, intelligent vehicle control, and other promising Intelligent Transportation System (ITS) concepts. At the time of the review, the systems were in the research and development phase. While some of these technologies may be used in future speed management techniques, they have not been implemented or evaluated at this time.

Traffic Management on Autobahns

Traffic management facilities have been used since 1960 on sections of the autobahn to improve traffic flow and adapt traffic to adverse environmental conditions. At present, Germany has 70 traffic management facilities in operation, covering 500 km. Current plans are to install an additional 60 facilities by the end of 1997 on another 300 km.

The cost of a comprehensive traffic management system is estimated to run between 0.5 million and 1 million DM ($0.4 and $0.7 million US) per kilometer. Due to the high costs involved, the systems are installed on a priority basis on hazardous sections, especially at locations where adverse environmental conditions exist.

Traffic flow is monitored through inductive loops buried in each travel lane, which provide a count of vehicles and measures speeds for cars and trucks. Fog, ice, wind, and other detectors are used to monitor environmental conditions. The data are transmitted to a traffic control center where computer algorithms switch the appropriate variable message signs for the conditions detected. The displays can be operated manually in the event of an accident or other emergency.

Shown in Figure 8 are typical messages and the range of speed limits that can be displayed to manage traffic. In addition to changing the speed limit, the reason for the restriction is also displayed.

Accident evaluations indicate that these systems reduce the accident rate by 20 to 30 percent, with an average reduction of 25 percent.[15]

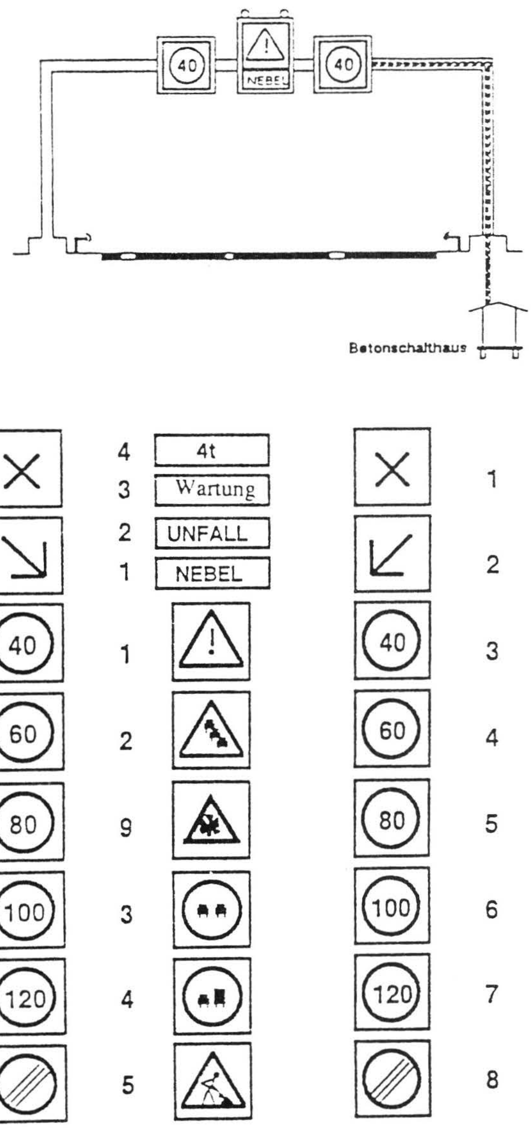


Figure 8. Variable Message Displays on the Autobahn.

Other Speed Management Methods

During the visit to Germany, the study team observed a number of other engineering, enforcement, and educational methods that were not discussed during formal meetings or field reviews.

Similar to other European countries, traffic calming techniques such as round-abouts, speed humps, road narrowing, etc., are used in residential areas to reduce vehicle speeds to 30 km/h. Some urban areas have car-free zones, and there are numerous bicycle paths to accommodate the high volume of cyclists. While the majority of Germans may favor unrestricted speeds on autobahns, it was observed that speed restrictions are widely accepted in urban areas.

3.6 General Observations and Conclusions

For many years, Germany has been a leader in highway infrastructure and traffic management systems. The variable speed limit systems on the autobahns are the finest in the world. Current ITS research and development efforts will undoubtably produce future traffic management systems that will control speed and improve safety and operations.

The major findings of the team are listed below:

- Speed management and enforcement is not a high priority at the Federal level in Germany. This observation is reflected in many ways, including low sanctions for speed violations, no current speed-related research studies, and no speed policy direction or formal programs from the Federal Government.

- There is no program where researchers, policy makers, law enforcement administrators, citizens, and judicial officials are brought together from all levels of government to develop an integrated approach to speed management. Some of these groups do come together to address other traffic-related problems, but the involvement is usually on the local level. Apparently, there is very little involvement of the courts, leaving a major void as far as the sanctioning part of a speed management program.

- German officials appear to take a "problem-oriented" or "community-based" policing approach in some areas when dealing with local speed problems. When citizens complain about a speeding problem in their area, police will go to the area and collect data. If they find a problem, they will return with enforcement equipment and personnel to combat it. The effectiveness of their activities is measured through accident statistics. In addition, public reaction is obtained through surveys. However, this approach appears to be limited to areas such as centers for the elderly, schools, and residential areas where public support for speed enforcement is high.

- German citizens and officials, including traffic safety researchers, appear to support the practice of not posting speed limits on autobahns outside of urban areas. According to officials of Germany's Ministry of Transport, most of the reasons given for implementing speed limits, i.e., safety, fuel conservation, etc., are not adequately supported by the facts.

- Public education programs relating to speed are typically targeted to specific audiences, as opposed to the general public. For example, excellent films have been developed for high school students. As in other countries, the Germans are innovative in using rock stars and other celebrities to target safety messages to specific audiences. Apparently, they feel education is a better preventative measure than repressive fines or punishment.

- German officials use technology more to manage speed than to enforce it. Variable speed limits are much more accepted and used than fixed speed limits. Variable speed limits, which advise motorists of the safe speed for prevailing conditions, are more beneficial than a fixed limit, which does not give drivers useful information during adverse traffic flow and weather conditions. Due to the use of electronic signage, the variable limits are enforceable. More importantly, they appear to have major beneficial safety and operational effects.

- Photo radar is used on a limited basis in Germany, but its effectiveness has not been adequately measured or studied. German law requires positive identification of the driver, which poses limitations on the use of photo radar. Also, due to some of the problems associated with this technology, i.e., repair costs, bad photos, out-of-country drivers, etc., police are moving toward laser speed measuring devices. Also, in some jurisdictions, the German police videotape traffic violations, including speed. This practice provides additional support in court, which results in an almost 100 percent conviction rate.

4. Summary Report on Sweden

4.1 Introduction

On April 28, 1995, the study team conducted a scanning review in Gothenburg, Sweden. The review consisted of formal meetings with and presentations by safety researchers from the Swedish Road and Transport Research Institute, the Swedish National Road Administration, and officials with Saab Automobile, Volvo, and Ultralux AB.

4.2 Overview of Speed Management

Safety management has been the responsibility of the Swedish National Road Administration since 1993. Prior to that time, the National Swedish Road Safety Office was responsible for safety programs. The organizations were merged to provide a more integrated approach to road safety. The other major participants in safety management are the National Swedish Police Board, with responsibility for traffic surveillance and enforcement, and the local communities.

In October 1994, a National Road Safety Program was developed for the period from 1995 to 2000.[16] The primary goal of the program is to improve road safety by 25 percent. The main characteristics of the program are to expand the focus from fatalities to include severe injuries; to increase the importance and valuation of road safety on all levels of society; to treat road users as partners and continually measure their behavior, knowledge, and views; to follow up all actions, thereby creating a result-based management system; and to foster cooperation between all partners.

There are 18 safety problems identified in the National Road Safety Program. Poor compliance with speed limits is listed as the number one safety problem. Through speed management techniques, speed limit violations are expected to be reduced 35 percent by the year 2000.

More than 50 percent of the motorists in Sweden travel at speeds above the speed limit. It is estimated by researchers that 100 to 200 people are killed each year as a result of exceeding the speed limit. It should be noted, however, that police officers only collect objective data at accident scenes; thus, no subjective judgment is made regarding excessive speeds as a contributing factor.

The speed management methods that are planned for implementation include increasing the perception of the risk of detection by more effective police enforcement, communication with the public, and providing information and education. The major problems to be addressed are public perception and attitudes about speeding. The program is estimated to cost about $3 million US per year.

The Swedes were successful in changing public perception on seat belt use and drinking and driving, but were unsuccessful in changing attitudes about speeding. The goal of the education program will be to influence attitudes and knowledge about speeding.

4.3 Speeding and Speed Limits

Speed limits have been raised and lowered many times in Sweden, especially on rural two-lane roads and motorways as shown in Table 5. The speed limit changes have been made for a variety of reasons, including energy, environment, and safety objectives. The Swedes have used several unique approaches to establish general speed limits. From 1971 to 1975, roadway and traffic characteristics were used to set speed limits on rural two-lane roads. Since 1975, the accident rate has been used as the primary factor in setting the speed limit. This process was achieved by classifying roadways by geometric design, i.e., high standard roadways, wide pavement shoulders, etc. Accident rates were then developed for each roadway category. Consequently, higher speed limits are used for the higher standard roadways which have the lowest accident rates. In effect, this process is similar to basing speed limits on geometric design criteria.

Local speed limits are set by local governments. The general speed limit is 50 km/h, and 70 km/h where there is good separation between vehicle traffic and pedestrians and bicyclists. Thirty km/h is used in residential areas. On motorways, the general speed limit is 110 km/h.

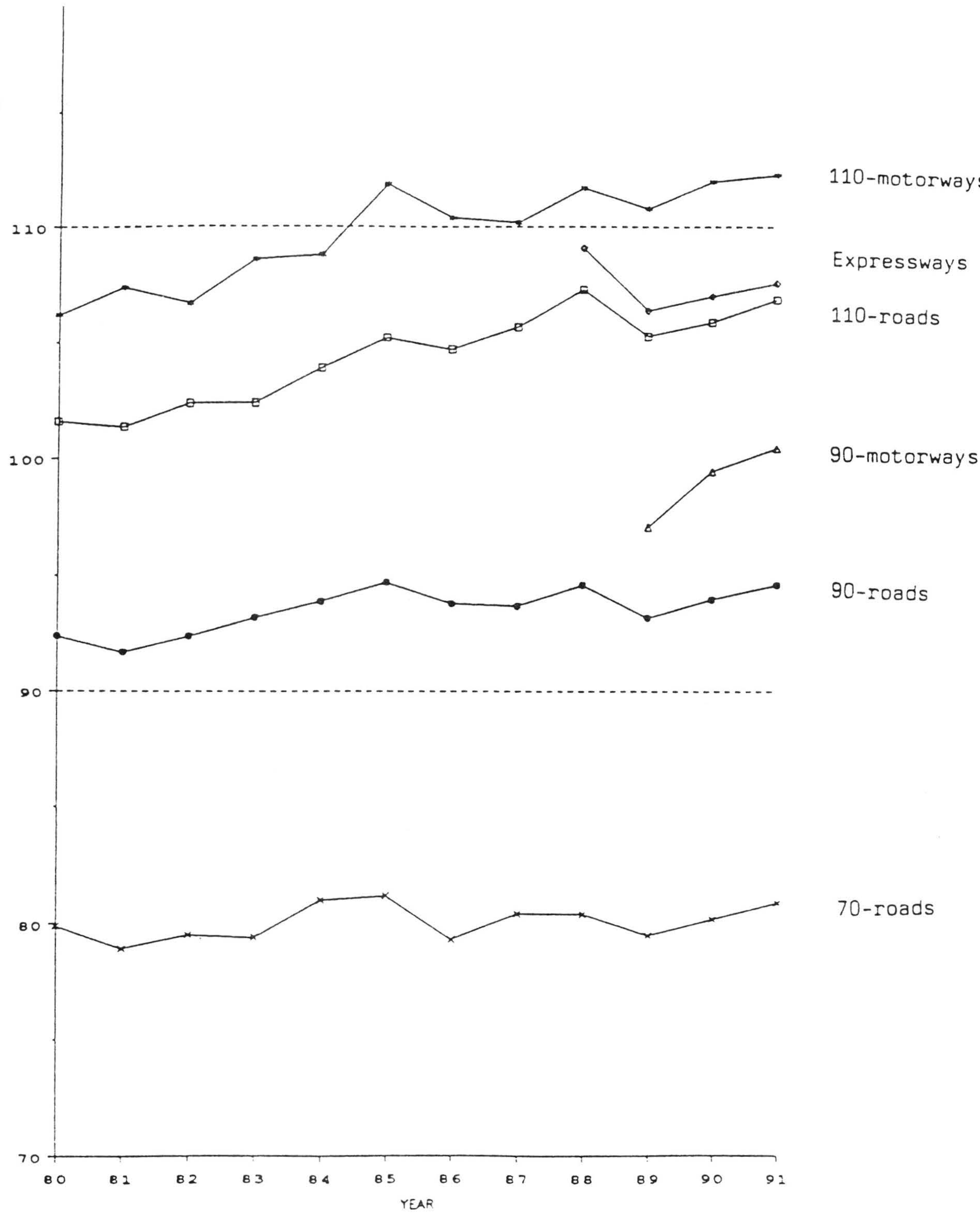
Changing the general speed limits over the years has provided a unique opportunity to study the effect of speed limits on driver behavior and accidents.[17] In the 1970s, when speed limits were lowered by 10 or 20 km/h on motorways, the mean speed of traffic decreased by 3 to 4 and 6 to 8 km/h, respectively.

In 1989, the speed limit on motorways was reduced from 110 to 90 km/h. The evaluation showed that speeds decreased both on roads where the speed limit was changed and on roads where it was not changed. When speed limits were raised, speeds increased on all roads. As shown in Figure 9, mean speeds on Swedish motorways and other high-speed roads have been increasing since the early 1980s and have now exceeded the posted speed limits.

A wide variety of differentiated speed limits exists for different vehicles. For example, some double and all triple trailers are limited to 40 km/h, while the maximum limit for buses is 90 km/h. The restrictive nature of these limits clearly discourages the use of certain vehicle and truck combinations.

Table 5. History of General Speed Limits in Sweden.

Time Period	Urban Areas	Local Limit	Rural Areas	
			Two-Lane Roads	Motorways
1960	50	50, 70	No speed limit	
1960-1967	50	50, 70	General speed limits of 80, 90, and 100	
1967	30-40		Changed to right-hand traffic. General limits of 60-80	
1968-1971	50	50, 70, 90	General limit 90 Differentiated limits 90, 110	General limit 130 Differentiated limit 110
1971-1975	50	30, 50, 70	Differentiated limits 70, 90, and 110 based on pavement width, ADT, and alignment in northern Sweden	110
1975-1979	50		Speed limits based on pavement width, alignment, and accident rate	110
1979	50	30, 50, 70	70, 90 (Energy)	90 (Energy)
1980-1989	50	30, 50, 70	70, 90, and 110 based on accident rate	110
1989	50	30, 50, 70	70, 90 (Safety)	90 (Safety)
1989-1992	50	30, 50, 70	70, 90 (Environment)	90, 110 (Environment)
1992-	50	30, 50, 70	70, 90, and 110 based on accident rate	110

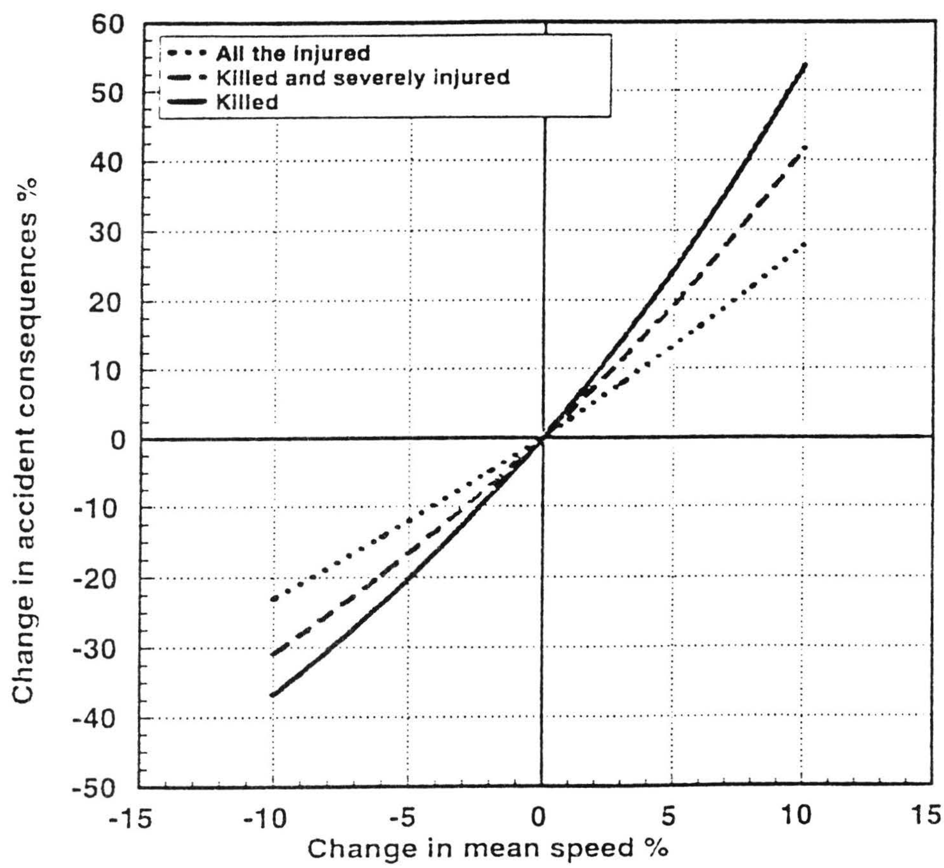


Source: Gunnar Anderson and Göran Nilsson, "Speed Limits, Speeds, and Safety," 1995.[17]

Figure 9. Mean Speed Trends on Rural Roads in Sweden.

As illustrated in Figure 10, researchers at the Swedish Road and Transport Research Institute (VTI) have developed a model for estimating the effect of changes in mean speed on road safety. This model is based on experiments conducted in Sweden between 1968 and 1971. The experiments involved increasing and decreasing speed limits on the same roadways over time. The model was validated with data obtained from changes in Swedish speed limits which were made in 1979 and 1989.

The VTI model was used to determine the safety potential of reducing the proportion of drivers exceeding the speed limit on various roadways. This information will be used in the development of strategies for the National Road Safety Program.



Source: Gunnar Anderson and Göran Nilsson, "Speed Limits, Speeds, and Safety," 1995.[17]

Figure 10. Relationship Between Changes in Speed and Safety.

4.4 Enforcement

Unlike its Scandinavian neighbors of Denmark, Finland, the Netherlands, and Norway, Sweden does not have a National Traffic Police Agency, i.e., highway patrol or state police. The law enforcement structure is one of regional and local responsibility. There is, however, a National Swedish Police Board that coordinates police activities throughout the country. The board has responsibility for all regions, thereby reflecting a consensus on issues of police importance. It sets standards for training and equipment and goals for effective countermeasures, which are identified by regional and local police in cooperation with the Swedish National Road Association and the Swedish Association of Local Communities.

Police play an important role in reducing and controlling speeds on roadways. Unfortunately, speed enforcement has traditionally been given a low priority in relation to crime problems. Although discretion is used, police officers generally allow a 10 km/h tolerance before issuing fines for speeding.

Increasing driver perception of the risk of being apprehended by police for speeding is an important safety objective. It has been estimated that the probability of being caught for speeding in Sweden is about once in 30 years; therefore, much has to be accomplished with the new speed management program.

Approximately 100,000 motorists are cited each year for speeding. Shown in Table 6 is a summary of the various enforcement methods and the number of citations issued during 1994.

Fines for speeding range from $110 US for less than 16 km/h over the speed limit to $138 US for exceeding the limit by between 16 and 30 km/h. Over 31 km/h, the fine is $166 US. Violations of 20 km/h or more over the speed limit in a 30 km/h zone lead to a suspension of the driver's license from two months to one year. The driver can also lose the license by exceeding the speed limit by 30 km/h or more in rural areas.

Sweden used automated enforcement technology as a pilot project from 1990 to 1992. Two fixed camera sites were established on each of the 16 sections of roadway included in the experiment. An officer operated the camera at each site in order to personally observe the violation. Drivers exceeding the speed limit by 13 to 14 km/h were photographed from the front in order to record the vehicle registration number and to identify the driver. Swedish law requires that the driver is responsible for traffic infractions and not the vehicle owner. Speeds at the camera sites decreased between 5 and 10 km/h. Mean travel speeds over all of the test sections decreased by 3 km/h. The sample size was too small to measure the effects of the speed cameras on accidents.

Table 6. Police Surveillance Methods and Violations in 1994.

Surveillance Method	Reported Violations in 1994
Radar	55,128
Police Pilot in Police Car	2,366
Police Pilot in Unmarked Car	9,100
Police Pilot on Police Motorcycle	1,690
Police Pilot on Unmarked Motorcycle	1,226
Manual Recording	281
Helicopter	2,719
Laser Instrument	44,114
Other Methods	3,221
Total	123,845

Note: Police Pilot is Visual Average Speed Computer and Recorder (VASCAR).

Listed below are some of the concerns the police have regarding the use of automated enforcement technology:

1. The length of time from detection to sanction is about three weeks.

2. Due to funding restrictions, there are not enough mounting units (devices along the roadside where the enforcement equipment is placed) installed on roadway sections.

3. Swedish law requires positive identification of the driver, not the owner of the vehicle, for violations.

4. Many photographs are not discernible and cannot be used for prosecution because the driver could not be positively identified. This problem occurred during inclement weather, dusk, dawn, and during other times of restricted visibility.

5. The equipment repair and maintenance costs are high.

6. Heavy traffic passing the camera sites affects the equipment operation.

7. Since most nationals have a passport, some thought has been given to using passport photographs and/or passport numbers for the identification of violators due to the poor quality of automated surveillance equipment photographs.

Automated surveillance equipment is currently used to target problem areas, e.g., work zones, school zones, high-accident locations, hospital zones, and citizen complaints, etc. Enforcement agencies limit its use while conducting general enforcement countermeasures. The cameras are operated by an officer who observes each infraction. The photograph is primarily used as supporting evidence in court.

Two technologies in use by Swedish police are in-car video camera radar systems and laser speed devices. Police pilot (VASCAR) is used extensively.

Sweden prohibits the sale and use of radar detectors, and consistent with other European Union countries, as of January 1, 1995, requires speed limiters (governors) on heavy trucks. These devices limit top speed of trucks to 85 km/h. Although the speed limit for automobiles on motorways is 110 km/h, transportation officials do not feel that the speed differential will be a safety problem.

4.5 Summary of Speed Management Techniques Reviewed by the Study Team

The Swedish National Road Administration is investigating a number of new technologies that could be used on board the vehicle to improve road safety. Some of these technologies could potentially be used to influence speeds or may have an effect on vehicle speeds.

UltraViolet (UV) Activated Fluorescent Roadway Delineation

Although not directly related to the speed management objectives of this report, UV technology is of interest due to its potential for improving visibility during nighttime and other periods of restricted lighting conditions. The Swedish government, in cooperation with Ultralux AB, is studying the potential of using UV headlamps to provide the driver with improved nighttime visibility.[18] UV headlamps would be used in conjunction with regular headlamps to provide longer detection distances for fluorescent delineator posts, raised pavement markers and pavement markings, and for pedestrians wearing certain colors of clothing. This technology is not yet commercially available, although one manufacturer is actively pursuing the development of a low cost (<$300 US) UV headlamp.

Intelligent Transportation System (ITS) Technologies

The Swedish National Road Administration, in combination with numerous private sector companies, has been testing a wide range of Intelligent Transportation System (ITS) technologies. Among the possibilities being tested is Aspen Track, which involves linking roadside information with the vehicle to improve safety.[19] Also being investigated is an intelligent cruise control, which monitors vehicle speed and distance to vehicles ahead, then automatically adjusts speed to prevent collisions.

The technology was tested using a 35-km loop involving a combination of road types.[20] Two vehicles were equipped with intelligent cruise control and short-range communications. Roadside transponders were used to transmit information on actual speed limits, warnings of pedestrian crossings, dangerous curves, and roadwork, along with recommended speeds. The information was presented graphically on dashboard displays. Sixteen test subjects were used and a variety of data were collected by speed logging, behavioral observations, and interviews.

In general, the conclusions of the study were positive.[20] The researchers found that it is possible to influence speed, and the technology was well received by the users. However, there were also some issues that need to be addressed:

- When using the informative mode where information on the speed limits are presented to the driver, there is an initial reaction when the information is fresh, but as time passes with no new messages, there is little substantial change in driving behavior.

- When using the assisting function (where the roadside information is used to set the vehicle speed), drivers were uncomfortable on curves and in urban areas. The set speeds were too high and had to be reduced manually.

Two different strategies have been discussed:

- Disconnecting the intelligent cruise control in areas where the driver feels uncomfortable.

- Implementing a speed limiter function for urban traffic. The driver would have full control of speed choice up to the legal speed limits.

Research and development of these and other similar technologies is continuing.

4.6 General Observations and Conclusions

In Sweden, speed management is recognized as an important element of road safety. Speed limits and roadway geometry are kept consistent. The government is also aware that future technologies can greatly improve road safety, and is taking steps to investigate the potential of these technologies.

Photo radar was examined, but did not work in Sweden because the individual driver is responsible for speeding under Swedish law and not the owner of the vehicle. Currently, no equipment is commercially available that will consistently and reliably identify the driver.

To date, there have been very limited speed education and information programs in Sweden. The most significant program was aimed at young men in the military. The administration is trying to expand the use of television and print media as part of the new safety program.

The fact that 50 percent of the motorists in Sweden exceed the posted speed limit indicates that the public perception and attitude about speeding need to be changed. The Swedes have been successful in changing public perception of seat belt use and drinking and driving, but apparently have not been successful in changing attitudes about speeding.

5. Summary Report on Australia

5.1 Introduction

The study team conducted a scanning review in Sydney, New South Wales, on May 1 and 2, 1995, and in Melbourne, Victoria, on May 3 and 4, 1995. The review involved formal meetings with and presentations by traffic and safety officials in each State, including the Roads and Traffic Authority of New South Wales, VicRoads, the Transport Accident Commission of Victoria and Victoria police, and Monash University Accident Research Centre. The team also made field visits to inspect the fog advisory system near Sydney, the Safe-T-Cam operations center, speed camera operations in New South Wales, speed and red light camera operations in Victoria, and the Traffic Camera Office in Melbourne.

5.2 Overview of Speed Management

The Commonwealth of Australia is composed of eight States and territories. Although the Federal Office of Road Safety, located in the capital of Canberra, has the responsibility for national policy, each State has a Department of Transportation, or Road and Traffic Authority, with responsibility for implementing safety management programs. As approximately 40 percent of Australians live in Sydney and Melbourne, the team decided to conduct the scanning review in the States of New South Wales and Victoria.

New South Wales and Victoria have implemented one of the most comprehensive and coordinated safety management programs in the world.[21,22] Among other factors, such as driving under the influence, speed management is a critical element in their safety management programs.[23,24]

As one in three fatal crashes in New South Wales is speed related, a long-term speed management program was developed to meet the following objectives:[25]

- To reduce road crashes and injuries by improving road user behavior.
- To reduce road crashes and injuries by improving engineering, road environment, and management of traffic.

The overall goal of the program is to achieve a situation where:

- Speed is not a major contributing factor in crashes.
- The road environment and speed zones are appropriate for safe and efficient travel.
- Drivers comply with speed limits.

- Speeds traveled by drivers are appropriate for prevailing conditions.

The program consists of a broad range of engineering, enforcement, and educational countermeasures. The key elements include:

- Collect speed, accident, and community attitude information to define the problem.
- Communicate to and educate the public.
- Impose credible speed limits and speed zones.
- Insure that the road environment is conducive to speeds that are safe.
- Use enforcement as a mechanism for enhancing deterrence and dealing with offenders.
- Promote legislation and regulations to control the problem and establish penalties that are acceptable to the community.
- Develop strategies to reduce speed-related heavy vehicle crashes.
- Explore and identify technology to improve speed management.
- Continue to monitor and evaluate the effectiveness of the program.

Both New South Wales and Victoria started their safety campaigns as a result of an observed increase in traffic fatalities and serious injuries. In New South Wales, the target reductions are based on the 1986 levels of fatalities and injuries, while in Victoria the targets are based on 1989 numbers.

While the speed management concept is similar in both States, the implementation is significantly different. Both States recognize that the long-term success of the program depends on coordination between engineering, enforcement, and educational elements. While we in the United States have also recognized the importance of these three elements, they have not been coordinated into a single campaign as effectively as has been done in Australia. The coordinated effort appears to be the primary reason for their success. The programs are based on the sequence of values, attitudes, perception, and behavior.

The attempt to change values is a common theme in both States and is based on educational programs oriented to pre-school and elementary school aged children. New South Wales appears to have a more extensive educational program than Victoria, but the concept is the same. *The goal is to make speeding a socially unacceptable behavior.*

The two States differ in their approach to changing attitudes. New South Wales has emphasized public information programs supplemented by enforcement, while Victoria has emphasized enforcement, supplemented by public information. In both States, these programs are coordinated with each other, as well as with the engineering components of setting realistic speed limits and providing a visual stimulus consistent with these limits.

The key features of the speed management program are:

- Credibility. The public must believe in the effort. This means they must understand the relationship between speeding and crashes and crash severity. They must also believe that the speed limits used on each road are reasonable and will contribute to increased safety.

- Visibility of enforcement. The public must have the perception that they will be apprehended if they speed, and the penalties will be severe.

The primary measures used to accomplish the speed management goals include:

- Perceptual countermeasures.

- Programs to change community attitudes.

- Enforcement using advanced technology.

Perceptual countermeasures are based on developing consistency between the physical environment and the speed limit. Where the two are not consistent, countermeasures to change the visual perception or the physical environment are introduced. One example is the use of traffic calming methods in residential areas where a 40-km/h speed limit is introduced. The physical characteristics of the road are altered through the introduction of speed humps, physical barriers, and roundabouts to create consistency between the speed limit and the operating speed.

Other examples include the use of painted medians to narrow traffic lanes and the uniform use of the same speed limits on similar roads with similar characteristics. It is difficult for a local community to successfully petition for a reduced speed limit if the visual perception of the roadway has not been changed. Consistent, rational, and enforceable speed limits on all types of highways are the objectives of their speed management program.

Hard hitting television advertisements and concentrated information campaigns are elements of their attempt to change community attitude. Speeding as an unacceptable social behavior will be stressed during one campaign, along with television and billboards displaying the consequence of speeding in rather harsh messages. Other campaigns, such as drunk-driving, fatigue, etc., will be conducted before repeating the emphasis on speeding. While a campaign is underway, all elements of communication focus on that theme.

Enforcement is the third element of the program. Both States make extensive use of photo radar in their enforcement effort. The use of photo radar required that the laws be changed from issuing penalties to the driver to fining the owner of the vehicle. In Victoria, enforcement is a major part of the speed management program, with about 500,000 tickets issued each year (1 for every 6 licensed drivers.) In New South Wales, there are only about 50,000 tickets issued a year. Victoria does not notify motorists of the location of the speed camera, so that optimum effect of both general and specific deterrence to speeding is obtained. By contrast, as shown in Figure 11, New South Wales posts signs in the zones where photo radar is used.

Figure 11. Speed Camera Sign on a Roadway in New South Wales.

Speed Camera Operations in New South Wales

Radar speed cameras were first introduced in New South Wales in March 1991.[23] Initially, nine cameras were used at 93 sites. Prior to using the cameras, an intense public information campaign was undertaken that included radio, television, and press coverage. Pamphlets, containing questions and answers, were distributed to all police stations. Based on the advice of the speed management task force, which included officials from enforcement, the Roads and Traffic Authority, the National Roads, and Motorists Association, signs with the message "Speed cameras used in this area" were erected on roadway sections where the cameras were likely to be used. Speed cameras were initially used in urban areas; however, in November 1993, the operations were extended to rural locations. Currently, New South Wales has 21 speed cameras which operate at 809 sites throughout the State. The cameras are located at high-accident sites.

In New South Wales, a 10 percent tolerance is used as a general guideline in enforcing the speed limit. Typically, there is a five-day turnaround between the time a motorist is detected for speeding and a speeding infringement notice is mailed. Fines for speeding range from $99 A ($73 US) and one demerit point for exceeding the speed limit up to 15 km/h to $608 A ($450 US), six demerit points, and loss of license for 3 months for exceeding the speed limit by more than 45 km/h. In 1994, 51,393 speed camera infringements were issued. A total of $4.5 million A ($3.3 million US) was collected in fines.

A before-and-after evaluation indicated a 22 percent reduction in serious accidents occurred at the speed camera locations. There was also a decrease in excessive speeding, i.e., the proportion of vehicles traveling 10 km/h or more, and 20 km/h or more above the speed limit.

Attitudinal surveys conducted before and after the speed cameras were introduced revealed that there was high public acceptance of the cameras. The public was also familiar with the fact that the cameras were used to improve safety.

Speed Camera Operations in Victoria

Radar speed cameras were introduced in Victoria in September 1989.[24] Initially, 54 slant-radar speed cameras were used for speed enforcement. In June 1990, the Traffic Camera Office was established and is responsible for the administration and management of the speed red light and bus lane cameras. Speed cameras in Victoria are located in areas where there are serious-injury collisions, and where there are validated complaints of excessive speeding. In special circumstances, speed cameras may be used to target specific local traffic problems. The cameras have been occasionally used on rural freeways. The Victoria police operate the mobile speed cameras using one officer operating the camera; however, the violation images are viewed by trained civilian staff, who issue infringement notices from a computerized system, under strict police policy and supervision.

There are no plans to use this technology in an automated mode at fixed locations. Currently, 13 police districts have two speed cameras, and four districts have one camera. In order to deter speeding, 130 camera enforcement hours per month per camera are used.

Similar to the method used in New South Wales, a cooperative enforcement effort between the police, VicRoads, and the community is used in Victoria. In concert with the enforcement activity, a multimillion dollar public awareness campaign was conducted. The high level of enforcement is intended to change driving behavior and reinforce the perception that speeders will be caught. Eventually, enforcement will be reduced to a maintenance mode when it has been established that speeding is socially unacceptable.

In Victoria, the enforcement tolerance is 10 percent of the speed limit, plus 3 km/h for measurement error. Approximately 28 percent of vehicles photographed are not prosecuted due to a variety of reasons, including inadequate vehicle identification, resulting from obscured license plates or database mismatches. Typically, there is a three-day turnaround between the time a motorist is detected for speeding and the speeding infringement notice is mailed. Fines in Victoria for speeding range from $105 A ($78 US) and one demerit point for exceeding the speed limit up to 15 km/h per hour to $360 A ($266 US) and six demerit points and loss of license for six months for exceeding the speed limit by 50 km/h or more. Overall, approximately 35,000 speeding infringements are issued each month. In four years, only five cases have been lost in court.

In five years of camera operation, the percent of vehicles exceeding the speed limit tolerance was reduced from 23 percent to 2.9 percent, with virtually no drivers exceeding the tolerance speed by more than 25 percent. Obviously, very high-speed driving has nearly been eliminated.

The impact of the probability of being detected speeding, and the penalty applied if apprehended, has led to few repeat offenders. Shown in Table 7 are the recidivism rates for 1992 through 1994.

Table 7. Recidivism Rates for Speeding.

Number of Tickets	1992	1993	1994
1	79.9	86.7	90.3
2	15.7	11.2	7.5
3	3.3	1.85	0.8
4 or more	0.12	0.04	0.01

Source: Victoria Traffic Camera Office, 1995.

An evaluation of the speed camera program and supporting publicity in Victoria revealed that there was a decrease in both the frequency of injury crashes and the severity of the injuries. The program appears to have the greatest effects on arterial roads in Melbourne (30 percent reduction in accidents) and on 60 km/h rural roads (20 percent reduction in accidents) where the majority of camera operations took place.

5.3 Program Effects

The comprehensive safety management programs in New South Wales and Victoria have led to impressive reductions in traffic fatalities and serious injury crashes.

In Victoria, prior to 1989, the death and injury rate was steadily increasing over a 10-year period.[26] The societal cost of the accidents was estimated at $1.5 billion A ($1.1 billion US). When the safety management plan was implemented in 1989, the goal was to reduce fatalities to less than 500 per year by the year 2000, and to reduce injuries per 10,000 vehicles from 40 to 24 by the year 2000. The fatality objective was achieved in 1992 and the injury objective was met in 1994.

In 1994, 378 persons were killed in traffic accidents in Victoria, less than one-half the number recorded in 1989, and the lowest number of fatalities since 1951. In addition, injuries were reduced by 38 percent and total accidents decreased by 22 percent. In New South Wales, the targeted reduction for the year 2000 was surpassed in 1994, and lower targets were set at that time. While these accomplishments are not all attributable to speed management, officials in both States believe that the program is a major contributor to the reduction in crashes and crash severity.

5.4 Summary of Speed Management Techniques Reviewed by the Study Team

During the scanning tour of Australia, the team visited sites to obtain firsthand knowledge about specific speed management techniques. A brief summary of these methods is given in the following sections of this report.

Fog Warning and Advisory Speed Limit System

A fog warning and speed advisory system has been installed along an 11-km section of the F6 Tollway south of Sydney.[27,28] The F6 is a four-lane divided motorway carrying an average of 12,500 vehicles a day in each direction. There are 12 fiber-optic sign locations, with signs in each direction, so the motorist encounters a sign about once per km. Each location is equipped with a sign connected to road loops and a visibility detector to provide motorists with an advisory speed for road conditions. The speeds of individual vehicles are measured over a distance of 200 m, and this speed is used to present an advisory speed to the next vehicle passing the station. The advisory speed is based on visibility distance and the speed of the preceding vehicle, i.e., a driver is advised of the speed to travel in order to avoid a rear-end collision with the preceding vehicle.

A prototype of the system was installed in 1993 at the request of the State Government to replace a driver aid system installed in 1974. Experiments were conducted to determine if the sign could be used to modify driver behavior for motorists exceeding the speed limit.[28] A motorist traveling more than 10 km/h over the 110 km/h speed limit was given a message displaying their speed and reminding them of the speed limit. The dynamic sign system resulted in a reduction of 60 percent of the vehicles traveling in excess of the speed limit. The system had a temporary effect in reducing speeds. At 300 m downstream, there was no reduction in speeds.

Currently data are being collected to conduct an accident evaluation of the system. Extensive data on the number of fog days at various locations (1 to 14 per month), the number of fog hours per year and by season of the year, and accidents by type, fog condition, and time of day, have been collected. There is no enforcement associated with the system at this time.

Safe-T-Cam System

The Safe-T-Cam system was installed in New South Wales to monitor heavy vehicle driver behavior and improve safety.[29]

A pilot study was conducted to demonstrate and further develop the technology. After four years of development, the system is now ready for deployment. A contract has been signed to install 20 sites across the State at a cost of approximately $200,000 to $250,000 A ($150,000 to $188,000 US) per site. The contract also included the establishment of a central monitoring and control center. The total cost, including development, communication links, and the control center is $13 million A ($9.8 million US).

The operation of the system involves the following steps:

- A video camera detects moving vehicles and classifies them by size and shape.
- When a vehicle meets a certain size and shape criteria, i.e., a heavy vehicle, a low-powered infrared flash and a high-resolution digital camera takes an image of the front of the vehicle.
- The digital image is processed to read the vehicle license plate. The location, time, and license number are transmitted to the central traffic management center and compared to the licenses in the data base. If the vehicle is exceeding the travel speed or the license information is suspect, the information is transmitted to the report center for further action.

The system employs two cameras. The first takes a digital image which is immediately processed to separate trucks from light vehicles. The arrival time of the truck is also noted and the second camera is triggered to capture an image of the license plate on the front of the truck. The driver is not photographed.

An optical scanner reads the license plate number and enters the number in the computer. At the control center, the number is checked to see if the registration is current. If not, action can be taken. Currently, only letters are sent to the vehicle owner; however, it is hoped that future legislation will allow the imposition of a violation and fine.

Each time a truck license plate number is captured at a location, it can be compared with truck information recorded at an upstream Safe-T-Cam location. Based on the travel time between the two stations, the average speed of the truck is calculated and compared to the speed limit. Currently, only letters are sent to the registered owner for speed violations. At this time, penalty citations are not issued for speeding; however, the issue will be addressed during the next session of Parliament. Legislation to make exceeding the average speed a violation is also pending in Parliament.

Another potential use of this technology is the ability to monitor the commercial driver's hours of service. A vehicle that continues to be operated beyond the maximum driving time can be contacted, the driver's logs inspected, and appropriate enforcement action taken.

If the necessary legislation is enacted, the Roads and Traffic Authority believes the fines collected will greatly exceed the system costs. Based on data collected at two test sites, it is estimated that $10 million A ($7.5 million US) per year in lost revenue occurs due to unregistered commercial vehicles. In addition, $1 million A ($0.75 million US) per year would be generated by fines for speeding.

The enforcement potential of this system is as yet unresolved in Australia. Privacy issues have arisen, as well as the concept of citing drivers for speeding based on average speed. It is expected that these same concerns will arise in the United States.

NLIMITS

NLIMITS (New South Wales speed limits) is the name for a PC-based expert system designed to assist regional road authorities to select appropriate speed limit values for various roadway and traffic conditions.[30] The computer program is an advisory system that uses knowledge from experts to set the speed limit based on traffic, environmental, and safety factors. The decisions produced match, as closely as possible, the decisions that experts would make in analyzing similar locations. The primary objective of the program is to provide uniformity and consistency, i.e., the same speed limit for similar conditions.

NLIMITS consists of a series of menus which prompt the user for information about roadside development, number of lanes, divided or undivided, median width, etc. Length of speed zone, accident experience, special activities, e.g., school environment, alignment, and 85th percentile speeds are also entered. The program produces an advisory speed limit value. The system is programmed to not allow a speed limit that is higher than the general speed limit established for the category of road being studied. The results of the program are not intended to be automatically adopted, but simply to serve as an aid to the engineer. In the future, a data base will be established that will keep track of the computed value from NLIMITS compared to the actual value authorized by the Roads and Traffic Authority. In the vast majority of cases, the program recommends a speed limit within 5 km/h of the 85th percentile speed.

The Roads and Traffic Authority sees significant benefits to using NLIMITS because it provides an objective method to a somewhat subjective process. It is a useful tool for staff members who do not have many years of experience. There appears to be good potential for adopting the NLIMITS concept in the United States.

VLIMITS

VLIMITS (Victoria speed limits) was the original expert system developed by the Australian Road Research Board to be used as an advisor for setting speed limits in Victoria.[31] Development of the system began in 1987, following a decision by the Victoria Speed Management Task Force that the current Speed Zone Index system was inadequate. VLIMITS has gone through several revisions to improve the knowledge base and operating environment. A Windows-based version of the program is currently being developed.

VLIMITS is used in Victoria to calculate a speed limit for each location under study. The speed limit value from the program is advisory; however, any deviation from the value must be clearly documented by the traffic engineer.

Plans are underway to develop a system in Queensland (QLIMITS) and New Zealand (NZLIMITS). The long term desire is to have one system in Australia (AUSLIMITS). A similar system has also been developed in British Columbia, Canada.

The cost to develop VLIMITS in 1988 was $50,000 A ($37,500 US), and NLIMITS was developed for $70,000 A ($51,800 US).

Traffic Calming

The results of opinion polls in New South Wales indicate people want speed limits to be appropriate for road and traffic conditions. Generally, they want lower speed zones near schools and shops (47 km/h on average), and in residential areas (48 km/h on average). In order to achieve lower operating speeds in residential areas, traffic calming techniques such as speed humps, diverters, roundabouts, etc., are installed. These techniques are frequently included in city and local road safety plans.[31,32]

While the general urban speed limit of 60 km/h applies to most roadways in urban areas, other lower speed limits have been established for special urban environments as listed below:

- 10 km/h in shared traffic zones, i.e., bikes, pedestrians, etc.
- 20 km/h in special zones, i.e., recreational areas.
- 30 km/h in special zones, i.e., recreational areas.
- 40 km/h in local traffic zones and in school zones at certain times.

The term "traffic calming" is usually associated with 40-km/h zones. Traffic calming techniques are physical changes in the road alignment, cross-section, or profile that are intended to physically force motorists to drive at slower speeds. Typical examples include speed humps at pedestrian crossings or at mid-block locations, centerline realignments caused by curb extensions and painted channelization, and small roundabouts constructed at intersections. "Wombat crossings," speed humps combined with curb realignment, are used at school locations.

Traffic calming techniques are usually applied in local residential areas where through traffic is discouraged. Substantial cooperation between community officials and residential groups is needed when pursuing a Local Area Traffic Management plan, which includes traffic calming devices and a 40 km/h speed zone.

There are some disadvantages with these measures. Some residents adjacent to the speed humps and centerline realignment sites complain about the noise caused by decelerating and accelerating vehicles. In one neighborhood, the traffic calming devices were removed following citizen complaints. Sometimes residents are disappointed with the results, which are less than their expectations. Generally, the majority of residents like traffic calming techniques. In New South Wales, requests for application of traffic calming methods exceed the funds available.

The Road and Traffic Authority in New South Wales is supportive of establishing and evaluating the effectiveness of Local Area Traffic Management plans in residential neighborhoods. Experience in Victoria is similar to that in New South Wales.

Traffic calming techniques are beginning to be used in the United States.[33] Possible disadvantages of the devices for implementation in the United States include:

- In snowbelt States, there may be problems with plowing operations due to the curvilinear curbs and raised crossings.

- Liability with the raised crossings is also a concern as the curbs are fixed objects. In addition, narrowing the roadway produces a lower design standard which may be viewed as counterproductive to safety.

Red Light Cameras

Red light cameras at signalized intersections have been used in Australia since 1979. The cameras are presently used in New South Wales and Victoria, and in several other States. In Victoria, 35 cameras are rotated among 132 sites in the Melbourne metropolitan area. A fixed sign displaying the message "Red Light Camera Ahead" is posted in advance of each intersection where cameras are used. The cameras are usually installed at high-accident intersections or other locations where motorists have been observed running a red light.

Failure to stop at a red light results in a fine of $165 A ($122 US) and three demerit points.

The consensus of evaluations is that red light cameras reduce the incidents of running the red light by 35 to 60 percent.[34] An evaluation of the reported accidents indicates a 6.7 percent reduction in total intersection accidents and a 10.4 percent reduction in injury accidents. It is also interesting to note that right-angle accidents were reduced by 32 percent, right-angle turning accidents decreased 25 percent, and rear-end accidents decreased by 30.8 percent. A 28.2 percent increase in rear-end turning accidents was also found.

A recent evaluation of the red light camera program in New South Wales found that right-angle and right-turn-against accidents decreased by 50 percent. However, rear-end accidents increased between 25 and 60 percent at the red light camera sites.

Perceptual Countermeasures for Managing Speed

Perceptual countermeasures for managing speed include changing the road environment to influence driver behavior. Typically, the treatments are low-cost modifications such as pavement markings, road edge markers, etc.

Researchers at Monash University are currently conducting vehicle simulator studies and field studies of several low-cost perceptual countermeasures.[35] The treatments being considered include various edgeline and centerline markings, transverse road markings and rumble effects, and several special treatments using road chevrons. The program began in 1995 and is scheduled to run for several years.

Local Council Safety Campaigns

In 1993, the Roads and Traffic Authority in New South Wales launched a program to bring highway safety engineering, enforcement, and education to local communities.[36] One difference between traditional local safety campaigns and the new program is that education and enforcement are combined with engineering techniques. In addition, a safety specialist is assigned to work with the local council on a full-term basis to develop and implement the program.

These safety efforts are funded for the first year partially by the Federal Government and partially by the State government. The local council is expected to share in the cost for the second year, and to eventually cover the total cost of the program. Sixteen of the seventeen local councils in New South Wales have accepted their financial responsibility in their second year.

Once the local safety office is established, the Roads and Traffic Authority provides a supportive role, much like the operation of the Technology Transfer (T^2) Centers in the United States. The local safety offices generally consider all safety problems, including speed management. The decision concerning which education, engineering, and enforcement methods to employ is left to the local council and the safety official assigned to that council. The program goals and safety targets are also decided at the local level.

The Local Council Safety Campaign objectives include:

- Continue to develop community ownership and participation in road safety.
- Extend the development of an integrated framework in local government areas for road safety planning and action.
- Define and meet local road safety targets.
- Establish and/or expand the budget within each local government area for road safety.
- Encourage further development of local road safety strategic plans.
- Increase the number of local councils participating in the project.

School Road Safety Education Program

New South Wales has an innovative and aggressive road safety education program for pre-schoolers, students, parents, and teachers.[37] The training program targets in excess of 4,500 learning centers and approximately 1.1 million students. The major elements of the program include:

- Development of a curriculum policy and syllabus.
- Development of curriculum materials of road safety subjects.
- Implementation of the curriculum.

Advisors provide support for classroom teachers, promote the development of the road safety policy for schools, support the integration of road safety materials into the state-wide curricula, and develop and conduct in-service training. Actual delivery of the road safety material to the students is the classroom teacher's responsibility.

The unique features of the program include integrating road safety materials into the learning process at an early age. The objective is to prevent future safety problems.

Speed Management Information Campaigns

As part of the speed management strategy in New South Wales, extensive use is made of television, radio, and print media in developing public relations and providing educational materials to the public.[38,39] The information campaigns concerning speeding are conducted periodically as part of the overall safety management plan. The primary education goals of the campaign are to achieve a situation where:

- Speeding is not a major factor in crashes.
- Drivers comply with speed limits.
- Drivers travel at speeds appropriate for prevailing conditions.

In addition to specific speed-related campaigns, public opinion polls are commissioned to obtain citizens' attitudes.

In Victoria, the Transport Accident Commission has had heavily funded road safety advertising on television since 1989. The goal of the advertising, which is usually targeted to a specific group, is to provide information that will prevent future accidents.

Based on the results of public opinion polls, the most effective advertising was found to include the following items:

- Be as emotional as possible.
- Be as shocking as you like.
- Leave people thinking "this could happen to me."
- Emphasize the link between behavior, i.e, speeding, and accidents.

An evaluation of the effects of television advertising indicated a clear link between the level of publicity and reductions in crashes related to speed and alcohol enforcement programs.[40]

Other Safety Measures

While visiting Australia, the team observed other safety measures which, although not related to speed management, are worth mentioning.

Bus lane cameras are installed in Melbourne on roadways where a lane is reserved for buses, transit bicycles, or trucks. The cameras photograph vehicles that unlawfully use these lanes. As in the case of the speed and red light cameras, the infringement notice is sent to the owner of the vehicle. The penalty for unlawfully using a priority lane is $75 A ($55 US).

VicRoads has developed a *Road Safety Review Manual,* which provides detailed checklists for conducting road safety audits for all highway projects.[41] Road safety audits are conducted during all phases of the project, including planning, design, and construction, and on maintenance and rehabilitation projects. The purpose of conducting safety audits is to ensure that safety is being considered from the inception to the completion of the project.

5.5 General Observations and Conclusions

The implementation of a comprehensive speed management program in New South Wales and Victoria has been highly successful in reducing excessive speeding and serious accidents over the short term. It is too early to determine the long-term effects.

The success of the speed management program is attributed to the following factors:

- Communication, cooperation, and involvement by the road safety officials, the police, and the public.
- Establishment of speed limits that are reasonable and consistent with the roadway geometry and driver perception.
- Legislation that makes the owner of the vehicle responsible for the infraction.
- Appropriate fines and penalties for excessive speeding.
- Continuing public information campaigns and school programs.
- Continuing evaluation and monitoring of speeds, crashes, and public attitude.

The use of research to identify target audiences, problem locations for engineering, and enforcement actions is a major part of the program.

Enforcement deterrents must be an element in the overall program. It is not possible to determine whether the high level of enforcement used in Victoria leads to better long-term behavior than the New South Wales program. However, short-term speeding behavior is altered with this high level of enforcement.

6. Findings and Transferability to The United States

Based on the findings of the Speed Management and Enforcement Technology scanning review in the Netherlands, Germany, Sweden, and Australia, much has been learned that can be applied by Federal, State, and local governmental agencies in the United States. A summary of the team's findings is given below. Additional information on specific speed management strategies can be found in the country summaries.

6.1 Speed Management

General Framework for a Speed Management Program

For any jurisdiction to be successful in addressing speed-related problems, there must be a clear vision of how speed will be managed. This vision must be shared by all participants. The public, road users, police, the courts, traffic safety specialists, road engineers, and others must know their role and responsibilities as they relate to the jurisdiction's vision of speed management.

For a speed management program to be successful, the following components are essential:

- The speed-related safety problem must be clearly identified and effectively communicated to everyone involved, especially the public. Quantitative goals for the program should be established and revised as needed.
- The strategy or methods selected for implementation must have the potential for solving the problem.
- Engineering, enforcement, and educational speed management techniques must be integrated and coordinated. No single technique can effectively accomplish the goals of the program.
- The plan must be fair and reasonable to the majority of road users, e.g., speed limits should be viewed as reasonable to the majority of drivers and be consistent for similar roadway and traffic conditions.
- Implementation must be augmented with a continuous ongoing evaluation program to monitor and determine the effectiveness of the management techniques.
- The plan must be flexible and change when safety conditions merit.

- The road safety community must work with legislators to insure that the necessary legislation is enacted and revised, as needed, to accomplish the speed management goals.

- Through each phase of the program, all participants must be kept informed and involved, especially the public.

From initiation, the speed management plan should emphasize unity of purpose and objective and foster coordination and cooperation. In particular, a coordinated approach to tactical planning of enforcement operations within an overall deterrence strategy appears to offer the greatest potential for achieving one of the key objectives of any speed management plan: a reduction in inappropriate speeds and speed-related crashes.

Borrowing from Australia's highly successful approach to strategic planning of speed management, any strategy selected should be based upon a general deterrence approach to behavior modification through a program involving public education, attitude change, special visible enforcement, and targeted promotion. This approach should be accompanied by continued development of appropriate engineering and legislative actions.

The strategy must be consistent, using proven highway safety methods and technology. The major components of the plan should include:

- **Long-term framework**—Public education through extensive advertising to address beliefs and attitudes and provide a rational basis to encourage change is essential. Continuous monitoring of knowledge and attitudes is important.

- **Medium-term reviews**—Examination and rationalization of the process, procedures, and practices, i.e, appropriateness of speed limits, engineering, penalties, etc., must be conducted to improve speed management efforts.

- **Short-term initiatives**—Special targeted enforcement activity, with appropriate warnings and action and associated publicity, is necessary to reinforce particular safety issues. Monitoring and evaluation of program effects is imperative.

Specific Speed Management Methods

Specific speed management methods that can be incorporated into a comprehensive speed management program are given below. The findings related to enforcement technology are given in the next section of this summary.

Realistic Speed Limits

A prerequisite to developing any effective speed management program is to establish realistic speed limits to match roadway design and area characteristics. The relationship between speed limits and the roadway environment must be credible and consistent. If speed limits are viewed as unrealistic for prevailing conditions by the majority of road users, the plan is doomed to failure. A knowledge-based expert system such as the VLIMITS or NLIMITS developed in Australia would assist engineers in selecting realistic speed limits. The study team agreed that modification and application of the system in the United States should be considered.

Variable Speed Limits

Flexible speed limits and warning displays that can be varied to match traffic and environmental conditions, including fog, have been in use for over 30 years. Experiences with variable speed limits on motorways in the Netherlands and on autobahns in Germany indicate that traffic flow can be improved, e.g., a 5 to 15 percent reduction in travel time has been reported. Accident reductions of 25 to 50 percent have also been achieved with these systems.

In view of the substantial traffic flow and safety benefits, the study team recommended that the concept should be transferred to the United States and implemented. Because variable speed limit systems cost between $0.4 and $1 million US per km, the system should be implemented in areas where environmental and/or traffic conditions result in significant fluctuations in the desired speed.

Differential Speed Limits by Vehicle Type

Differential limits for cars and trucks are used in most countries. For example, general speed limits of 110 and 120 km/h for light vehicles were used in the countries visited, except for German autobahns, which have no posted limits. General speed limits for heavy vehicles are typically 80 km/h.

Differential speed limits can lead to large differences in speed which may have adverse safety effects. No studies have been conducted in the countries visited to determine if the effects are real or imagined. There is not enough evidence at this time to suggest application of differential speed limits by vehicle type in the United States.

Speed Governors on Heavy Vehicles

As of January 1995, the European Union countries have required speed limiters on all heavy vehicles. It is too early to tell if speed differences between heavy vehicles and other road users will lead to safety problems. This technology could be implemented on heavy vehicles in the United States.

Traffic Calming Techniques

Speed humps, roundabouts, lane narrowing, and other traffic calming methods were employed to reduce vehicle speeds in residential areas in the countries visited. These measures may be applicable for many areas in the United States. Some localities such as Howard County, Maryland, have already implemented residential traffic calming.

Although experience indicates that traffic calming techniques are effective in reducing vehicle speeds, there are concerns with using these methods. Plowing difficulties may be encountered in heavy snow areas due to the raised curbs and humps. Also, the majority of residents in the area must be informed about and agree to the implementation. Because the calming techniques physically reduce vehicle speed, response times by emergency medical and fire vehicles may be reduced. In addition, the narrow lanes and curbs are fixed objects, which may invoke legal liability concerns in some communities. Finally, funding may be a problem if a number of communities within a jurisdiction elect to install traffic calming. Road agencies with limited funding may have to install the methods on a priority basis.

Speed Limits Based on Driver Perception

Perceptual techniques, i.e., road narrowing through pavement markings, tactile strips, etc., give the driver visual indications that the roadway is intended for lower speed operations. Experience in the Netherlands on rural roads indicates that these methods can reduce vehicle speeds by 5 to 10 km/h and reduce accidents by 35 percent.

The major problem envisioned with using these methods in the United States is liability. Throughout most of the road building history in the United States the practice has been to design and construct highways with wide lanes, recovery areas, and clear zones to improve safety. The use of perceptual techniques tends to run counter to current design and safety standards. Further research is suggested before implementation of perceptual techniques can be recommended.

Public Education and Information

The importance of educating and communicating information to the public regarding speeds, accidents, and speed management measures can not be overemphasized. Several innovative education and information techniques were found in the countries visited. For example, in the Netherlands, Germany, and Australia, specific safety messages are conveyed to high-risk groups (based on their accident involvement) through rather unconventional methods, e.g., music and sports figures were used to relay safety concepts to teenagers. In New South Wales, traffic safety curriculums have been developed and introduced into all grade levels in secondary schools. The safety materials are presented by the teachers along with other subjects such as mathematics and science. In Victoria, multi-million dollar advertising campaigns are used to convey safety messages to the public and to measure attitudes. Consideration should be given to employing, wherever possible, these educational techniques in the United States.

6.2 Enforcement Technology

The Europeans and Australians appear to make more use of enforcement technology in comparison to jurisdictions in the United States, particularly photo radar and red light cameras. Law enforcement personnel in both Europe and Australia have been trying to find more efficient ways of using existing technology without increasing personnel.

In the European countries visited, enforcement of traffic laws appears to be secondary to deterrence, as voluntary compliance is promoted through heavy educational campaigns. Education is also a major component of the Australian approach to speed management, but it is done in concert with legislation and enforcement. While all countries visited attempted to change attitudes and behaviors through education, the Australians also place strong emphasis on enforcement to deter inappropriate speeding behavior.

Using existing enforcement technology more effectively without increasing personnel has important implications in the United States. Specific enforcement technology and deployment methodologies that may be applicable in the United States are summarized below.

VASCAR (Visual Average Speed Computer and Recorder)

VASCAR was used to differing degrees in all countries visited. Based on conversations with officials during the scanning review, it appears that VASCAR is deployed in the same manner in which it is used in the United States. In the enforcement district surrounding Gothenburg, Sweden, VASCAR is the primary enforcement tool. All new police vehicles in Gothenburg are equipped with VASCAR.

Radar (RAdio Distance And Ranging)

Moving and stationary radar was used in all countries visited in a manner similar to how it is used in the United States. In New South Wales, Australia, radar was the primary enforcement tool. It is interesting to note that all radar in the State is mounted outside the police vehicle to eliminate the potential of injury to the officer in case of an accident and to eliminate unnecessary exposure of the officer to radar microwaves, believed by some to cause cancer.

Lidar (LIght Distance And Ranging)

Lidar, often referred to as laser, is used or being reviewed in each country visited. For example, the enforcement area surrounding Gothenburg, Sweden, had four laser units available for approximately 100 traffic officers. Contingent upon funding, New South Wales, Australia, plans to purchase as many lasers as they can for use by their 1,000 traffic officers. The lasers being used and those under consideration for use are all made by American companies.

Photo Radar

Photo radar was used in some manner in all countries visited. In the Netherlands and in New South Wales, Australia, photo radar was used as an enforcement tool. In Victoria, Australia, widespread use of photo radar was employed as a general deterrent. Because photo radar substantially increases police visibility without the need for additional personnel, the team recommended this technology be considered for use in the United States. Although photo radar can be deployed without human intervention, in all countries visited it was used with an officer present. The reason for this deployment strategy is to remove the impression that it is used only to generate revenue. In addition, an officer witnessing the infraction provides additional evidence for prosecutors.

Photo radar was successfully and extensively used in the Netherlands and in Australia primarily because legislation was enacted that permitted issuing citations to the vehicle owner and not to the driver. Photo radar was not successful in Germany and Sweden because their laws require that tickets be issued to the driver. Current photo radar technology does not consistently and reliably identify drivers.

It is important to stress that photo radar must be used in conjunction with a comprehensive and coordinated speed management program such as the one outlined above. For additional details on successful implementation of photo radar, the reader is encouraged to examine the summaries on the Netherlands and Australia.

Red Light Camera

Although not directly related to speed management, red light cameras were used in the countries visited to improve safety at signalized intersections. Typically, the cameras were installed at high-accident intersections or at locations where drivers were disobeying traffic signals. Experience with red light camera installations in the Netherlands and in Australia indicate that this technology can reduce incidents of running the red light by 35 to 60 percent. Furthermore, reductions in right-angle accidents of 32 percent have been reported. In order to effectively use red light cameras, it is necessary to have legislation that permits issuing tickets for infractions to vehicle owners. Because of the beneficial safety effects of red light cameras, the U.S. DOT has initiated a red light program for local governments. Additional application of this technology is recommended.

7. Acknowledgments

The study team is grateful to all the transportation ministries, researchers, and private firms in the Netherlands, Germany, Sweden, and Australia for their warm hospitality and for generously sharing their time, expertise, and information.

Special acknowledgment is due the hosts for arranging presentations and scheduling site visits. Some of the individuals who deserve special mention are Mr. Jan Bustra, Office of Road Safety, Ministry of Transportation, the Netherlands; Dr. Jürgen Behrendt, Ministeriaiart, Federal Ministry of Transport, Germany, and Dr.-Ing. R. Ernst, Head of Traffic Engineering, BASt, Germany; Mr. Göran Nilsson, Chief Researcher, and Mr. Gunnar Andersson, Senior Researcher, Transport Safety Analysis, Road and Transport Research Institute, Sweden; Mr. Ray Taylor, General Manager, Road Safety Development, and Mr. Peter Croft, General Manager, Road Environmental Safety, Roads and Traffic Authority of New South Wales, Australia; and Mr. Geoffrey H. Westcott, Executive Officer, Parliament of Australia, Mr. David T. Anderson, General Manager, Road Safety, VicRoads, and Mr. John G. Bodinnar, Superintendent, Traffic Camera Office, Victoria Police, Victoria, Australia.

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Appendix A: Speed Management and Enforcement Technology Questionnaire

Speed Management

1. How are speed limits established? Do standards exist on how speed limits should be established? Is the design speed of a roadway and/or roadside development a specific factor in the establishment of speed limits? Do different speed limits exist for commercial vehicles or for different weather conditions?

2. Are there national speed limits or are speed limits a local responsibility?

3. Once a speed limit is established, is it routinely reviewed to insure it is still appropriate? If so, please describe the process.

4. Can private citizens request a review or alteration of an existing speed limit?

5. Do you routinely collect speed data? For what purposes?

6. What are the penalties and/or fines when convicted of a speed limit violation?

7. With respect to violations, are speed limits considered absolute or prima facie? What, if any, tolerances are given by law enforcement officials when enforcing the speed limit?

8. Are commercial vehicles targeted for special speed enforcement programs?

9. Are speeding penalties higher for commercial vehicles?

10. How is speeding defined? How was the speeding problem identified? How many accidents, injuries, and fatalities are associated with speeding? How was speed data defined and collected? How is speeding perceived by the citizens, the courts, enforcement agencies, and law enforcement?

11. When a section of roadway is identified as a "speed-related " problem area, is active enforcement increased or are other passive means (e.g., enhanced signing) utilized instead?

12. Could we obtain a copy of relevant accident report forms?

13. Were the relationships between speed and accidents/injuries/fatalities established before the program was implemented? How long did it take to accurately identify the problem? How is the speed of the accident-involved vehicles obtained?

14. In investigating traffic accidents, do you list causative factors/contributing factors (i.e., speeding, drinking, etc.)? If so, do you list multiple causes in some priority order? If so, could we obtain a copy of the priority order?

15. Have any policies been established to try and manage speed?

16. Have these speed management programs been implemented on a national or local level? Have these programs targeted specific areas such as school zones, residential areas, etc.?

17. How many alternatives were considered as solutions? How many were tried before the "successful" one? What were the results of the programs and how were they determined to be "successes" or "failures"?

18. How comprehensive were the programs? Did they include engineering (setting of speed limits), enforcement, and public education/information? Were all these aspects of the program identified at the start or did some evolve with the program implementation?

19. Were there any political/social issues? Was any legislation required to initiate or operate the speed management program? If so, please describe the required legislation and the process to have the legislation enacted.

20. Were any attempts made to inform or educate the court system about the effects of speed on accidents or the public benefit of the program?

21. What type of community participation was required or identified? What were the issues in getting participation from the various interested parties?

22. What part did technology play in developing and implementing the speed management program? Did you use off-the-shelf technology? Was there much competition for the technology? Did the project encourage/enhance technology development and deployment? Has technology improved?

23. How were test sites selected (if at all)? Please discuss the logistics of bringing all the pieces of the process (engineering, education, information, enforcement) together.

24. What operational and/or program issues were identified during the course of implementing the program?

25. If you used public service announcements as part of a speed management program, please describe the process of having these announcements developed and aired.

26. Were special segments of the population specifically targeted in any anti-speeding campaign?

27. What types of evaluations of the speed management program were planned and/or conducted? When during the process were the evaluators included in the process?

28. What has been the public's reaction? How is it measured? Has behavior changed, i.e., has the problem been solved?

29. Are there plans to expand the applicability of the speed management program?

30. Has there been any application of variable speed limits? If so please discuss, including any evaluations.

Enforcement Technology

1. Within the enforcement community, what priority is given to speed enforcement in relation to other traffic safety issues? For example, in one State Patrol, the priority for traffic violations is as follows:

   a. Drunk-driving violations.
   b. Hazardous moving violations.
   c. Seat belt violations.
   d. Speed violations.
   e. Driver license violations.
   f. Equipment violations.
   g. Vehicle registration violations.
   h. Other violations.

2. How do you envision enforcing speed violations in 5 years/10 years? Do you envision speed enforcement will receive higher or lower priority in the future? Please explain.

3. What is your most successful means of speed enforcement?

4. What types of detection methods are available for (1) speed limit enforcement; (2) compliance with traffic control devices; (3) HOV enforcement; and (4) other traffic enforcement?

5. What are the initial costs of equipment and installation?

6. What are the annual maintenance costs for the equipment identified?

7. What are the operational experiences for each type of equipment?

   - How much training is required?

- Who is trained?
- What kind of certification is available for accuracy and performance specifications?
- What is the calibration process?
- Is repair and service support available?
- Can equipment be operated by one person?
- Is equipment compact and portable?
- Can equipment be easily deployed?
- In what range of temperatures will the equipment operate?
- Will equipment withstand exposure to the elements?
- Is equipment capable of monitoring at least two lanes of traffic simultaneously?
- Does photo system have an automatic exposure control?
- Can system record information on all vehicles passing though the enforcement area, not only those detected in violation?

8. What are the experiences of using still cameras v video?

9. Are CB radios effective in avoiding photo radar installations?

10. Does photo radar adequately identify commercial vehicles for enforcement purposes? What are the legal issues associated with the operation of automated enforcement equipment? Have there been any problems in prosecuting and adjudicating automated violations/citations? Are automated violations/citations easier to prosecute than those issued by officers? If so, please explain.

11. What is the experience with public acceptance?

12. How do you process speed violations detected and documented by automated methods (e.g., photo radar), when the violation is committed by a vehicle with a foreign registration? or a rental vehicle?

13. Where automated methods are used, how much enforcement is done with this technology v how much is done by traditional methods using traffic/police officers? (e.g., 40% automated v 60% with police officers; 12 automated sites v 180 traffic/police officers).

14. Does any revenue generated as a result of speed violations go back into the speed management program, including equipment? If so, please explain. How is this perceived by the public (i.e., are citations viewed as issued only to generate revenue)?

15. Could we obtain a summary of enforcement and accident statistics to include:

    - Three-year history of fatalities, injuries, and accidents?
    - Three-year history of the number of citations issued by officers and issued by automated equipment.

Appendix B: Individuals Contacted by the Study Team

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Appendix C: Study Team Biographical Information

Janet A. Coleman, Chairperson of the Speed Management Panel, is the leader of the Speed Management and Strategic Planning teams in the Federal Highway Administration's Office of Highway Safety. The Office of Highway Safety is responsible for establishing U.S. safety policy and for providing assistance to the States in the area of highway safety. Ms. Coleman has been with the FHWA for 27 years and has worked in various areas of safety research. She headed the FHWA railroad-highway grade crossing research program and served as Branch Chief for the State and Local Programs Branch in the Office of Technology Applications prior to coming to the Office of Highway Safety. As Branch Chief in the Office of Technology Applications, Ms. Coleman was responsible for administration of a nationwide network of 55 technology transfer centers to provide training and technical assistance to small, local and, Indian governments. Ms. Coleman holds Bachelor's and Master's Degrees in Mathematics from Boston College.

Raymond D. Cotton holds the rank of Major and is Commander, Commercial Vehicle Enforcement/Automotive Safety Enforcement Division, Maryland State Police. Major Cotton is a 27-year veteran of the Maryland State Police. His past assignments included Staff Assistant to the Superintendent; Acting Director of the Maryland State Police Crime Laboratory; Special Operations Bureau staff; Northern Troop Commander; and Commander of Traffic Programs Planning Unit, where he managed various statewide highway safety programs, including speed enforcement programs. He currently serves on the Governor's Motor Carrier Task Force on Safety and Uniformity, and the Commercial Vehicle Safety Alliance Driver/Traffic Enforcement Committee. He has served on various National and State highway safety committees. Major Cotton has a Master's Degree in Special Studies from George Washington University and a Bachelor's Degree in Criminology from the University of Maryland. He is also a 1981 graduate of the Police Administration Program at the Northwestern University Traffic Institute, Evanston, Illinois.

Rod Covey is a Lieutenant Colonel with the Arizona Department of Public Safety and is currently the Assistant Director, leading the agency's Highway Patrol Bureau. Colonel Covey manages a $35 million budget and oversees the activities of 705 Bureau personnel who are responsible for over 5,850 miles of roads throughout the State of Arizona. The Patrol Bureau enforces State, traffic, and criminal statutes, as well as State and Federal commercial vehicle regulations. It also investigates traffic collisions and conducts safety information programs. During his 18 years of service, he has held a variety of operational and administrative positions, including the State's Training Academy Director; the Public Safety Director's Chief of Staff; and the agency's government liaison. Colonel Covey has a Bachelor's Degree in Management from the University of Phoenix and is a graduate of the FBI National Academy. He serves on several State and Federal highway safety committees.

Douglas Graham is the Assistant Traffic Engineer for the New Hampshire Department of Transportation (NHDOT). The Bureau of Traffic is responsible for all signs, signals, and pavement markings on state maintained roads, which total approximately 4,000 miles. The Bureau also works closely with each of the District Maintenance Engineers in reviewing and establishing speed limits on the state system. Mr. Graham acts as traffic engineering liaison to the Division of Project Development for the design and construction of road and bridge projects. Mr. Graham began his career at NHDOT in 1978 in the Bureau of Construction and has been in his current position since 1989. He also is a representative for the Department on such committees as the Highway Innovative Technology Center (HITEC) Technical Evaluation Panel and the New England Transportation Consortium Technical Team. Mr. Graham has an Associate Degree in Civil Engineering from Vermont Technical College and is a Registered Professional Engineer.

Jim McCauley is a Transportation Specialist assigned to the Federal Highway Administration's Office of Motor Carriers in Washington, DC. Mr. McCauley has been with the FHWA and the Research and Special Programs Administration for a total of 15 years. He has served in a variety of division and regional positions, including Hazardous Materials Instructor at the Transportation Safety Institute and Drug Interdiction Program Manager. In his current position, he has been working in the State Programs Division, which is mainly concerned with distribution to the States of Motor Carrier Safety Assistance Program funds. His primary responsibilities include programs dealing with drivers' issues, such as Random Roadside Drug and Alcohol Testing, traffic law enforcement and hours-of-service. Mr. McCauley holds a Bachelor of Arts Degree from the University of Colorado.

Garrett Morford is a Senior Highway Safety Specialist with the National Highway Traffic Safety Administration (NHTSA), Police Traffic Services Division in Washington, DC. This agency is responsible for providing national leadership for traffic safety initiatives in the United States through technical assistance, technology, research and development, and other programs. Mr. Morford has held this position for 5 years. Prior to NHTSA, Mr. Morford spent 17 years with the Louisiana State Police, retiring as Deputy Commander of the Operational Development (Planning) Unit. Mr. Morford holds a Bachelor of Science Degree in Criminal Justice from the University of Southwestern Louisiana and is a graduate of the FBI National Academy.

Jeffrey F. Paniati is a Program Manager with the Federal Highway Administration's Office of Safety and Traffic Operations Research & Development in McLean, Virginia. Mr. Paniati has been with the FHWA for 12 years. He is a graduate of the three-year FHWA Highway Engineer Training Program and has completed a variety of field and division office assignments throughout the United States. As a highway research engineer, Mr. Paniati has been involved in a variety of traffic and safety research efforts, including new traffic control devices, advanced technologies for data collection, geographic information systems, safety analysis techniques, and safety data management. He is currently the program manager for the FHWA research program on highway safety and analysis technologies and methods. Mr. Paniati holds a Bachelor of Science Degree in Civil Engineering from the University of Connecticut and a Master of Science Degree from the University of Maryland. He is a Registered Professional Engineer in Virginia.

Martin R. Parker, Jr. is the Principal Research Engineer of a consulting firm that bears his name. Mr. Parker provides engineering services to Federal, State, and local government agencies in the fields of traffic operations and highway safety. Prior to his consultant experience, he served 18 years with the Virginia Department of Transportation, including positions in highway construction, traffic engineering, and as a research scientist with the Virginia Transportation Research Council. Mr. Parker received his Bachelor of Science and Master of Science Degrees in Civil Engineering from the University of Virginia. He is a Registered Professional Engineer in the states of Michigan and Virginia. He is a member of the Institute of Transportation Engineers (ITE), the American Society of Civil Engineers (ASCE), and the Transportation Research Board (TRB). He has published numerous highway safety reports and articles.

Hernan E. Peña, Jr. is the Assistant Director of the Department of Traffic and Transportation for the City of Charleston, South Carolina. Mr. Peña's department is responsible for all transportation functions with the City's public right-of-way, including administration, engineering, and planning to provide for a safe and efficient movement of people and goods. He has served with the Department of Traffic and Transportation for eight years, five years of which were in the capacity of Systems Engineer and three years in the capacity of Assistant Director. Mr. Peña holds Bachelor and Master of Science Degrees in Engineering and is the author of several technical papers on transportation engineering. He is a member of the Institute of Transportation Engineers (ITE) and was a member of the 1992 ITE Delegation that traveled to Japan and met with the Japanese government and private industry to evaluate the Intelligent Vehicle Highway Systems (IVHS) technology.

Michael L. Robinson is the State Traffic Engineer for the Minnesota Department of Transportation. The Office of Traffic Engineering is responsible for managing statewide policy and procedures for traffic signals, street and sign lighting systems, highway signs, pavement markings, safety research, and electronic/electrical maintenance. Mr. Robinson has 21 years experience with the Minnesota Department of Transportation, primarily in traffic engineering, including 7 years as District Traffic Engineer and the last 5 years as State Traffic Engineer. Mr. Robinson holds Bachelor and Master of Science Degrees in Civil Engineering and Transportation Engineering from Iowa State University. He is active in the programs of the Institute of Transportation Engineers (ITE), American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB).

William C. Taylor is a Professor of Transportation Engineering and Director of the Transportation Center at Michigan State University. Dr. Taylor has been active in traffic research for over 30 years, including serving as head of the traffic research division of the Ohio Department of Transportation. He currently is Chair of the Institute of Traffic Engineering Committee on speed zone guidelines. He is a member of the executive committee of the Research Center for Region 5 of the United States Department of Transportation, and is a commissioner of the Michigan Truck Safety Commission. Among his active research projects is the evaluation of the traffic impacts of the Intelligent Vehicle Highway Systems (IVHS) federal demonstration project in Michigan. Dr. Taylor has Bachelor and Master Degrees from Case Institute of Technology and a Ph.D. from Ohio State University.

Endnotes

1. National Safety Council, *Accident Facts*, 1995 Edition, Itasca, Illinois.

2. National Highway Traffic Safety Administration, "Fact Sheet—Speed," Washington, DC, 1994.

3. Ministry of Transport, "Long-term Policy for Road Safety," Public Works and Water Management, The Hague, the Netherlands, Spring 1991.

4. Ministry of Transport, "Annual Report Rijkswaterstaat 1993," Public Works and Water Management, The Hague, the Netherlands, 1993.

5. J.H. Hogema and A.R.A. van der Horst, "Evaluation of the A16 Fog-Signaling System with Respect to Driving Behavior," TNO Human Factors Research Institute, Soesterberg, the Netherlands, November 1994.

6. Transport Research Centre, "Motorway Signaling—New Initiatives Put Traffic on the Right Track," Rotterdam, the Netherlands, undated.

7. Ministry of Transport, "Towards a Better Use and Less Congestion," Public Works and Water Management, The Hague, the Netherlands, November 1994.

8. Oei Hway-liem, "Effective Speed Management Through Automatic Enforcement," Institute for Road Safety Research (SWOV), Leidschendam, the Netherlands, 1994.

9. Oei Hway-liem, "Speed Management on The Motorway A2," R-94-66, Institute for Road Safety Research (SWOV), Leidschendam, the Netherlands, 1994.

10. Federal Ministry of Transport, "Roads in Germany," Bonn, Germany, 1994.

11. *European Drivers and Traffic Safety*, "Social Attitudes to Road Traffic Risk in Europe," Presses Ponts et Chaussées, Paris, France, 1994.

12. Statistisches Buendesamt, "Verkehr," Bonn, Germany, 1993.

13. Straßenverkehrs-ordnungswidrigkeiten, "Tatbestandskatalog," Bonn, Germany, April 1993.

14. Ruediger Lamm and Juergen H. Kloeckner, "Increase of Traffic Safety by Surveillance of Speed Limits with Automatic Radar Devices on a Dangerous Section of a German Autobahn: A Long-Term Investigation," Transportation Research Record 974, Washington, DC, 1984.

15. Ministry of Transport, "Safety Through Flexible Speeds, Autobahn and Federal Highway Traffic Management Program til 1997," Bonn, Germany, undated.

16. Kåre Rumar and Lars Stenborg, "The Swedish National Road Safety Programme—A New Approach to Road Safety Work," Swedish National Road Administration, November 1994.

17. Gunnar Andersson and Göran Nilsson, "Speed Limits, Speeds and Safety," Swedish Road and Transport Research Institute, Linköping, Sweden, April 1995.

18. Swedish National Road Administration, "From Vision to Reality—Safer Night-time Driving with UV Light," undated.

19. S. Almqvist and M.Towliat, "Road Side Information Linked to The Vehicle for Active Safety—Aspen Track," University of Lund, Sweden, March 1993.

20. A. Lindkvist, M. Gistell, M. Weiman, and Peter Geen, "Evaluation and Results of Field Trials," Swedish National Road Administration, February 1995.

21. Roads and Traffic Authority, "Joint RTA/Police Road Safety Action Plan 1993/94," Sydney, New South Wales, Australia.

22. R. Ungers and T. Vincent, "How The Road Toll Can Be Managed," *Road and Transport Research*, Vol. 4, No. 1, March 1995.

23. Peter Croft, "Speed Management in NSW: An Overview," Roads and Traffic Authority, Sydney, New South Wales, Australia, November 1992.

24. John Bodinnar, "Securing Road Safety Through Synergy, Perception, and Images," Victoria Police Traffic Camera Office, Melbourne, Victoria, Australia, 1994.

25. Roads and Traffic Authority, "NSW Speed Management Program 1994-95," Sydney, New South Wales, Australia.

26. M. Cameron, S. Newstead, and P. Vulcan, "Analysis of Reductions in Victorian Road Casualties, 1989 to 1992," Proceedings of 17th Australian Road Research Board Conference, 1994.

27. Graham Brisbane, "Driver Behavior During Periods of Restricted Visibility," Proceedings of 16th Australian Road Research Board Conference, 1992.

28. Graham Brisbane, "Speed Modification—Intelligent Signs for the Future?" Proceedings of 17th Australian Road Research Board Conference, 1994.

29. Telstra, "Safe-T-Cam Heavy Vehicle Safety Monitor."

30. Deborah Donald, "NSW Speed Limits System: NLIMITS," Australian Road Research Board, June 1993.

31. Roads and Traffic Authority, *Traffic Engineering Manual*, Section 3—Speed Zoning, New South Wales, 1994.

32. VicRoads, *Traffic Engineering Manual*, Section 7—Speed Zoning Guidelines, Edition 1, Revision 2, March 1994.

33. C. Edward Walter, "Suburban Residential Traffic Calming," *ITE Journal*, Institute of Transportation Engineers, Washington, DC, September 1995.

34. Dominic Zaal, "Traffic Law Enforcement: A Review of the Literature," Monash University Accident Research Centre, Report No. 53, April 1994.

35. B.N. Fildes and J.R. Jarvis, "Perceptual Countermeasures: Literature Review," Monash University Accident Research Centre, Report CR4/94, November 1994.

36. Fairfield City Road Safety Action Team, "Fairfield City Road Safety Strategic Plan 1994 - 2000," November 1994.

37. Roads and Traffic Authority, "Educating the Next Generation of Road Users," New South Wales, Australia, May 1995.

38. Road Safety Bureau, "Advertising Media and Public Relations Requirements, Program Brief for Speeding Campaign," September 1994.

39. Roads and Traffic Authority, "Communication Strategies for a Speed Management Campaign," New South Wales Road Safety Bureau, Sydney, Australia, November 1992.

40. Max Cameron, et al., "Evaluation of Transport Accident Commission Road Safety Television Advertising," Monash University Accident Research Centre, Report No. 52, September 1993.

41. VicRoads, *Road Safety Review Manual*, January 1993.

List of Video Tapes

1. Telstra Applied Technologies, "Driver Advisory Fog Warning System," duration 9 minutes, U.S. format.

2. Telstra Corporation Australia, "Safe-T-Cam—An Innovative Image Capture and Identification System," duration 8 minutes, U.S. format.

3. Grey Advertising, Pty., Ltd., 10 Safety messages including a 60-second spot on speed cameras, U.S. format.

4. New South Wales Department of Transport, "Bus Zone—The Computer Game Video," duration 12 minutes and 30 seconds, non-U.S. format.

5. New South Wales Department of Transport, "The Safest Way: Safe Travel To and From School—A Guide for Parents and Carers," duration 10 minutes and 15 seconds, non-U.S. format.

6. Roads and Traffic Authority, "The Speeding Campaign," duration 23 minutes, non-U.S. format.

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Notice

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official policy of the Department of Transportation.

The metric units reported are those used in common practice by the persons interviewed. They have not been converted to pure SI units since, in some cases, the level of precision implied would have been changed.

The United States equivalents to the foreign currency amounts appearing in this report are based on the rates of exchange in effect during the time of the study tour.

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