POLICE ENFORCEMENT PROCEDURES FOR UNSAFE DRIVING ACTIONS. VOLUME II: A REVIEW OF THE LITERATURE

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Ann Arbor, Michigan 48109

December 1980

Prepared for
U.S. Department of Transportation
National Highway Traffic Safety Administration
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16. Abstract

Literature on police enforcement procedures directed at the unsafe driving actions (UDAs) of speeding, following too closely, and driving left of center was reviewed. Speeding was emphasized in the review. The review presents and discusses literature describing police enforcement procedures for these UDAs, identifies legal factors that influence the use of the procedures by police agencies, considers the effects of the procedures on traffic safety and related variables, and identifies knowledge gaps that need to be filled by future research.

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Kent B. Joscelyn, J.D.
Principal Investigator

Ralph K. Jones
Principal Investigator

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CHAPTER ONE
INTRODUCTION

This volume, a review of the literature on police procedures for enforcing certain unsafe driving actions (UDAs), was prepared under National Highway Traffic Safety Administration (NHTSA) contract number DOT-HS-8-01827, entitled "Police Enforcement Procedures for Unsafe Driving Actions." The review is one volume of a three-volume final report of work conducted under this contract. The remainder of the final report is presented in "Volume I: Summary" and "Volume III: Field Studies." The project was conducted by staff of the Policy Analysis Division of The University of Michigan Highway Safety Research Institute.

The UDAs treated in the review are:

- speeding,
- following too closely, and
- driving left of center.

Much of the review concerns the speeding UDA because of the large traffic safety problem it creates nationwide and because of the great volume of literature that exists on speeding.

This review was conducted as a part of a joint effort supported by the police enforcement contract and another NHTSA contract of broader scope entitled "Identification of General Deterrence Countermeasures for Unsafe Driving Actions" (Contract number DOT-HS-7-01797). The part of the review that is applicable to countermeasures other than those employed by police agencies is presented in a separate volume to be published as a part of the final report of the general deterrence project.

The term "police enforcement procedure" as used in this review is defined as follows:

> A police enforcement procedure is a sequence of tasks performed by police personnel to deter drivers from committing UDAs.

This definition specifically excludes the process of designing tasks or sequences of tasks.

OBJECTIVES

The general objective of the review was to identify and discuss literature germane to three UDAs. Specific objectives were to:

- describe police enforcement procedures in terms of their objectives, activities, and resource requirements;
- identify legal factors that influence the use of the procedures by police agencies;
- determine the effects of the procedures on traffic safety and related variables; and
- identify knowledge gaps that need to be filled by future research.

This volume is one work product developed to support a larger analytic study. The report is a collation of the identified literature, and it is not intended as a critical review, analysis, or synthesis. It is designed as a tool to support analysis. The summary volume (Volume I) of this project presents analytical findings and more specific recommendations. A third volume contains information developed through telephone contacts and site visits with enforcement agencies and related organizations.

DEFINITIONS OF THE SUBJECT UDAs

As noted above, this review deals with three UDAs: speeding, following too closely (FTC), and driving left of center (DLOC). One of the first tasks of the review was to seek rigorous definitions of these UDAs. This search was not successful. Most studies either did not define the UDAs at all or defined them incompletely or ambiguously. Definitions that were found varied widely among the studies even though the same terminologies were often used.

To help fill this definitional gap, a substudy was intitiated to develop operational definitions of the three UDAs. Because the definitions were needed by the companion project on general deterrence countermeasures as well as by this project, the substudy was supported by funds from both projects and involved the staff of both projects. The detailed results of the definitional study are described in a separate volume to be published as a part of the final report of the general deterrence project (Jones, Treat, and Joscelyn 1980). A synopsis of the definitions is provided in Volume I of the police enforcement project.

SCOPE AND LIMITATIONS

Literature on police procedures for enforcing laws on all three UDAs defined above was sought in the course of the review. Despite an intensive search effort, **no pertinent literature was found for the DLOC UDA.** Further, **only one document was found on enforcement procedures for FTC**, although a few more documents describing the effects of police procedures for the speeding UDA on the FTC UDA were found.

Thus, with a few exceptions, this review deals only with the speeding UDA. This limitation is stated here as a ground rule to avoid distracting repetitions of it throughout the reivew. **Unless explicitly stated otherwise, all of the discussion in this document pertains to speeding.** Procedures for enforcing laws pertaining to both types of the speed UDA defined in Volume I of this report were sought in the review.

We found that the documents usually did not specify which type of speeding UDA was the target of a given procedure, but most seemed to be aimed at the absolute-speed UDA. When the target was a relative-speed UDA, the specific conditions under which a driving act was so classified were not stated in the report or article. The actual use of the 95th percentile criterion for determining when to initiate enforcement action for speeding was not reported in the literature. Nor was there any explicit mention of the use of traffic flow information for determining an enforcement threshold for relative-speed UDAs.

Finally, our review emphasizes more recent literature and discusses earlier literature to provide a historical perspective. Also, earlier work is discussed when there are no recent publications that cover a particular topic. Previously published reviews in one important area of research, the effect of enforcement procedures, are compiled separately in Appendix B for ready reference.

APPROACH

This review was a part of a larger review that addressed a wide range of countermeasures against the subject UDAs. In addition to the police enforcement countermeasures that are of concern here, literature on adjudication, social influence, public information, and citizen-participation countermeasures was reviewed. Theories, concepts, and factors influencing deterrence, driver decision-making, and risk-taking were also sought. This approach was essential for developing information for use in attacking the UDAs along a broader front, as required by the general deterrence project. However, it was also beneficial to the police enforcement project in providing more avenues to relevant material, thereby reducing the risk of overlooking documents of interest.

Literature on police procedures and their effects was sought from several sources, our own HSRI library being used as a source most frequently. Other major sources were the International Association of Chiefs of Police, the Criminal Justice Periodical Index, the National Criminal Justice Reference Services, the National Safety Council, the Northwestern University Traffic Institute, the Transportation Research Information Service, and the NHTSA library.

The documents obtained from these sources included police manuals, journal articles, research reports, articles in trade magazines, and sales brochures, among others. Most of the manuals described how to perform police traffic tasks such as approach a car, approach a driver, and write a citation. The articles and reports often contained descriptions of innovative or experimental police programs in cities, counties, or states, and sometimes described evaluations of police procedures. However, most documents did not contain an evaluation of the procedures described. There was little information on all aspects of a given procedure, and only one study (Darwick 1977) of police procedures for a UDA of interest (exceeding the 55 mph national maximum speed limit) attempted to document a range of procedures comprehensively.

One of the objectives of the review was to describe the resources used in given procedures. For our project, a particularly important resource was the equipment used by police to detect and "measure" UDAs. A wide range of measurement equipment was identified in the search, including radar, VASCAR, the Following Too Closely Monitor, the Visual Speed Indicator, ORBIS, vehicle sensing devices, closed-circuit TV, and high-speed cameras. Many of the documents describing this equipment included an assessment of it, instructions on how to use it, and its cost. A separate appendix listing and summaries of major source documents about equipment has been provided (Appendix D).

ORGANIZATION OF THIS VOLUME

The review is presented in two formats. The first of these is a narrative synopsis of relevant literature. This synopsis, the body of this report, is presented in five chapters, including this introductory chapter (Chapter One). Chapter Two discusses enforcement procedures within the context of the other functions of police traffic services. Two classes of procedures are treated: general-deterrence procedures and special-deterrence procedures. The former are aimed at creating a deterrent threat among drivers who are not actually apprehended for a traffic law violation, while the latter are concerned with deterring a special group of drivers who first must be apprehended for a violation. Legal factors that inhibit or preclude the use of certain procedures in some jurisdictions are also discussed in Chapter Two.

Chapter Three discusses empirical literature dealing with the effects of police procedures on three types of traffic variables: traffic flow variables, traffic crash variables, and traffic law violations. Each class of variables is examined with respect to general-deterrence procedures and special-deterrence procedures.

Chapter Four reviews literature on the allocation of police resources among enforcement procedures. The review identifies philosophies, policies, and strategies for assigning police manpower and equipment as functions of location, time, and type of procedure.

The last section (Chapter Five) summarizes the findings of the three preceding sections. It also presents the authors' conclusions about the overall state of knowledge in the field and makes recommendations for filling identified gaps in the literature.

The second format used in this review is a series of appendices that present information on types of literature. This format differs from that used in the body of the document, in that the information is organized by source document rather than topic.

Appendix A contains a tabular presentation of the descriptive literature on enforcement procedures and their effects. Appendix B lists and discusses a collection of empirical literature on the nature and effects of procedures.

Appendix C summarizes literature on police procedures for enforcing violations of a subclass of traffic laws that is of current interest, the 55 mph national maximum speed limit. Most of the documents in this appendix are descriptive and nonempirical.

Appendix D deals with measurement techniques and instruments used for enforcing laws on the subject UDAs. Each source document in this appendix is summarized in terms of the characteristic measured, the measurement technique, and the measurement method.

Appendix E summarizes representative statutes and court cases dealing with the legality of certain police enforcement tactics and the use of certain detection and identification equipment.

CHAPTER TWO
ENFORCEMENT PROCEDURES

This chapter of the review presents descriptions of police enforcement procedures for relevant unsafe driving actions (UDAs). The concern here is the "what" and "how" of enforcement procedures rather than their effect or value. Legal factors that affect the selection and use of procedures are also considered briefly. Literature on the performance and effectiveness of procedures and literature on the allocation of resources among procedures are discussed in later sections.

The literature describing operational procedures is surprisingly sparse. Most research reports and journal articles discuss procedures incidentally in the course of describing an experiment or "crackdown." We have found only one study with the explicit objective of identifying and describing relevant procedures, and that study was limited to one traffic law violation--exceeding the 55 mph national maximum speed limit (NMSL). The study was performed by the International Association of Chiefs of Police (IACP) under contract number DOT-HS-6-01345 with NHTSA and is reported by Darwick (1977). Because of its relevance to other speeding UDAs, the IACP study is cited extensively in this section, along with other literature that deals with enforcement procedures in a more peripheral way.

As will be seen, each procedure is made up of several component subprocedures. While the components are relatively few, possible combinations of them into full procedures are many. This section concentrates on components of procedures and discusses a few of their more common combinations as illustrations of full procedures. The discussion of specific procedures is preceded by a background discussion of the role of enforcement in police traffic services in general and traffic safety in particular.

ENFORCEMENT AND POLICE TRAFFIC SERVICES

Enforcement is one of the three most common traditional approaches to managing the negative effects of our nation's Highway Transportation Systems (HTS). Enforcement and the other two approaches, education and engineering, were at one time called the "three Es" of traffic safety. Enforcement, in this context, encompasses all police traffic services and is concerned with the day-to-day regulation of human behavior. As one authority put it:

> I am sure, of course, that traffic law enforcement is at least one of the most important activities by which we can deal effectively with the motor vehicle traffic problem and reduce accidents and losses. (Ashworth 1959, p. 22.)

This same writer also recognized that the reduction of accidents is an extremely complex problem and that there is no one "simple answer" that will solve this problem. As he stated:

> I am equally sure that police enforcement cannot do the job that must be done all by itself. In fact, it now seems clear that the role of enforcement and the influence of enforcement tend to change, from time to time and from situation to situation, and that it must be related to many other factors which have nothing to do with the law or enforcement. (p. 22.)

Other agencies (motor vehicle departments, courts, insurance companies, etc.) also exist to regulate driver behavior either directly or indirectly, but the police have the responsibility to ensure that the system continues to function efficiently. The primary stress in the literature is that, among the three basic components of the system (drivers, vehicles, and roadways), the police can exert significant influence only on the driver. Some police agencies conduct vehicle inspections or perform certain kinds of traffic engineering, but their primary goal is to regulate the behavior of the people who use the system.

Of the other agencies helping regulate human behavior in the system, the driver licensing process can only screen out the most obviously defective driver applicants. There is no guarantee, however, that these rejected applicants will not use the system. The courts and motor vehicle departments also act to regulate the use of a driver's license once issued, but again there is no guarantee that a person without a license will refrain from driving. In fact, statistics on arrests for driving while under suspension or revocation reveal that a surprisingly large percentage of drivers are not deterred from driving by official denial of this privilege (Coppin and Van Oldenbeek 1965). In the end, the responsibility for enforcing licensing regulations and court decisions becomes a police function.

In the mind of the public, the police represent a public service agency. While the police were originally formed for the single purpose of law enforcement, over the years they have been continually looked to when the need has arisen for some public agency to perform an additional service. Thus, we often see the police in a role that is quite unrelated to law enforcement. This view, coupled with another public image of the police as the "righter of all wrongs," has resulted in a profusion of unrelated tasks being thrust upon the police.

It is quite clear that police agencies have assumed traffic supervision responsibilities simply because there was no other agency available to handle the task. As one early report of a New England town notes:

> By 1908, however, a serious traffic problem had developed and a new use for bicyclemen was found. Although there were only 700 automobiles registered in the City of New Haven, seven pedestrians had been killed in 1908 alone. To cope with this situation, Chief Cowles set up an embryonic traffic division composed of the bicyclemen and two patrolmen on foot. (New Haven Police Department 1961.)

The reasoning the Chief used to support this program was, in his own words:

> On account of so much reckless driving of automobiles about the city, I decided on April 1, 1908 to detail two patrolmen in plain clothes, their special duty to be on watch for violation of the automobile laws. (Price 1969.)

It is reasonable to assume that most police agencies got into the traffic supervision business in much the same way.

To examine the nature of police traffic responsibilities and practices, it is necessary to identify each function or service that the police provide to the motoring public. It is apparent from review of the literature and from discussions with experienced police officials that, on a national basis, the police perform four relatively common or primary functions on the roadway:

- traffic law enforcement,
- accident management and investigation,
- traffic direction and control, and
- general motorist services. (Fennessy et al. 1968, p. 25.)

To understand the first function (which is the subject of this review) it is necessary to view it within the context of the other three functions. Traffic law enforcement is conducted in conjunction with the basic surveillance and patrol function of police agencies. The basic assumption underlying traffic law enforcement is that drivers regularly violate (inadvertently or deliberately) the guidelines or rules that are established to promote safe use of the highway system. The basis for these laws is the body of system-usage customs that has developed over the years. In a Northwestern University Traffic Institute publication, this development is traced as follows:

> When automobiles first appeared on the highway it became necessary to establish certain rules as to how individual drivers should use the highway. Since most conflicts occur because two vehicles attempt to occupy the same space at the same time it is not surprising that most early traffic laws were concerned with specifying who had the immediate right to use the road. As motor vehicles became more numerous, highway systems more extensive, and people learned more about the problems involved in driving, additional laws were derived to define safe driving in general. (Northwestern University Traffic Institute 1959.)

As this comment indicates, these rules do not relate to behavior that is necessarily bad; they exist to encourage behavior in accord with a generally accepted form. As stated earlier, a key assumption underlying traffic law enforcement is that drivers do not voluntarily regulate their behavior to conform with the norms established for system usage and, therefore, these norms must be enforced with punitive measures—primarily fines, but occasionally revocation of driving privileges or imprisonment. The objectives of enforcement in regulating driver behavior are:

- to develop, through the application or threat of application of an enforcement symbol or enforcement action, an avoidance reaction on the part of the driver toward potentially dangerous behavior,

- to remove obviously dangerous drivers from the highway transportation system,

- to educate drivers, either through direct contact or observation of enforcement action, about the implications of driver behavior that differs from the accepted norm, and

- to induce compliance with traffic laws and ordinances through continuous enforcement pressure.

The second function of police traffic services is **accident management and investigation.** The term "accident investigation" has come to represent, in police usage, all police activities that are performed in connection with a traffic crash. A commonly accepted definition has been provided by Baker and Stebbins (1964) as follows:

> . . . the part of street or highway traffic supervision performed by police in connection with traffic accidents. This activity includes but is not necessarily limited to accident reporting by police; on-the-scene accident investigation; follow-up accident investigation; police traffic law enforcement arising from the accident; police traffic direction and other emergency services to prevent additional injury, damage or loss; and preparing in addition to a routine traffic accident report, a traffic citation or special accident investigation report stating conclusions about how and why the accident occurred. (p. 172.)

The International Association of Chiefs of Police has adopted a resolution concurring in the use of the Baker and Stebbins definition of Police Traffic Accident Investigation. In addition, they have also approved the definition below concerning the distinction to be made between "reported" and "investigated" accidents:

> **On-the-Scene Accident Investigation.** All police traffic accident investigation at the first visit to the scene after the accident for the purpose of gathering information and handling

the emergency.

Follow-up Investigation. All police traffic accident investigation except on-the-scene accident investigation, completion of the official traffic accident report and appearance in court in connection with the accident.

Traffic Accident Reporting. Collecting information for, preparing, and submitting to a designated agency an official report of a traffic accident by some person involved in or connected with the accident or by police who learn about it. (International Association of Chiefs of Police 1964.)

The third function of police traffic services, **traffic direction and control**, involves the following activities:

1. Answering questions, especially about local traffic rules and how to reach places or routes.

2. Indicating to drivers and pedestrians what to do, especially at congested points or where hazards make streets and highways dangerous or difficult to use.

3. Making emergency rules for the flow of traffic when the usual regulations prove inadequate or when special regulations have not been made to meet unusual or unexpected or temporary traffic conditions.

Additional traffic direction and control definitions have been specified in the Police Yearbook as:

1. **Police Traffic Direction:** The part of police traffic supervision that involves telling drivers and pedestrians how and where they may or may not move or stand at a particular place, especially during periods of congestion or in emergencies; i.e., generally all police activities necessary to ensure smooth and orderly flow of traffic.

2. **Police Traffic Control:** The part of police traffic direction which is concerned with the control of vehicular and pedestrian movement at a particular place on the road such as an intersection.

3. **Police Traffic Escort:** The part of police traffic direction that involves mobile supervision of movement of one or more traffic units from one point to another. This may include directing movement of surrounding vehicles and pedestrians by means of audible and visible signals in

> such a manner as to permit free and safe movement of the vehicle or vehicles being escorted. (International Association of Chiefs of Police 1961.)

Miller and Baldwin (1944) define the problem as follows:

> The problem of traffic control is first one of area control, which consists of the plan and techniques involving the selection of routes, the separation of various types of traffic, determination of safe speeds, the elimination of conflicts both at intersections and between intersections as well as the provision for storing parked or standing vehicles. It is the result of planning by both enforcement officials and traffic engineers.

Unfortunately, cooperative effort between traffic engineers and enforcement officials is often not as formal as is needed. The development of such a plan often finds the traffic engineer and the enforcement planners operating independently of each other.

The last function of police traffic services is **general motorist services.** The stranded or disabled motorist is increasingly becoming a topic of concern to police traffic administrators. This problem is particularly acute on the controlled-access highway and in rural areas. In an urbanized area the motorist can generally cope with the situation through his own means, but when, for example, he is out of gas on an isolated section of the Interstate System, with no means of reaching a gas station, he looks to the police for assistance. Typical services that the police may provide to a motorist in this situation include:

- Relay a message,
- Transport the motorist,
- Provide fuel or mechanical assistance (for cooling system failure, tires, etc.),
- Push or tow the vehicle,
- Supply first aid or medical assistance,
- Perform a public safety service (e.g., removing hitchhikers, and responding to criminal incidents),

- Give information and directions.

Bradford Crittenden, formerly Commissioner of the California Highway Patrol, has written of the problems a policeman can expect in terms of service needs on the Interstate System. Examples of such problems include:

> Mrs. X has a sick child and needs a doctor, Mrs. Y is having labor pains and her husband is rushing her to the hospital.
>
> Mr. Z was traveling with another car and somehow the two vehicles got separated.
>
> Mr. Q has an urgent message for his brother who is right now on the highway.
>
> Mr. A has a flat tire; Mr. B is out of gas; Mr. C has a dead battery.
>
> Mr. F, who stopped for an hour to nap, was held up at gun point.
>
> Mr. G, who also stopped at a roadside park, was attacked and his wife assaulted. (Crittenden 1964.)

Another article stresses that:

> The police are the only organized "safety group" in service three hundred sixty-five days a year, twenty-four hours a day, and by the nature of their responsibility and authority, in direct contact with highway users. (Tamm 1964.)

It is clear that motorist services, as well as other functions indirectly related to law enforcement, are becoming accepted police functions.

Police traffic services also involve many auxiliary and support functions. Safety education and public information are among the most important of these. Safety education is usually directed at specific persons or groups, while public information about traffic is directed more toward the general public. The more highly specialized police agencies usually combine the two functions. In less specialized agencies, these functions are usually performed by both staff and field personnel.

Since the theory of traffic law enforcement requires that both a fear of punishment and a belief in "omnipresence" be ingrained in the driving population, a public information program that gives wide publicity to police enforcement action is absolutely essential. As Miller and Baldwin (1944) state:

> The value of traffic law enforcement is fully realized only if adequate publicity is given to it. The deterrent effect of a single arrest is increased by the publicity it receives from the violator himself, but the department can multiply the effect many times by publicizing totals of arrests and convictions for various offenses in particular areas and in the state as a whole. The distribution of this information can do much to keep the public conscious of the need for proper driving as well as to make them aware of the service and protection rendered by the department.

In most agencies, safety education often takes the form of lectures and film presentations to schools and citizen groups and "campaigns" directed to specific groups (e.g., pedestrian safety, school safety, etc.). In some jurisdictions, police personnel are assigned full-time or part-time to the schools to conduct driver training classes. Cooperation with official and unofficial traffic safety groups is also usually considered part of safety education activities.

Other auxiliary functions of police traffic services vary among the jurisdictions. They include, or have included:

- driver licensing examining
- traffic engineering
- vehicle inspecting
- court services
- maintaining "pounds" for abandoned or junked vehicles
- investigating hit-and-run incidents and stolen cars (Fennessy et al. 1968.)

The preceding discussion briefly illustrates the extremely broad scope of police activities in the traffic area and shows that enforcement is but one of those activities. This background is an essential prerequisite to interpreting the more specific literature on police enforcement procedures for the subject UDAs.

THE ROLE OF POLICE ENFORCEMENT IN TRAFFIC SAFETY

Various views on the role of police enforcement in traffic safety have been expressed by analysts and practitioners. The range of these views is illustrated by the following statements:

> Traffic law enforcement has as its pri ary objective the creation of a deterrent to violators and potential violators of traffic laws and regulations. One of the important kinds of deterrent thus supplied is the fear of fines, imprisonment or loss of driving privilege. (International Association of Chiefs of Police 1966.)

> Enforcement is directed toward developing negative or avoidance actions on the part of drivers. The principal power of enforcement is the power to punish or to make the consequence of committing a forbidden act unpleasant. If enforcement is frequent and certain this produces a strong negative response to committing certain acts. If the negative implications developed through enforcement are strong enough they will resolve conflicts concerning prohibited actions by making the anticipation of unpleasantness outweigh temporary desires to behave illegally. (Northwestern University Traffic Institute 1959, p. 8.)

> The ultimate aim of traffic law enforcement is voluntary compliance with traffic regulations on the part of motorists and pedestrians. Enforcement is at best a deterrent; it can be a compellant only when the potential violator is taken into custody and is therefore physically unable to violate the law . . . Three purposes are served by enforcement contacts with violators. First, any hazard resulting from the violation is immediately halted; second, opportunity is provided to create a deterring influence which will keep the particular violator from further violations; and third, it affords an opportunity for creating in the minds of other drivers and pedestrians the fear of punishment if they violate. (Miller and Baldwin 1944.)

> Some time ago, a group of law enforcement officers were asked to define the word enforcement. Their replies were to the effect that enforcement is the process of ensuring compliance with or observance of regulations. In a limited and technical sense, enforcement means compelling people to observe the rights of others. A more nearly correct definition of the term . . . would be the overall process of encouraging, persuading, and finally, as necessary, compelling drivers to exercise a due regard for the life, safety, and property of others. (Kunz 1950.)

> The function of enforcement is to ensure compliance with laws and ordinances. It cannot ensure absolute compliance all the time by everyone, particularly in the area of traffic—the number of drivers and vehicles and the extent of the opportunity to violate is simply too great. (Northwestern University Traffic Institute 1959.)

> Our aim in police enforcement is directed toward educating the motorist into voluntary compliance with traffic laws. I am certain that, in most instances, the recipient of a speeding summons has learned that the slight amount of time saved by his reckless driving is small compensation for the time lost answering the summons, and no compensation at all when he is involved in a bone-shattering accident. This is education. (Kennedy 1958.)

A more useful framework for analysis can be constructed by envisaging enforcement as a part of a larger societal control system that attempts to maintain traffic crash risk at some level that is acceptable to society as a whole (Joscelyn and Jones 1978). We call this system the Traffic Law System (TLS) (Joscelyn and Jones 1972). Its operating principle is deterrence, which presumes that a behavior (in this case, a UDA) can be prevented by the threat of punishment. Theory has it that deterrence is accomplished through the effect of the punishment in preventing the punished parties from committing further UDAs (called **special deterrence**) or by preventing drivers from committing UDAs even if they are not caught and punished (called **general deterrence**) (Gibbs 1975; Zimmering and Hawkins 1973).

The TLS tries to create deterrence threats by performing four general functions:

1. The generation of laws prohibiting the risky behavior (Law Generation)
2. The enforcement of these laws (Enforcement)
3. The official determination of guilt for those accused of not complying with the laws (Adjudication)
4. The imposition of legal sanctions against those found guilty of disobeying the laws (Sanctioning)

Enforcement operates in a special-deterrence mode through police apprehension of drivers who have already committed a UDA. Usually, the drivers are then referred to subsequent TLS components for possible punishment. When operating in a general-deterrence mode, enforcement attempts to create a **perception** of police presence and associated punishment, and actual apprehension is not required.

A variety of procedures have been used by police in attempting to create special- and general-deterrent threats. Special-deterrence procedures are often **covert**, since their objective is to catch drivers who have violated a UDA law. Such procedures have been established as a part of Americana by the comic strip motorcycle cop who hides behind the signboard or the rube sheriff on TV who conceals his car just inside the county line.

By contrast, general-deterrence procedures tend to be **overt** to create the impression that police officers are everywhere and that any violation will be followed by certain apprehension. However, covert procedures can also support general deterrence by creating a fear that a police officer **might** be behind every signboard or in every unmarked car.

Another difference between special- and general-deterrence procedures is that the former require surveillance, detection, apprehension, and sanctioning or presanctioning activity by the police. General-deterrence procedures do not, in general, require these activities, but may involve them in establishing a credible threat.

In view of the different roles played by police enforcement in special deterrence and general deterrence, the discussion of the literature in this section treats these two basic types of procedures separately. The discussion covers both the nature of the procedures and legal factors that affect their use in an operational setting.

GENERAL-DETERRENCE PROCEDURES

The literature indicates that the components of general deterrence procedures tend to fall into four major categories:

- intensity of enforcement,
- visibility of enforcement symbols,
- patterns and configurations of patrol, and

- type of patrol vehicle.

Procedural components in each of these categories are discussed in this section.

Intensity of Enforcement

The most obvious way of creating an increased atmosphere of police presence is to have more police units on a given stretch of roadway in a given time period. This may be accomplished by increasing the number of police units that patrol the roadway, by increasing the frequency of patrol of existing units, or by both. Either of these approaches will increase the probability that a driver will encounter a patrol unit in a given time period.

The number of patrol units passed by a driver per mile of travel has been defined as the **intensity** of enforcement (Michaels 1960). Clearly,

$$\text{Intensity} = \frac{\text{Number of patrol units on the roadway}}{\text{Length of the roadway}}$$

A given level of enforcement intensity is achieved in the course of surveillance and basic patrol of the roadway system. The International Association of Chiefs of Police (1964) states that it is fully a police responsibility to:

> Patrol public ways to observe all vehicle use and users, roadway and vehicle conditions and to deter would-be violators of traffic law.

Some authorities on traffic services claim that the most important standard that can be applied to police traffic services is the ability to patrol actively all road segments 24 hours a day. Scanlon (1964), for example, states that:

> Surveillance of the entire system twenty-four hours a day every day of the year is the patrol agency's primary responsibility. Manpower should not be allotted for other patrol functions of the system, such as the use of radar or selective enforcement, until adequate surveillance is accomplished. (p. 12.)

It is also quite obvious that around-the-clock surveillance and patrol of all roadway segments is almost impossible in nearly all large-area, undermanned, police jurisdictions. The problem basically concerns adequate manpower levels and the need to manage these resources as effectively as possible. As Franklin Kreml (1953) stated on the police manpower problem a number of years ago:

> In states the problem is with rare exception, one of sheer inadequacy. In cities it is one of the effective use of the force available. (p. 42.)

The amount of police supervision allocated to individual road segments varies widely among the states (see Table 2-1). However, while length of the patrol route is one important factor in maintaining adequate surveillance, traffic density is another: increased traffic density appears to increase directly the service demands placed on the police officer and, if most of his time is spent in responding to these demands, the level of surveillance or moving patrol time per police car may drop proportionally.

In regard to surveillance one publication states that:

> Some states recommend a minimum patrol frequency on freeways of at least one pass at a given point each half-hour, and a somewhat reduced frequency in rural areas and elsewhere during periods of light traffic. (American Association of State Highway Officials 1961, p. 12-13.)

A policy of this sort may be applicable in some states, but it is clearly impractical in states that are severely undermanned. On the county and municipal levels, such a policy may be impossible because of other factors and demands (e.g., crime, nonpolice services, manpower limitations, nature of jurisdiction).

In some jurisdictions, the use of helicopters and airplanes, operating in conjunction with ground vehicles, has proved helpful in maintaining a high level of surveillance in order to locate sources of congestion, disabled vehicles, and accidents, as well as in the enforcement of traffic laws. Bad weather and darkness, however, limit the effectiveness of aircraft. Electronic surveillance (television, etc.) of the freeway system has also proved helpful. Even so, twenty-four-hour-a-day surveillance of the

TABLE 2-1

FULL-TIME STATE POLICE AND HIGHWAY PATROL EMPLOYEES
October 31, 1978

State	Police Officers*	Miles of primary highway per police** officer	State motor vehicle registrations per police officer	State	Police Officers*	Miles of primary highway per police** officer	State motor vehicle registrations per police officer
Alabama	660	16.2	4,051	Kentucky	951	4.9	2,576
Alaska	282	14.4	913	Louisiana	864	5.7	2,803
Arizona	845	7.1	1,839	Maine	326	12.2	2,204
Arkansas	444	36.0	3,205	Maryland	1,523	.7	1,699
California	5,044	3.0	2,966	Massachusetts	1,007	2.8	3,495
Colorado	551	14.1	3,925	Michigan	2,200	4.3	2,721
Connecticut	908	1.3	2,301	Minnesota	499	24.1	5,638
Delaware	433	1.1	864	Mississippi	561	18.5	2,663
Florida	1,167	10.5	5,223	Missouri	752	10.5	4,059
Georgia	761	23.9	4,594	Montana	220	30.4	3,298
Idaho	192	26.0	3,738	Nebraska	406	24.3	2,975
Illinois	1,871	9.1	3,667	Nevada	155	14.9	3,541
Indiana	953	11.8	3,763	New Hampshire	196	10.4	2,874
Iowa	563	18.0	3,947	New Jersey	1,781	1.2	2,475
Kansas	414	25.3	4,572	New Mexico	357	14.8	2,541

* From our personal experience these figures are subject to misinterpretation. The figures probably include personnel who are not actively engaged in traffic supervision.

** Since these police agencies generally work around the clock, the manpower is allocated to three shifts and to other supporting or overhead activities, these figures are misleading and, in fact, probably should be multiplied by a factor of four or five. In addition, divided highways without adequate crossovers create further problems with these statistics.

Source: Federal Bureau of Investigation 1979

TABLE 2-1 (continued)

FULL-TIME STATE POLICE AND HIGHWAY PATROL EMPLOYEES
October 31, 1978

State	Police Officers*	Miles of primary highway per police** officer	State motor vehicle registrations per police officer	State	Police Officers	Miles of primary highway per police* officer	State motor vehicle registrations per police officer
New York	3,343	4.5	2,312	Tennessee	781	12.4	3,836
North Carolina	1,093	12.5	3,732	Texas	2,461	28.4	3,856
North Dakota	103	68.7	5,635	Utah	418	13.3	2,173
Ohio	1,098	17.5	6,835	Vermont	258	9.8	1,242
Oklahoma	572	21.4	4,015	Virginia	1,216	7.4	2,678
Oregon	960	5.1	1,850	Washington	784	8.8	3,692
Pennsylvania	3,678	4.7	2,203	West Virginia	549	10.8	2,070
Rhode Island	156	5.7	4,291	Wisconsin	485	23.5	5,499
South Carolina	748	13.4	2,483	Wyoming	142	43.5	2,648
South Dakota	177	51.0	3,168				

* From our personal experience these figures are subject to misinterpretation. The figures probably include personnel who are not actively engaged in traffic supervision.

** Since these police agencies generally work around the clock, the manpower is allocated to three shifts and to other supporting or overhead activities, these figures are misleading and, in fact, probably should be multiplied by a factor of four or five. In addition, divided highways without adequate crossovers create further problems with these statistics.

Source: Federal Bureau of Investigation 1979 system, as recommended by Scanlon, is costly.

Brackett and Edwards (1977) have considered strategies to increase the **perceived** intensity of enforcement without necessarily increasing the **actual** intensity. The aim of these strategies was to convince drivers that a roadway is patrolled every day; thus, the deterrent threat created by a patrol vehicle could be carried over to days when the vehicle was absent. Patrol costs would thereby be considerably reduced.

These investigators have varied the presence of patrol according to two different schedules: a fixed ratio of patrol presence to patrol absence and a decreasing ratio of patrol presence to patrol absence. In the first schedule, the patrol is present for three of the days of the working week and absent two. In the second schedule, police presence decreases gradually from continuous presence (five days of the working week) to two days. For both, the days of the patrol vehicle's presence are selected on a random basis.

This manipulation of patrol frequency draws heavily upon the concepts of behavioral reinforcement theory. In the above-mentioned work, the authors discuss the relationship of reinforcement theory to traffic behavior; they note:

> Reinforcement is generally regarded as anything that facilitates learning. In the case of avoidance learning reinforcement is the avoidance of an unpleasant situation. In terms of the traffic situation, drivers have learned to associate . . . the presence of a patrol vehicle with the possibility of receiving a traffic citation, either through personal or vicarious reinforcement. (p. 13.)

Thus, driver compliance with the traffic law is instrumental in avoiding traffic citations.

Central to this entire reinforcement process, and to the manipulation of patrol frequency, is the schedule under which the behavior is reinforced. Two general kinds of schedules can be identified. Continuous or 100 percent reinforcement occurs when reinforcement is provided every time the appropriate behavior appears. This is akin to a patrol unit always being present and in view on a particular stretch of roadway. Partial or intermittent reinforcement schedules also reinforce the behavior of concern but not on every occurrence; for example, a highway patrol unit is present on three, not five, randomly selected days of any given work week. The nature of partial reinforcement allows for the desired behavior to be effectively maintained with fewer incidences of actual reinforcement.

Some "procedures" for increasing the perceived intensity of enforcement do not necessarily involve the police directly, for example, public information and education (PI&E) campaigns. These campaigns usually consist of press conferences, news releases, and public service spot announcements for use by local newspapers, radio stations, and television stations. Use has also been made of outdoor billboard advertising. In addition, members of law enforcement agencies have appeared at high schools, colleges, service clubs, and community organizations to discuss highway safety. A more detailed discussion of PI&E activities related to UDA enforcement can be found in such sources as U.S. Department of Transportation (1978); Clark (1976); Elliott (1977); Reinfurt, Levin, and Johnson (1973); and Witheford (1970). In addition to PI&E campaigns run by police departments, many departments in effect create their own advertising by selecting a clever or easily-recognized theme or symbol for their speed enforcement campaign; one of the best known of these is Maryland's "Operation Yellowjacket" (Clark 1978).

Another mode of communication that has been utilized by enforcement officials to publicize their presence is the citizen band (CB) radio. It is well known that the recognition of an enforcement vehicle by drivers is often accompanied by CB broadcasts regarding its presence. Use of this mode requires little or no additional outlay in resources; drivers do the advertising for the traffic enforcement organization (Booth 1978).

Roadside signs have also been used to advise motorists about safe and unsafe driving behaviors. In a sense, such signs serve as reminders of police presence and possible negative consequences of risky driving. Visual speed indicators have been used to display the message YOUR SPEED IS . . . . as vehicles pass over induction loop detectors in the pavement. If a vehicle is traveling at 56 mph or more, the words **SLOW DOWN** are displayed. Warning signs indicating "Speed Check Zone" have also been displayed in efforts to control traffic speed in both the absence and presence of patrol units (Dart and Hunter 1976; Hunter and Bundy 1975).

Both electronic systems and warning signs have also been used to encourage safety gap acceptance. Signs have presented such messages as: **FAST TRAFFIC AHEAD; ALLOW TIME TO TURN; FAST TRAFFIC;** and **HAVE YOU TIME TO TURN.** More elaborate is the FTC (following too closely) Monitor. The FTC Monitor is an electronic system that measures gap time and signals if it is too short; it includes:

> . . . a detector in the roadway that locates the front and rear of every automobile passing in its lane of travel, a logic system that throws a signal to a sign on the highway (or to a police car) and a sign that flashes a "danger" signal to the following motorist if he is dangerously close. There is an additional signal that flashes "violation" if he is flagrantly too close. In addition, the "violation" signal triggers an audible signal to emphasize the violation. (Traffic Safety Systems, Inc. 1971, p. 5.)

With either warning signs or elaborate electronic systems, the objective is the same; that is, to increase the intensity of police enforcement perceived by the motoring public.

Visibility of Enforcement Symbols

As was noted earlier in this chapter, there are two opposing viewpoints on the use of enforcement symbols for generating deterrent threats. The first holds that enforcement symbols (e.g., patrol cars, traffic monitoring equipment, etc.), should be made as visible as possible to "advertise" their presence and induce compliance with traffic laws. The second viewpoint is that enforcement symbols should be hidden or disguised, so that the driver will be unsure where they are and might assume that they could be everywhere.

Darwick (1977) has defined three degrees of openness of patrol used by state agencies for traffic enforcement. The most open is that of "utilizing plainly marked patrol vehicles being operated by uniformed officers who are instructed that they may under no circumstances conceal themselves in order to effect apprehensions for traffic violations" (p. 120). In the second and less open group of procedures, the patrol vehicle may be positioned in such a way that motorists will either see the vehicle "only after they are too close to reduce speed or never become aware of the police presence at all" (p. 121). In the third procedure, the patrol vehicle is made to appear to be a civilian vehicle.

A number of actions have been taken to increase the visibility, and therefore the recognizability, of patrol. Foremost among these is to have the patrol vehicles be in full view of motorists, for example, parking vehicles on freeway ramps, or overpasses, or in the median. Darwick (1977) also notes that a patrol car parked at right angles to the traffic flow provides the best visibility for passing motorists.

Police observation platforms have been used on roadways in England to make police presence more conspicuous to drivers. Southgate (1975) has identified several general principles to be followed in the siting, layout, and construction of roadway police observation platforms. The primary requirement is "a comfortable and unobstructed view of the road in both directions with the ability to gain immediate access to the road in either direction" (p. 34). Other criteria specified by Southgate include: spacing platforms about ten miles apart; constructing the platform one meter above the roadway with an exit tapered to the back of the hardshoulder to allow police vehicles a straight run on to the road; and designing the platform so that vehicles may park at about ninety degrees to the traffic flow.

Additional procedures for making enforcement symbols more visible include plainly marking the patrol vehicle and its personnel as such. This may be accomplished by mounting decals on the vehicle's side and rear and emergency lamps on the roof. Also, officers are frequently instructed to wear their uniform hat while in the car (Darwick 1977).

The most obvious procedure for making enforcement symbols **less** visible is to hide them. This has been accomplished by having police park their vehicles on entrance ramps, behind overpass supports, behind trees or other growth in medians, on overpasses, and any other places where motorists may not expect police to be, or may see the vehicle too late to change their driving behavior (Darwick 1977; Smith 1962).

The second commonly used procedure for reducing the visibility of enforcement symbols is to disguise them. Often, police vehicles are disguised as civilian vehicles. Darwick (1977) notes that this has been accomplished by state enforcement agencies by one or more of the following techniques:

> There would be no departmental or state seal displayed.
>
> The license plate would not be identifiable by a governmental, tax exempt number.
>
> The vehicle would be equipped with options not associated with public vehicles, for example, white wall tires, concealed radio antenna, decals on bumpers, vinyl top, and even clothing on hangers.
>
> There would be no departmental restriction to prevent the officer from wearing civilian garb over his uniform or otherwise covering the top part of his uniform while driving. (pp. 121, 124.)

A less extreme procedure for disguising patrol vehicles as such is the use of unmarked patrol cars; the same color, make, and model of vehicle is used but without a light dome and with plain license plates and luggage rack on roof (Klebelsberg 1963).

Law enforcement agencies may reduce the recognizability of marked patrol vehicles by implementing one or more of the following strategies identified by Darwick (1977):

> Patrol vehicles may not all be the same color or color scheme.
>
> Emergency lights are mounted below the roof line.
>
> The seal of the state or the police agency on the door may be the only mark of identity except the license plate.
>
> The officer, in uniform, is not required to wear his hat when in the car. (p. 121.)

Patterns and Configurations of Patrol

A number of police procedures focus on how to most effectively position the visible patrol unit. Both moving and stationary patterns of patrol have been used.

Moving law enforcement vehicles usually are standard patrol cars or motorcycles. They travel with the flow of traffic usually at the posted speed limit and often around five mph below the limit (Baker 1954; Council 1970; Joscelyn, Bryan, and Goldenbaum 1971). Baker (1954) has reported that a motorcycle patrolman in motion could be seen by cars as much as half a mile behind him and a quarter of a mile ahead.

In addition to making motorists aware of patrol presence, moving enforcement units can also be used to set a pace for traffic flow. State police cruisers have been used as "chaperones" on highways by moving at the 55 mph speed limit, thereby encouraging motorists to do the same. In some instances, the conspicuity of these units is increased by having them cruise with all lights on (U.S. Department of Transportation 1977a).

Stationary patrol vehicles are positioned in a variety of visible configurations in attempts to create deterrent threats. Conspicuously marked vehicles are stationed on the roadside. Patrol units have been parked:

- perpendicular to the roadway on the side of predominant traffic flow;
- perpendicular to the roadway on the side of nonpredominant flow;
- parallel to the roadway on the side of nonpredominant flow;
- parallel to the roadway on the side of predominant flow and facing in the direction of travel; and
- parallel to the roadway on the side of nonpredominant flow and facing in the direction of travel.

These enforcement units may or may not be equipped with visible radar. In some instances, patrol units are placed in a "pack" position; Joscelyn, Bryan, and Goldenbaum (1971) describe one variation of this approach as follows:

> . . . two marked police vehicles were positioned along the side of the road at a prescribed distance from one another (approximately 0.1 miles). The first vehicle deployed a radar antenna. The second, the "catch" vehicle, possessed no radar device. (p. 29.)

In the above patrol configuration, the patrol officer is passively waiting in the vehicle. In other patrol configurations, the officer appears to be giving a ticket to a stopped driver. In these instances, a civilian vehicle is stationed immediately in front of the police vehicle. The police officer may either be: (1) accompanied by another person, (2) the driver of the civilian vehicle, (3) in the police car, or (4) standing beside the civilian vehicle.

The above patterns and configurations of patrol have been drawn from descriptions in Baker (1954); Calica, Crowther, and Shumate (1964); Council (1970); Joscelyn, Bryan, and Goldenbaum (1971); Organisation for Economic Co-Operation and Development (1974); and Smith (1962). It should be noted that these procedures are not used exclusively of each other; more frequently, they are found in combination (e.g., a marked vehicle with radar moving with traffic or a motorcycle parked perpendicular to the road).

Type of Patrol Vehicle

It may be expected that different types of patrol vehicles generate different deterrent threats, depending on their attention-getting properties and the degree to which they are associated with enforcement action. Automobiles, motorcycles, and aircraft are used as patrol vehicles, and police sometimes patrol on foot.

All law enforcement agencies make use of marked patrol cars as patrol vehicles (Darwick 1977). These vehicles are usually four-door police-package patrol sedans, and may or may not be equipped with radar.

Motorcycles are usually used with either hand-held or vehicle-mounted radar units operated by the cycle rider. Motorcycle operators also work with marked patrol cars or another cycle (Darwick 1977). Although motorcycles are not used as extensively as patrol cars, Booth (1978) has found that they are more easily recognizable as enforcement vehicles.

Aircraft is a third vehicle type employed by traffic enforcement agencies. The types of aircraft most commonly used for highway patrol are fixed-wing and STOL (short takeoff and landing) airplanes, and helicopters (Darwick 1977). The visibility of aircraft is an important factor in fostering patrol presence, but as Rasmussen (1977) notes: "The greatest advantage in aircraft is its ability to cover vastly more territory than a conventional ground unit" (p. 11). Moreover, signs are often present on selected highways to advise drivers that the road is patrolled by aircraft. Measured miles are marked on the pavement so aircraft can pace speeding drivers and report them to ground units. In some cases, pilots have slowed speeders on remote highways by flying into visual range and using sirens and a public address system (Craig 1975).

Traffic patrol on foot is not commonly used by enforcement agencies. It appears to be most useful in instances where highway conditions are not conducive to parking a patrol vehicle safely (Darwick 1977).

The Maryland State Police reported using "camouflaged" vehicles (rental cars, trucks, vehicles confiscated from drug traffickers, etc.) to heighten perceived enforcement; they want drivers to have the impression that any car on the highway may be driven by a police officer (Clark 1978).

SPECIAL-DETERRENCE PROCEDURES

As we have noted, the aim of special deterrence is to prevent or reduce the incidence of UDAs among drivers who have been caught and punished after committing a UDA. To do this, police officers perform the following functions:

- surveillance,
- detection,
- apprehension, and
- presanctioning/sanctioning.

Literature on procedures that are used in performing these functions is discussed below.

Surveillance and Detection

Surveillance, a function that supports general deterrence as well as special deterrence, was discussed generally earlier in this chapter in connection with procedures for increasing enforcement intensity. The discussion here is concerned with more specific aspects of surveillance as related to procedures aimed at apprehending UDA violators. Because of the intertwining of surveillance and detection in special-deterrence procedures, the two functions are discussed together.

The type of equipment that is used for detection appears to have the strongest influence on a jurisdiction's choice of a surveillance/detection procedure. The discussion below provides a synopsis of various types of detection equipment and related procedures that have been used by the police in enforcing laws relating to speeding, following too closely, or driving left of center. More detailed information on such equipment is presented in Appendix D.

The speedometer and odometer in the police vehicle were widely used twenty years ago in a procedure known as **pacing**. The procedure is still used today, but not as extensively (Darwick 1977; Witheford 1970).

The pacing of another vehicle by the use of a patrol vehicle's speedometer is performed in two ways. In each, the police officer is either behind or abreast of the subject. In the first procedure:

> The officer may concentrate his attention on the suspect vehicle and adjust his speed until the two vehicles are judged by him to be traveling at the same rate, after which the officer will look at his speedometer to ascertain its reading. The speed registered will be then of the suspect vehicle as well as that of the officer. The closer to the suspect vehicle the officer is at the time he conducts his pacing, the more likely it will be that he will determine speed by this method. (Darwick 1977, p. 48.)

The second technique is performed by holding the patrol vehicle at a steady pace while judging the apparent change in the distance between the patrol vehicle and that of the suspect.

> If the officer has judged the speed of the violator when first noticed as not being particularly high, although fast enough to be in violation, he will adjust his speed either to that at

> which he will ordinarily make a speed arrest or that above which he will effect an arrest. . . . If the officer is holding a speed at which he will take enforcement action, he will make a stop if the suspect vehicle holds an even distance or pulls ahead. If the officer holds a speed above which he will take enforcement action, he will stop the violator only if the distance between the two vehicles increases. Where the speed of the violator is obviously much above the limit, the rate held by the officer will be the five mph increment closest to that which he believes is the violator's speed. Dependant (sic) on the accuracy of the officer's original estimate of the violator's speed, he will arrive at his decision to apprehend or not either immediately or after trying several pacing speeds. The farther away from the suspect vehicle the officer is and the more time and distance there will apparently be to perform the pacing, the more likely it is that the officer will employ this type of pace--holding his own speed and then judging the change of distance, or lack of change, between the vehicles. (Darwick 1977, p. 48.)

Because of the availability of more precise methods (for example, radar), odometer pacing is used infrequently in most jurisdictions. Again, Darwick (1977) describes this procedure:

> . . . The officer utilizes the speedometer to hold a steady speed and the odometer to determine whether he is overtaking, holding even or falling back from the target vehicle at the speed held. As the suspect vehicle passes checkpoints . . . for example the shadow beneath an overpass, the officer notes the odometer reading and subtracts that figure from the reading when he reaches the same checkpoint. He then knows how far behind the target he was when the target passed that checkpoint. By following this procedure twice, the officer determines two odometer differences, which are two following distances. If the second difference is greater, then the target vehicle's speed is higher than the officer's. If the second difference is smaller, then the suspect's speed has been less than the officer's; the officer was overtaking at speed held. (p. 49.)

The standard patrol car and the motorcycle have been the vehicles most commonly employed for pacing purposes.

The **stopwatch** was perhaps the first instrument used to enforce speeding UDAs, predating even the speedometer and odometer. Today, its main use is in conjunction with procedures that employ aircraft. One procedure using aircraft has been described by Rasmussen (1977) as follows:

> The Aircraft Division contacts District Headquarters for a particular county. The District advises the pilot of the number and location of the ground unit assigned to work with the aircraft. . .
>
> When the pilot nears the designated location, he contacts the ground unit by radio. The ground trooper takes his assigned place beside the road.
>
> Slowing the plane to about 100 miles an hour . . . the pilot cruises at an altitude of 1000 feet. He clocks the speed of a car over a mile, using section lines or prepainted markings as checkpoints.
>
> If a car is speeding, the pilot radios his partner in the ground unit, who writes it down as the pilot calls it out--color of car, location (distance from ground unit), speed checked and time. As the violator approaches the Patrol vehicle, the ground trooper waves him over. (pp. 11-12.)

Darwick (1977) reports that twenty-five state police enforcement agencies said they use stopwatches from aircraft for enforcement of the 55 mph NMSL. Fixed-wing aircraft were said to be most common, but some agencies also used helicopters.

Stopwatches are used not only in aircraft measurement of speed, but also by officers measuring speeds in school zones and other low-speed zones in urban or residential areas. Some police departments have begun to use electronic stopwatches (Kukla 1979).

Radar began to be applied to speed enforcement around 1947. Radar devices used by enforcement agencies are based on the Doppler effect. The devices measure the change in frequency between the radio signal transmission and the signal reflected from a moving object (Witheford 1970). They can be attached to patrol cars (usually on the top edge of the glass of a side window or on the dash), to motorcycles, or to a fixed mount (e.g., a tripod or a bridge railing). Hand-held radars are also available and because of their portability, compactness, and light weight, are favored by motorcycle patrolmen (Darwick 1977; Goetzke 1974).

Surveillance and detection procedures using radar are best classified according to whether the devices are attached to a moving or a nonmoving mount. Nonmoving radar is used to determine "the speed of a vehicle, which is approaching or receding while the radar itself is not in motion" (Darwick 1977); it must remain stationary in order to accurately read the speed of the target vehicle. It may be used from parked patrol cars or motorcycles, from a fixed installation, or by an officer on foot (hand-held). Both overt and covert procedures are used to measure the speeds of approaching or departing vehicles. Hand-held radars are particularly useful for such applications because they can be aimed at target vehicles in both directions. Hand-held radars are often used covertly from nonmoving (and moving) mounts because they can quickly be moved out of sight when not in use.

Moving radar is aimed in the same direction that the patrol vehicle in which it is mounted is moving; it determines the closing speed of the patrol vehicle and the target vehicle. The target's speed is calculated by subtracting the patrol vehicle's speed from the target vehicle's speed. Moving radar can be converted to nonmoving radar for stationary operation. As with nonmoving radars, moving radars are used overtly or convertly on patrol cars and motorcycles to measure the speeds of approaching or departing vehicles.

The present generation of radars have a range of a half-mile or more. Some have an automatic "lock-on" feature that signals the officer when a vehicle is detected exceeding a preset speed (Darwick 1977), although new standards will prohibit the use of the lock-on feature.

That radar devices can produce erroneous speed measurements has been known for a long time. Recently, however, critics of radar have attacked its reliability and at least one court decision has explicitly disapproved its use in speeding trials. In that case, a Dade County (Florida) district judge concluded that the validity of radar speed measurements cannot be established beyond a reasonable doubt, and therefore cannot be offered as evidence of guilt. The so-called "Miami radar decision" has since generated extensive comment in the literature (e.g., Blackmore 1979; Shaw 1980; Smith 1979).

The error most often cited by critics of radar is the so-called **cosine error.** Radar speed measurements are accurate only when the angle between the radar unit and the target vehicle is small (see Figure 2-1). This is so because the radar unit measures the **component** of the target's speed along the line of sight between the radar and its target. The size of that component is proportional to the cosine of the angle between the radar and the target: if the angle is zero, its cosine is equal to 1.0 and the measured component equals the target vehicle's actual speed; as the angle increases, the cosine becomes less than one, and the measured component less than the target speed. In the stationary mode, cosine error presents no serious problem, because it always favors the driver and is not a valid defense. However, since moving-mode radar also measures the patrol vehicle's speed, cosine error could result in the undercalculation of how fast the patrol vehicle is traveling, which could in turn overcalculate the driver's speed. To minimize the effects of cosine error some police departments have instructed officers to ensure that the radar antenna is aligned with the patrol vehicle's direction of travel to within eight degrees (Michigan State Police 1979). As the table in Figure 2-1 indicates, the cosine error resulting from a deviation of less than eight degrees is minimal.

Research has also identified a number of other potential errors that are associated with radar speed measurements. These include:

- **Shadowing**, the tendency of a moving radar unit to confuse the speed of large, slow-moving vehicles (e.g., trucks traveling in the same direction of the patrol vehicle) with that of the patrol vehicle itself;

- **Batching** (bumping), changes in the displayed target vehicle speed caused by sudden changes in patrol vehicle's speed;

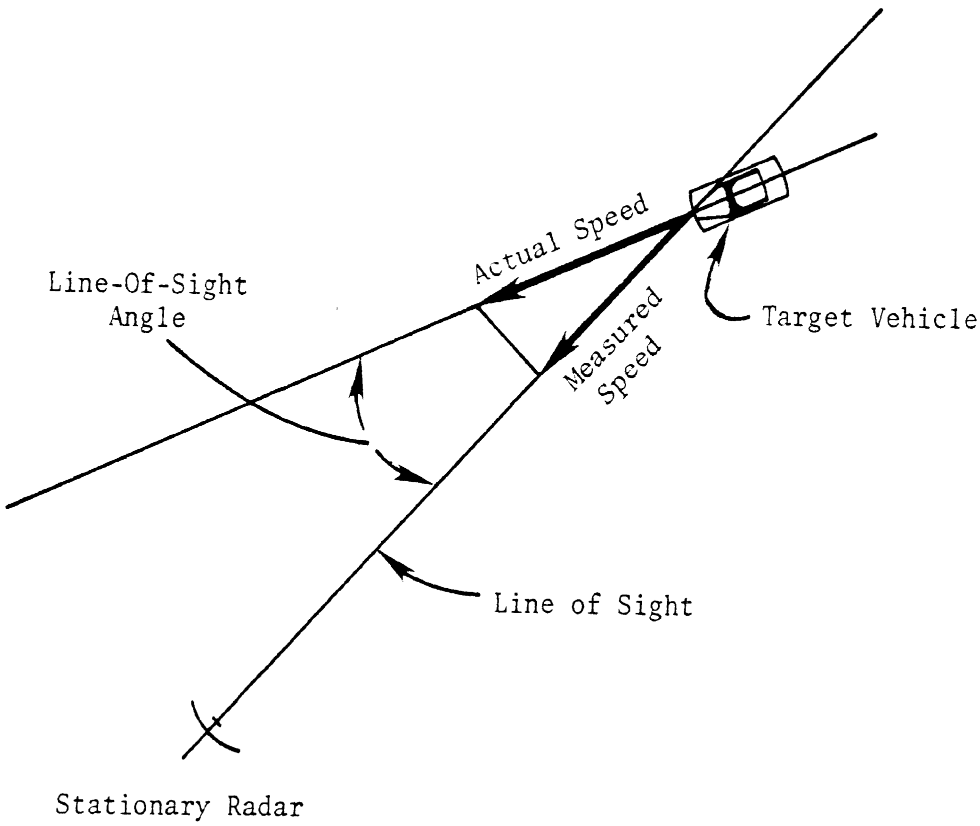
- **Panning**, erroneous readings caused by the radar's antenna moving through its own display;

- **Scanning**, erroneous readings caused by too-rapid movement of the antenna, or by placing the antenna too close to fans or heaters; and

- **Ghost readings**, caused by interference from police band and CB radio transmissions within the patrol vehicle, as well as by overhead power lines, neon lights, etc. (U.S. Department of Transportation 1980)

FIGURE 2-1

EFFECT OF LINE-OF-SIGHT ANGLE ON
THE ACCURACY OF POLICE RADAR



Line-Of-Sight Angle, Degrees	Radar Speed Error, %
0	0
8	1.0
15	3.4
30	13.4
45	29.3
60	50.0
75	74.1
90	100.0

In addition, the "automatic lock" feature found on modern radar units observes and alerts an offficer to violators that the officer might not have seen. This raises the possibility of incorrect identification. For example, the alarm might not have been set off by the vehicle closest to the patrol vehicle, but by a larger vehicle overtaking the closer one. It should be pointed out that each of these potential sources of error can be minimized or even avoided by trained and experienced officers who observe proper instructions for operating radar units (Denver Police Department 1979; Michigan State Police 1979).

The most recent court decisions dealing with radar also reflect this approach: courts are willing to accept radar speed measurements as reliable, but they do require a showing that proper procedures were followed, and that the area where the observation occurred was free of distorting influences.

A device called **VASCAR** (Visual Average Speed Computer And Recorder) is favored by some jurisdictions when conditions for radar use are unfavorable. The VASCAR operation is based on the simple formula: Distance divided by Time equals Speed. It is a speed computer into which distance traveled and elapsed time data are fed. The VASCAR operator stores distance in the unit by activating an electrical switch on the unit when his patrol car passes a certain point on the highway; he turns off that switch when his car reaches another point farther down the road. Thus, a measured distance is recorded.

Time is stored on a VASCAR unit when the operator activates a second electrical switch as a target vehicle passes either of the two predetermined distance points. Location points can be almost anything: shadows, guard rails, painted lines, etc. The time switch is turned off when the target vehicle reaches the second point. This method of timing results in an average speed. A target vehicle can be clocked from a minimum distance of one-tenth of a mile to a maximum of one and a half miles (O'Neal 1967). VASCAR is mounted in a patrol car and may be used in both moving and nonmoving modes.

VASCAR is not as widely used as it once was; reasons cited by departments include the extensive downtime problems and the fact that radar is as effective. However, VASCAR cannot be found by radar detectors because it emits no radiation (Darwick 1978).

The surveillance and detection devices outlined above have to be attended by a human operator. **Automated detection devices** (for example, ORBIS) have been designed to eliminate this need. ORBIS III determines speed by pavement sensors and automatically photographs violators, their vehicles, their speeds, and the violation date, time, and location. Prosecution is based on registration information obtained from the vehicle's license number (Myers and Ottman undated). Darwick (1977) reports that no state agency said it was using an automated device for enforcing the 55 mph national maximum speed limit. A pilot test of the ORBIS III automated detection system was conducted in Arlington, Texas, in 1970-1972. The photographs of speeding vehicles were used primarily as a basis for warning letters; citations were seldom issued (Vought Missiles and Space Company undated). The warning letters were sent to the car owners who were identified from the license plate numbers that appeared in the photograph. It appears that ORBIS effects on speed were more due to general deterrence than special deterrence (see discussion in Chapter Three).

Video recording equipment has also been used to support police traffic enforcement. Portable videotape units have been mounted in troopers' cars to film drivers' behaviors. These portable units have pistol grips and can be moved left or right, or tilted up or down. They are equipped with zoom lenses to make close-ups possible. In addition, the units have attached microphones and are equipped for instant replay. The equipment does not appear to have been widely used for the UDAs of concern in this report. It has been used by some enforcement agencies in providing evidence for prosecuting drunk driving cases.

Apprehension

Procedures for apprehending violators of speeding laws are largely dependent on the patrol configuration being used. Solo configurations require those in the detecting vehicle to apprehend law violators. Team configurations use one or more units for detection and one or more additional units for apprehension.

A common team configuration deploys one detecting unit parked at the side of the road and a second unit parked downstream of traffic at the side of the same road (Figure 2-2a). The first unit detects violators passing by, radios their identify ahead to the "catch" unit. The catch unit then pursues and apprehends the violator. Sometimes, more than one catch unit is used, especially when many violators are being detected in a short period of time.

Another variation of the team approach has the detecting unit parked on one side of a divided highway surveilling traffic on the other side (Figure 2-2b). The catch vehicle is also on the other side of the highway and apprehends the violator after being notified via radio.

Automobiles, motorcycles, and aircraft are used in team configurations. All three types of vehicles are used for detectors, but only the first two apprehend violators.

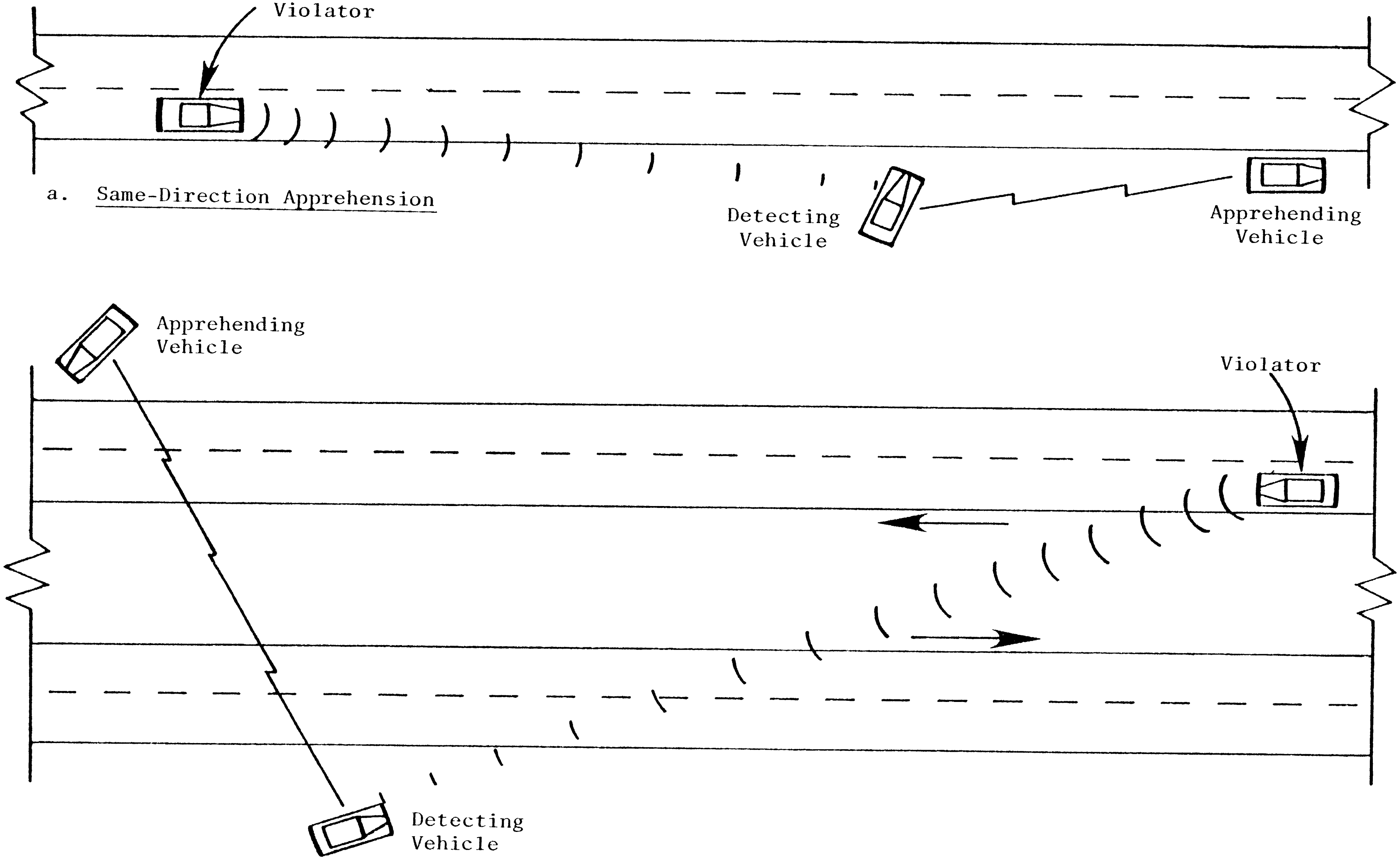
Marked and unmarked vehicles are used for apprehension. Also, the apprehending vehicle may be moving as well as parked prior to initiating pursuit. When a moving vehicle is used in a solo configuration, a rapid turn-around is required for apprehending vehicles traveling in the opposite direction. For a further description of police procedures for apprehending violators see Darwick (1977); Joscelyn and Jones (1972); Joscelyn, Bryan, and Goldenbaum (1971); and Weston (1960).

Policies for pursuing vehicles that attempt to escape vary among jurisdictions. Fennessy et al. (1970) identified three types of such policies being followed **circa** 1970:

> Type 1: Officer Judgment Model--All basic decisions to initiate, conduct, or terminate hot pursuit are made by the street officer. His decisions are subject to internal review and possibly legal action depending on 'due care' provisions.
>
> Type 2: Restrictive Police Model—In these agencies there are certain restrictions on the officer's decision to initiate conduct, or terminate a pursuit (e.g., only pursue for felonies, no speed above 20 mph over posted limits, stop at intersections, etc.)

FIGURE 2-2

DETECTION AND APPREHENSION APPROACHES USING TEAM CONFIGURATIONS



a. Same-Direction Apprehension

b. Opposite-Direction Apprehension

> Type 3: Discourages Pursuit--These policies caution or discourage the officer from engaging in hot pursuit. However, none of the agencies expressly forbid pursuit, if there is no other choice, or if there is an extreme emergency. (p. 153.)

Fennessy and associates found the type 1 model to be "by far the most predominant among U.S. Police agencies," with few agencies following type 2 and even fewer following type 3 policies. The researchers also found that nearly 90% of all hot pursuits in four jurisdictions stemmed from traffic law violations and estimated that between 300 and 400 people are killed in pursuit-related crashes every year in the United States.

Presanctioning/Sanctioning

Following apprehension, the police officer initiates actions leading to the imposition of sanctions on the violator. First, the officer must decide whether to release or arrest the accused violator. An arrest is rarely made for the violations that are of concern in this review. Usually, the driver is given a warning (either verbal or written), or a citation requiring him to appear at an adjudicative agency (for example, a traffic court), or to post bond or collateral pending appearance. A citation or "traffic ticket" is the most common outcome (Fitts 1966; Institute for Research in Public Safety 1973; Joscelyn and Jones 1972; and Lewis 1976).

Police agencies vary greatly with respect to the number of tickets they issue. In this respect, Gardiner (1969) reported that:

> The police in Boston and Dallas, two cities that in 1960 had populations of approximately 700,000, wrote 11,242 and 273,626 moving-violation tickets respectively-a twenty-four-fold difference. Niagara Falls, New York, and Wichita Falls, Texas, with populations of slightly over 100,000 in 1960, saw 1,245 and 10,211 tickets in 1964. Police in Springfield, Massachusetts, wrote 14,720 tickets, while their counterparts in Grand Rapids, Michigan (also with a population of 175,000), were writing 36,727. Finally, in Cambridge and Somerville, Massachusetts, two adjacent cities with populations of 100,000, the police wrote 5,457 and 750 tickets respectively. (pp. 6-8.)

Because of a lack of data relating ticketing action to crash reduction, police have had great difficulty in articulating specific policies in this area. Many police agencies have written manuals governing virtually all aspects of police procedure, but not the department's policy on the enforcement of traffic laws. There are numerous unwritten guidelines (e.g., "concentrate on the quality of enforcement action" or "have X number of motorists contacts per shift") but very little formal guidance. One highway patrol believes that formal policy on enforcement action serves as a constraint to effective performance, and states:

> The Patrol's basic philosophy is that with proper training and selection of personnel a department can rely upon the judgement of an officer regarding enforcement contacts and that guides often become a 'straight jacket,' which eliminate individual actions based on conditions existing at the time of violation or infraction. (Hathaway 1966, p. 20.)

Some departments have a written policy that officers must take enforcement action against every violation that they observe. However, as most police officials (especially in urban jurisdictions) will admit, this is clearly impossible.

Nearly all citations for the violations that are of concern here have led to determinations of guilty and the imposition of fines as sanctions. License suspensions are imposed for more flagrant violations and when too many "points" are accumulated. Jail sentences are rare (Gardiner 1969; Joscelyn and Jones 1972).

Note that state judicial or administrative agencies are not the only elements that impose sanctions. Apprehension and a verbal or written warning are in a sense sanctions that most motorists want to avoid, and these sanctions are imposed by the police.

LEGAL FACTORS AFFECTING THE SELECTION AND USE OF POLICE ENFORCEMENT PROCEDURES

A number of factors influence whether and how a procedure will be used in a given jurisdiction. Such factors may be classified as institutional, political, economic, social, and legal, among others. A full discussion of all of these factors would be beyond the scope of this review. However, the last class of factors (legal factors) has such a strong influence on police procedures (and, indeed, on the procedures used by other elements of the Traffic Law System) that it must be dealt with here.

Police officers who enforce traffic laws are constrained by prevailing constitutional, legislative, and administrative restrictions governing enforcement techniques. Failure to observe these legal constraints not only provides drivers with defenses to their being convicted of traffic offenses, but also could expose the police to civil or even criminal liability.

Legal factors of particular importance to traffic-law enforcement include: restrictions on the use of certain surveillance and detection procedures; requirements governing the use of evidence obtained from surveillance and detection devices in traffic-case adjudications; and the impact of sanctioning practices on traffic enforcement itself. Each of these factors is discussed below.

The legality of various highway crash countermeasures has been the subject of extensive examination in another NHTSA-sponsored study entitled, "Legal Constraints Relevant to Countermeasure Development," contract number DOT-HS-7-01536. Readers interested in a detailed treatment of the legality of speed countermeasures as well as other highway crash countermeasures should refer to the following documents:

> Ruschmann, P.A.; Carroll, H.O.; and Joscelyn, K.B. 1979. An analysis of the potential legal constraints on the use of mechanical devices to monitor driving restrictions. National Highway Traffic Safety Administration report no. DOT-HS-805-523.
>
> Ruschmann, P.A.; Greyson, M.; Joscelyn, K.B.; and Carroll, H.O. 1979. An analysis of the potential legal constraints on the imposition of owner liability for moving traffic violations. National Highway Traffic Safety Administration report no. DOT-HS-805-526.
>
> Ruschmann, P.A.; Greyson, M.; McNair, J.W.; and Joscelyn, K.B. 1979. General legal considerations relevant to highway safety countermeasure program development and implementation. National Highway Traffic Safety Administration report no. DOT-HS-805-525.

Ruschmann, P.A.; Joscelyn, K.B.; and Carroll, H.O. 1980. An analysis of the potential legal constraints on the use of advanced alcohol-testing technology. National Highway Traffic Safety Administration report no. DOT-HS-805-453.

Note that citations to cases and statutes in this subsection do not appear as footnotes to the text; instead, these are collected in Appendix E in the form of a bibliographic essay.

Restrictions on the Use of Certain Enforcement Procedures

As pointed out earlier in this section, enforcement procedures may be classified as either "overt" or "covert." Because many enforcement procedures are covert, and because the advent of radar detectors and citizens band (CB) radio has caused some police departments to perceive a greater need for covert procedures, this section is chiefly concerned with them.

Generally, the use of technology to aid law enforcement is not only permitted by law, but there is language in some court decisions to the effect that traffic violations demand the use of modern technology to detect and identify them. There are some circumstances under which the use of certain devices would violate the Constitution; however, these circumstances generally involve intruding into private places, or restricting one's freedom to move, without having sufficient cause to do so. Therefore, these constitutional provisions likely would not apply to the detection of speeders and other moving traffic violators.

However, apart from constitutional considerations, considerations of fair play have led a number of state legislators to prohibit or restrict certain traffic-enforcement practices, especially clandestine monitoring of traffic and the use of devices that allegedly "entrap" drivers. (Entrapment can loosely be described as police conduct that encourages individuals to commit offenses they were not otherwise inclined to commit.) One example of a fair-play issue involves police use of a speedometer "pacing" technique in which the patrol vehicle drives faster than the posted limit (usually adding a few mph "tolerance") and measures the speed of traffic behind it. When the patrol vehicle paces traffic by increasing speed until vehicles are no longer gaining on it, those drivers behind the patrol vehicle might be enticed into travelling faster than they intended (Darwick 1977, pp. 48-49). Owing to the perceived unfairness of this technique, at least one state (California) has prohibited this tactic by agency procedure (Darwick 1977, p. 48).

Another legislative constraint, found chiefly in California and Washington, is the prohibition of "speed traps" or time-distance speed measurements. These statutes prohibit the use of VASCAR and stopwatches, which use the time-distance principle; however, they do not prohibit the use of radar speedmeters.

In addition, some states have prohibited the use of radar under circumstances that lend themselves to abuse: for example, Mississippi prohibits local police in small communities from using radar on federal and state highways; Illinois forbids the use of radar within 500 feet of a change in the posted speed limit; and Georgia prohibits or restricts its use in a variety of locations. Finally, a number of states have passed legislation requiring the placement of warning signs in areas where radar is being used. The apparent intent of such restrictive legislation is to discourage police from unfairly preying on unsuspecting drivers. Moreover, some police departments have adopted policies prohibiting or discouraging unmarked or plain clothes traffic patrols, and the lack of funds has prevented some departments from acquiring certain enforcement devices (Darwick 1977, pp. 120-21).

Restrictions on the Use of Devices in Connection with Traffic Prosecutions

Even in states where unmarked patrols are allowed by law and department policy, and where the police use of certain detection devices is permitted, legislation and a number of legal constraints influence the use of these devices in obtaining convictions for traffic offenses.

Due process of law requires that guilt of a traffic offense be shown by reliable evidence; furthermore, to convict in most states it is necessary to establish the driver's guilt beyond a reasonable doubt. To be reliable, evidence obtained from an electronic or mechanical device must meet three requirements: (a) the device itself must be accepted in principle as scientifically reliable; (b) the specific device used in a particular traffic prosecution must be established as accurate; and (c) that device must have been operated properly (that is, the operator must have been properly qualified and trained, and he must have followed standard operating procedures) (Goger 1973, p. 827).

The first of these requirements—establishing the validity of a device's operating principles--initially requires that an expert testify at each prosecution in which the device is used and prove its scientific validity (Goger 1973, pp. 833-34). However, once a device comes into wide use, courts may become familiar with its operating principles in question and become satisfied that they are valid. At that point courts will accord that device "judicial notice," that is, they may dispense with the time-consuming requirement that an expert be brought in at each trial to prove principles that have already been widely accepted (Cleary 1972, pp. 763-66). Beginning in New Jersey in 1955, courts have accorded judicial notice to radar speedmeters (Cleary 1972, pp. 514-17); in addition, many states have passed legislation having the same effect as judicially noticing the principles of radar. Thus, in prosecutions using radar the ritual of expert testimony is no longer necessary. On the other hand, most courts have refused to judicially notice VASCAR; likewise, ORBIS has not been accorded judicial notice in any state.

Whether a device's operating principles are established by expert testimony or by judicial notice, that alone does not establish the accuracy of every such device. That, too, must be established through appropriate testimony. For example, the accuracy of radar devices can be verified through one of three methods: internal tests on the device itself; tuning fork tests (for example, a fork calibrated at 55 mph must produce a 55 mph reading on the radar device); and road tests using a vehicle with a calibrated speedmeter (Goger 1973, pp. 830-31). It is also necessary to show the device was accurate at the time of the alleged violation; thus verifications must have occurred at times reasonably close to the incident, and the equipment used to verify must have been accurate

(Goger 1973, pp. 843-58). Finally, a device--even when valid and accurate—must have been operated by a qualified person in accordance with standard procedures (Goger 1973, pp. 858-61).

The requirements of accuracy and proper operation may in effect become legal constraints if the equipment used frequently breaks down or requires constant maintenance and calibration. Thus, for example, VASCAR's reported downtime (Darwick 1977, pp. 138-39) could result in its being found inaccurate more often than would the radar speedmeter.

Thus, while the requirements of scientific recognition, accuracy, and proper operation do not prohibit police from using radar and other enforcement devices, they may require that additional time and effort be spent to ensure that these devices produce reliable evidence that is sufficient to obtain convictions; their occasional failure also might result in the loss of some convictions.

The Impact of Sanctioning on Enforcement Procedures

Even when a device is readily available for use and the evidence it produces makes convictions easily obtainable, its use still might be prevented or limited because of laws (and law-based practices) governing sanctioning. This is especially true with respect to enforcement directed at NMSL violations, because of hostility towards the NMSL in some sections of the county (Darwick 1977, pp. 104-5, 112-3). For example, some states have refused to assess violation points against NMSL violators unless their speeds exceeded previously posted limits, or exceeded the NMSL by a specified number of miles per hour. Other states have made "minor" violations of the NMSL (typically violations involving speeds below prior posted limits) punishable by nominal fines.

A small number of states continue to treat maximum speed limits as "prima facie," rather than absolute. This means that a driver is entitled at a trial to introduce evidence showing that his exceeding the posted limit was not unreasonable considering such conditions as weather, time of day, and the presence of other traffic. Retention of prima facie limits conceivably could give judges authority to find drivers not guilty of speeding offenses, even when their speeds are found to be above 55 mph.

However, prima facie limits have been disapproved of by the Uniform Vehicle Code, and all but a handful of states have replaced them with absolute maximum limits (National Committee on Uniform Traffic Laws and Ordinances 1972). It is also conceivable that in those states in which judges have discretion as to sanctions for speeding, comparatively light penalties could be imposed on NMSL violators.

Legislation and judicial practices that result in the imposition of relatively mild penalties on traffic violators are likely to be perceived by police officers as showing a lack of support for their enforcement practices. Thus, adjudication and sanctioning patterns could in some states impose de facto legal constraints on enforcing the NMSL and other traffic laws.

SUMMARY

Enforcement is one of four top-level functions that police agencies perform in the course of providing police traffic services. The other functions are accident management and investigation, traffic direction and control, and general motorist services. The police also perform numerous auxiliary and support functions including safety education, public information, vehicle inspecting, and others.

The role of enforcement in dealing with UDAs is to operate as a part of our Traffic Law System in deterring drivers from violating related laws. Procedures aimed primarily at deterring drivers without the necessity for apprehending them first are called **general deterrence** procedures and include methods for increasing the intensity of enforcement, making the enforcement effort more or less visible, positioning patrol vehicles within a sector of highway, and transporting police officers.

The intensity of enforcement may be increased either by increasing the actual or perceived number of police units performing surveillance and basic patrol of a given sector of roadway. Procedures for increasing the number of units perceived include methods for varying patrol schedules, public information and education campaigns, and signs and messages displayed along the roadway. One such display system, the Following Too

Closely Monitor, was the only procedure for following too closely that was found in the literature.

To make enforcement activity **more** visible, police park their vehicles so as to be in full view of drivers, use highly conspicuous observation platforms (in England), and mark their vehicles to make them more recognizable as police symbols. Enforcement activity is sometimes purposely made **less** visible to increase a driver's perception that the police could be anywhere ("Smokey is there, but you don't know where," to quote Brackett and Edwards [1977, p. 4]). This is accomplished by police hiding their vehicles (e.g., behind trees, or overpasses) or by disguising them as nonpolice vehicles (e.g., no red light visible, different color car, no departmental or state seal).

Police procedures also include different ways of positioning patrol units. Moving police vehicles of all types are used to travel with the traffic and more recently, to act as "chaperones" for a group of vehicles. Stationary vehicles are placed at the roadside in a variety of positions to make them more or less visible and may or may not be equipped with visible radar.

The three types of police vehicles that have been used in both general and special deterrent procedures are automobiles, motorcycles, and aircraft. Frequently, more than one type of vehicle may be used in a given procedure (e.g., automobiles and motorcycles). Both airplanes and helicopters are used, usually in combination with automobiles or motorcycles or both.

Special-deterrence procedures are used by police for deterring drivers who must first be apprehended for a UDA-related violation. These procedures involve surveillance, detection, apprehension, and various presanctioning and sanctioning activities. Surveillance/detection procedures tend to be equipment oriented. The speedometer and odometer of a police vehicle are still used in some jurisdictions in estimating the speed of a suspected violator by a technique known as pacing. Odometer pacing is used in most jurisdictions, but not as frequently as more modern instruments and methods (for example, radar). The stopwatch was once widely used for measuring speed but is generally restricted today to measuring speed from an aircraft.

Radar appears to be the most common speed measurement device in current use. Radars are attached to patrol cars, motorcycles, and fixed mounts. Both moving and stationary vehicles employ radar in covert and overt modes. When radar is impractical (e.g., when the angle between the radar line of sight is large), many jurisdictions use a device called VASCAR. This instrument computes speed when provided the distance traveled and the travel time of a vehicle.

Automated detection devices have been designed to eliminate the need for a human operator in detecting speeders. One such device was used experimentally in a city in Texas over the period of a year. It provided photographs of speeding drivers for use as a basis for warning letters sent to the owners of the vehicles in the pictures.

Both solo and team procedures are commonly used for apprehending speeders. The detecting patrol unit does the apprehending in solo procedures. Team procedures use a separate vehicle (or vehicles) to catch drivers who are identified as speeders by a detecting patrol unit. Team procedures involve moving patrol units, stationary units, or a combination of both. The units may be marked or unmarked. When target vehicles try to escape, most jurisdictions engage in "hot pursuit," although the policies for this practice vary widely among jurisdictions.

A citation or "traffic ticket" is the most common immediate outcome of an apprehension for most violations related to the UDAs of interest here. Nearly all of these citations lead to determinations of guilt and to impositions of fines and sanctions. License suspensions are imposed sometimes, but jail sentences are rare.

Legal factors have a great influence on the enforcement procedures that are used in a jurisdiction. Constitutional considerations limit the degree to which the police may intrude on a citizen or restrict his freedom to move. Some states have enacted laws explicitly prohibiting some practices and devices believed to entrap drivers. When such devices are permitted, due process of law places strict requirements on the admissibility of the information that they provide as evidence in a court of law. Finally, legislation affecting the sanctioning of suspected violators may, by treating the violations as nonrisky, discourage the police from vigorously enforcing those laws and act as a de facto constraint on police enforcement.

CHAPTER THREE
EFFECTS OF POLICE ENFORCEMENT PROCEDURES ON TRAFFIC VARIABLES

The preceding chapter has described enforcement procedures for UDAs and some conditions affecting their use. This chapter reviews empirical literature on the effects of the procedures on crash risk and on variables thought to be related to risk. Specifically, three types of dependent variables are considered:

- traffic flow variables (for example, speed and volume of traffic);
- traffic crash variables (for example, number of crashes per unit time); and
- traffic law violations (for example, number of vehicles exceeding the speed limit).

Both classes of enforcement procedures discussed in the preceding section are considered here, that is, general-deterrence procedures and special deterrence procedures. Each type of risk variable (for example, traffic flow) is discussed with respect to each class of procedure (for example, general deterrence).

A tabular presentation of the studies that form the basis of this section is contained in Appendix B. The appendix also contains detailed reviews of key studies done prior to 1973. These reviews were done in the course of earlier NHTSA-sponsored studies by the principal investigators for the present study and by other investigators (e.g., Joksch 1972; Fennessy and Joksch 1968). They are presented here to provide more detail and historical perspective for interested readers.

ENFORCEMENT PROCEDURES AND TRAFFIC FLOW

Measures of traffic flow include: volume, speed, and density; mean speed determinants; longitudinal distribution (headway); lateral clearance;

time of day and day of week; and weather (Joscelyn, Bryan, and Goldenbaum 1971). Most relevant to this discussion are volume, speed, density, and logitudinal distribution. The first three variables, as Joscelyn and associates (1971) note, are the most basic. "The fundamental relationship is V=SD, where V is the average volume in vehicles per hour, S is the average speed in miles per hour, and D is the average density in vehicles per mile" (p. 10). The longitudinal distribution of vehicles is measured as headway; this is "the time interval between the passage of successive vehicles going past a fixed point, or the distance between two vehicles as they move along the roadway" (p. 13). Most of the studies reviewed have focused upon speed; a few have dealt with headway and the other traffic flow variables. Their results are discussed below.

General-Deterrence Procedures

Evaluation of the effects of this class of procedures on traffic flow have focused on flow per se and on changes in flow. The procedural elements studied most often have been intensity of patrol and the characteristics of patrol. Most of the studies have dealt with the effects of procedures on speeding, but a few have examined other traffic flow variables such as headway and volume.

Intensity of Patrol. Both the effects of variations in the quantity and the frequency of patrol on traffic flow variables have been investigated. The results, particularly with regard to intensity of patrol, have not always been consistent.

Positive effects of law enforcement on speed reduction were reported in an early study by Baker (1954). Speed observations were made by day and night at eight locations before enforcement was increased and the first and third year following. Findings indicated that the increased enforcement resulted in slightly less than halving the excess speed per vehicle.

Shumate (1958) observed that the proportion of passenger vehicles exceeding the legal speed limit is reduced with the addition of patrol units to a given stretch of highway, but the average vehicle speeds are not affected by the addition of such units. As a measure for the intensity of enforcement, the average number of patrol units that a driver passed per mile was chosen. To study the effect of enforcement on vehicle speeds, a sample of 3000 vehicle speeds was obtained on four test routes in 1955, 1956, and 1957, and compared with samples from six similar highways. Speed limits were 65 mph, and data were taken in periods of free-flowing traffic. Both on test routes and control routes, the percentage of vehicles exceeding the speed limits decreased during 1956 and 1957 compared to 1955.

A chi-square test showed that the reduction of passenger vehicle speeds in 1957 was significantly greater ($p < .02$) than on control routes. However, there was no indication that level of enforcement influenced the average speed of traffic. In addition, there were indications that vehicle speeds tend to group more closely around the average when additional patrol units are placed on a given stretch of highway.

Michaels (1960) reanalyzed Shumate's data using different statistical assumptions. His analysis of speed variability agrees with Shumate's; that is, on the test routes, drivers cluster more nearly about the mean speed and do so in some relation to the frequency with which drivers encounter police patrol. Michaels' analyses also support Shumate's contention that enforcement level had little influence on the average speed of vehicles. Michaels reports:

> In general, the mean speed for both trucks and passenger cars decreased for both test and control routes from 1955 to 1957. In view of this, it is difficult to place much reliance on a hypothesis that increased enforcement reduced the average speed of vehicles. While there were definite decreases in average speeds in 1957, as compared with 1955, such decreases followed a similar pattern throughout the State and could not be related to an increase in enforcement activity. (p. 112.)

Differences in data interpretation between Michaels and Shumate arise in regard to the proportion of drivers exceeding the speed limit. Michaels notes that this proportion followed the same pattern as did the mean speeds; that is, there were decreases in the percentage of drivers exceeding the speed limit from 1955 to 1956 on both the experimental and the control routes. Thus, he maintains, there is little evidence to support the hypothesis that the decreases in the proportion of vehicles over the speed limit on the test routes were due to increased patrol.

As Michaels points out, the results of these data analyses suggest that effects of enforcement on traffic behavior may be quite indirect. The finding that variability in speed is influenced by enforcement and proportion of speeders is not (or is, depending upon the statistical assumptions employed in this case), indicative of the complexity of factors involved in enforcement and traffic control. Moreover, these results are further complicated by the results of a later study by Shumate (no date); here, he reports that neither the average speed, the proportion of speeders, nor the variance of vehicle speeds about the average are affected by an increase in enforcement activity. Reports such as these point out the necessity of understanding the methods of statistics and field study for investigations in highway safety.

The effects of varying levels of enforcement on traffic volume have also been investigated by the California Highway Patrol (1966), Michaels (1960), and Shumate (1958). None of these investigators found significant changes in traffic volume. In light of this evidence it seems reasonable to conclude that modest increases in enforcement activity do not greatly impede traffic flow.

The effects of manipulating the frequency of patrol presence on traffic flow have been investigated by Bracket and Edwards (1977). These investigators drew heavily upon operant learning theory in their research. As noted in Chapter Two, they studied the effect of the presence of a patrol unit on vehicular speeds under two reinforcement schedules. The aim of these different schedules was to convince motorists that a certain segment of roadway would be patrolled every day. A two-week period in which a patrol car appeared every day at the same hour was thought to be sufficient for this purpose; this condition effectively set up the process of continuous reinforcement to establish the association between the roadway and the presence of a patrol car. The investigators then hypothesized that a partial schedule of reinforcement would maintain the association, meaning that the patrol would not always have to be present to keep speeds suppressed. Two partial reinforcement patrol schedules were devised. One was a fixed ratio of patrol presence to patrol absence: of the five working days of the week, the patrol would be present three days and absent two days; the days of the vehicle's presence were to be selected on a random basis (Strategy I). The second partial reinforcement schedule was that of a decreasing ratio of patrol presence to patrol absence; the days of patrol's presence were to be selected on a random basis (Strategy II). The actual number of days the patrol car could be present were the same for both strategies.

Sites selected for study included both two-lane and four-lane roadways in Texas. These sites were chosen on the basis of five criteria: traffic density, accident rates; percentage of vehicles exceeding 60 mph; percentage of commuter volume; and roadway geometry. In addition, sites selected were not scheduled for construction activities during the experimental period. The experimental plan was a counterbalanced implementation of the two strategies on each highway. Strategy I was employed on U.S. 71 followed by six weeks of no treatment and then by Strategy II. The order of presentation was reversed for U.S. 105. Pretreatment speed measurements were taken the week prior to the implementation of each strategy.

The location of the patrol vehicle on the seventeen-mile segment was randomly selected for the first strategy implemented on the first roadway. This location schedule was then followed for each subsequent condition. The patrol vehicle was operated from the assigned fixed location. It was parked on the shoulder parallel to the primary lane of traffic (the lane having the largest volume). Officers operated their radar set under standard fixed radar operating procedures. When they left their position to cite a violator they always returned to their assigned location. The patrol vehicle remained on station for one and one-half hours in the morning from 1:00 to 8:30 a.m.

The implementation of these speed control strategies did affect speed-related traffic parameters over time. It was found that a speed control strategy employing a decreasing ratio schedule patrol vehicle presence (Strategy II) has a greater immediate impact on mean traffic speeds than a fixed-ratio strategy (Strategy I). The impact on the traffic parameters (i.e., mean speed and speed variance) created by the presence of a patrol vehicle did carry over to days when the patrol vehicle was absent; however, it took at least six weeks of strategy employment to generate this effect.

The effects of the speed control strategies were found to vary with road and traffic characteristics. For a four-lane highway, where traffic speeds were high, the speed parameter reduced was the mean speed; for a two-lane highway, where traffic speeds were moderate, the parameter reduced was speed variance. In addition, the impact on the mean traffic speeds was greater for the primary lane than for the secondary lane of traffic. Interestingly, no correlation was obtained between ticketing activity on a given day and the mean speed of traffic for that day. Brackett and Edwards also reported that the "halo" (spread of effect on traffic flow) surrounding the stationary patrol vehicle equipped with radar in this study can be as great as fourteen miles; the spread of effect extends to traffic from three to four miles upstream of the stationary patrol vehicle to ten miles downstream.

Characteristics of Patrol and Traffic Flow. The visibility and recognition of patrol and patterns of patrol are the two general deterrence characteristics that have been evaluated for effects on traffic flow variables. Most of the studies reviewed below have focused on the speed of traffic; a few have dealt with headway. In general, results seem to indicate that highly recognizable patrol activities have a positive effect on traffic flow variables.

The effects of highly visible and recognizable enforcement symbols are fairly clearcut with regard to traffic speed. Reductions have been reported in the mean traffic speed, in the proportion of vehicles exceeding the speed limit, and in speed variance. Moreover, these changes have been found to be significantly different from the speeds observed in the presence of unmarked patrol units (Duff undated; Dougherty 1977; Joscelyn, Bryan, and Goldenbaum 1971; Organisation for Economic Co-Operation and Development 1974; Reinfurt, Levine, and

Johnson 1973; Rowan and Keese 1962; Smith 1962).

The presence of a marked patrol vehicle also has been found to affect driver gap acceptance. Cooper and McDowell (1977) report an experiment to determine the effect of police on the merging gap acceptance response of drivers. The situation involved a left turn from a minor road into a major road at a T-junction. Police presence consisted of a manned police vehicle (either a patrol car or a motorcycle) parked in full view of minor road vehicles. Vehicle gaps were recorded with a portable television camera. The median accepted gap increased significantly from 4.6 seconds to 5.7 seconds when police were present ($p \leq .05$). No difference was detected between the effects of the patrol car and the motorcycle.

The above findings are supported by the work of Calica, Crowther, and Shumate (1964), who found that the presence of an enforcement symbol resulted in significant changes in headways. These changes, however, were small, that is, an increase of less than three percent in the percentage of vehicles traveling with headways greater than two seconds.

The data are not quite so clearcut in regard to the effects of patrol patterns of traffic flow variables. This is especially true for the moving versus the stationary patrol unit. Both positive and negative effects on traffic flow have been found. Baker (1954), for example, reports "some slowing of traffic" for both stationary patrol units and moving patrol units.

Several investigators have found the moving patrol unit to be the more effective enforcement symbol for reducing traffic speeds. Smith (1962) measured the immediate effects of moving and stationary enforcement symbols on driving behavior on two-lane, rural roadways. The speed limit on all test sites was 65 mph during the period of the experiments. The patrol vehicles used in the study were those regularly used in traffic enforcement by the state patrol. Smith's results indicate that the average traffic speeds were lowest during exposure to the marked car moving with the traffic flow.

Similarly, a study of Byvanen (cited in Organisation for Economic Co-Operation and Development 1974) found the effect of a single patrol car on speed to be most apparent while moving in the traffic and at a slower speed than the traffic stream; the effect of patrolling was identifiable within five kilometers (or four minutes) after overtaking the patrol. In contrast, hardly any effects were noticed approximately two kilometers after the parked patrol car was passed.

The effects on vehicular speeds of stationary and moving enforcement symbols on rural roadways were also investigated by Council (1970). The stationary vehicle was parked adjacent to the roadway in a position visible to oncoming traffic; the moving vehicle traveled in the traffic stream at five mph below the posted speed limit. The effect of the two symbols was indicated by changes in traffic of mean speeds, speed variances, the percentage of vehicles traveling at speeds above the posted speed limit, and the percentage of vehicles traveling at speeds above the posted speed limit, plus a 5 mph tolerance. Data were collected one and one-quarter miles upstream from the patrol unit and one and one-quarter miles downstream from the unit.

Council's analyses indicated a reduction in mean speed, variance and percentage of vehicles traveling above the posted speed limits and the speed limit, plus tolerance at the stationary unit. No significant changes in any of the measurements occurred with the moving patrol unit. Data collected by both Calica, Crowther, and Shumate (cited in Brackett and Edwards 1977) and Joscelyn, Bryan, and Goldenbaum (1971) also support the stationary patrol unit as a more effective enforcement symbol for affecting traffic speed variables than the moving patrol unit.

Stationary patrol vehicles may be placed in a variety of configurations. A number of researchers have also investigated configuration of patrol to determine which can most effectively influence traffic flow variables. Joscelyn, Bryan, and Goldenbaum (1971) examined the effects of six stationary enforcement configurations, representing various levels of police threats. The vehicle configurations chosen for study were: civilian; unmarked police; marked police; marked police with radar; marked police in arrest configuration with stopped civilian vehicle; and two marked police, one with radar. Results indicated that the more threatening enforcement configurations (i.e., arrest configuration) produced greater immediate decreases in mean speeds in percentage of speed violators. These decreases in speeds and speed violators generally were greater for same-lane than for opposite-lane traffic, when traffic is considered in relationship to the enforcement vehicle. The effects, however, died out more quickly than those produced by less threatening enforcement symbols. In general, reductions in speed were found to taper off at distances of about three miles. Neither traffic headways, percentage of headway violators, traffic densities, nor standard deviations in traffic speed were found to be significantly affected by the presence of the stationary enforcement symbols.

Smith (1962) also found that of several stationary patrol configurations, the simulation of an enforcement task had the greatest effect on mean travel times. The following enforcement configurations were employed: the control symbol (the complete absence of any enforcement unit); marked and unmarked patrol units parked perpendicular to the roadway on the side of predominant traffic flow; marked and unmarked patrol units parked perpendicular to the roadway on the side of nonpredominant traffic flow; marked patrol units parked parallel to the roadway directly behind a civilian vehicle on the side of nonpredominant traffic flow; marked patrol units that move into traffic on the side of predominant flow; and marked patrol units that move into traffic on the side of nonpredominant traffic flow. Each patrol unit was a vehicle regularly used in traffic enforcement by the state patrol and was manned by a uniformed officer.

Effects of the treatment conditions were examined by rank ordering them according to the mean travel times of the vehicles observed (i.e., the time, in seconds, required for a vehicle to travel from one observation point to another two miles downstream within the test site) for each condition after the introduction of the enforcement symbol. Based upon this rank ordering of travel times, Smith concludes that: (1) a greater effect is observed with the enforcement symbol parked or operating on the side carrying the predominant flow of traffic; and (2) while the marked patrol unit moving with the predominant traffic flow has the greatest effect, it is followed by the stationary unit simulating an enforcement task.

No significant differences on speed variables were found for three stationary enforcement techniques by Dart and Hunter (1976). Also included here was a speed enforcement scene. The other two techniques were a speed-check zone sign with a partially concealed, radar-equipped patrol car and a stationary marked patrol car. An analysis of variance yielded no significant differences among the three enforcement techniques. All treatments were accompanied by a substantial reduction in mean, median, and 85th percentile speeds in the vicinity of the enforcement unit; these reductions ranged from five to eight mph at the treatment location. The number of vehicles traveling faster than 55 mph was reduced by thirty to fifty percent. Traffic, however, began to recover speed within one thousand feet of the enforcement symbol and completely regained its speed within two miles of the treatment location.

Findings such as these indicate that police presence can indeed affect traffic flow. The exact nature of the effects, however, has yet to be determined. As Dart and Hunter (1976) state:

> The use of various enforcement techniques has received rather widespread attention over the years, yet there does not exist a firm relationship as to the effect the various techniques have on traffic behavior. . .
>
> There are perhaps other innovative enforcement techniques that may be considered in the future. . . . However, before any ideas are advanced to any degree, the concepts should be evaluated like other improvement programs. Only through such evaluation programs can the maximum payoff for each enforcement dollar spent be realized. (pp. 33, 35.)

Warning Signs and Automated Detection Devices. A variety of warning signs have been used to support police enforcement. The aim of such signs is to heighten drivers' awareness of their own driving behavior and to remind them of possible police actions against unsafe driving behaviors. A number of investigators have analyzed the effect of these roadside signs on traffic flow variables.

The Visual Speed Indicator (VSI) is a device for warning drivers about their speed (see Chapter Two for a description). This warning system appears to have an initial effect on drivers' speeds equal to that of police presence. However, the effects have been found to dissipate rapidly and disappear completely as early as two and one-half months after installation (Bundesanstalt fur Strassenwesen cited in Organisation for Economic Co-Operation and Development 1974; Eagle and Homans 1976). Neither Dart and Hunter (1976) nor Hunter and Bundy (1975) found any significant changes in their measures of speed for the VSI or a speed-check zone sign, respectively.

Warning signs have also been used to affect headways or gap acceptance in drivers. Comparable to the VSI is the electronic Following Too Closely (FTC) Monitor system (described in Chapter Two). This system appears effective in reducing the incidences of following-too-closely behavior. The monitors have been reported to be effective for as long as nine months after installation. Minimal police enforcement campaigns, interjected at such points, have been useful for again decreasing the number of short vehicle-gaps (Parker 1976; Traffic Safety Systems, Inc. 1971).

The Vought Missiles and Space Company (undated) report on the ORBIS III application in Arlington, Texas, stated that there were an average of at least 800 cars per day driving ten or more miles per hour over the speed limit on the test section of road prior to the installation of ORBIS. One week after the installation of the ORBIS stanchions but before activation of the ORBIS equipment, "hidden" radars revealed that the number of speeders had been cut in half, suggesting a general deterrence effect. The likelihood that any effect was due to general deterrence is strengthened by the fact that a PI&E campaign preceded the installation of ORBIS. The number of speeders continued to decrease after ORBIS was activated to a steady-state value of "15 to 25" per day, according to the Vought report. During a period of about one year, ORBIS was activated about 12% of the time, and a total of 231 warning letters but only fourteen citations were issued.

Dreyer and Hawkins (1979) field tested a mobile ORBIS III in Arlington, Texas, during January-April 1976. In this experiment, ORBIS was mounted in a van and used at four roadway sites having different speed limits (from 40 to 55 mph) and different roadway environments. The researchers found that the mobile configuration of ORBIS also reduced the precentage of speeders, having its greatest effect on the urban roadways at high "levels of enforcement" (i.e., percentage of the time the van was present). Mean speed was decreased slightly during the experiment, with the effect lasting several weeks after the van was removed.

The authors also estimated the cost-effectiveness of the mobile ORBIS operation and concluded that it was "less cost-effective than traditional enforcement methods" (p.vii). Effectiveness was defined in terms of citations issued, activity measure rather than an impact measure. NHTSA rejected the conclusion about cost-effectiveness, arguing, in effect, that it was improper to so assess an application that was experiental rather than operational.

Special Deterrence Procedures and Traffic Flow. Several studies have attempted to determine the traffic flow effects of procedures aimed at catching and punishing traffic law violators. As was noted in Chapter Two, such special-deterrence procedures are inherently more complex than current general-deterrence procedures in that they involve more functions. Unfortunately, the literature provides little evidence of studies of the effect of **functional** procedures on traffic flow.

Most studies have investigated the effects of the **total** procedure, and usually have not described the procedures in much detail. Thus, it is often difficult or impossible to determine conditions under which a change in a procedural component caused an observed effect. For example, a total procedure might involve parked, unmarked, solo patrol cars using radar for detecting speeding violators and might result in citations being given to all apprehended drivers, ninety percent of whom were then "convicted" and given $25 fines. A study might evaluate the effect of increasing the fine to $50 but fail to describe the other procedural components. Thus, generalization about the effect of doubling a fine is impossible, because of the possible influence of other components on the results.

Most special-deterrence studies reported in the literature examine the effect of increased numbers of citations on various dependent variables. For example, the California Highway Patrol (1972b) increased the number of speeding citations on one stretch of road by doubling the number of traffic officers patrolling that road. One would expect a general-deterrence as well as a special-deterrence effect as a result of this action. Although forty percent of the total arrests by the traffic officers were for speeding, no significant reductions in speed violations were observed on the roadway.

Booth (1978) has suggested that a traffic enforcement agency use unmarked vehicles if its goal is to increase arrests. However, Finkelstein and McGuire (1971) found "no overwhelming evidence regarding its use" (p. V-12) and recommend having the patrol unit in view of the motorist. The research on patrol configurations done by Joscelyn, Bryan, and Goldenbaum (1971) and Smith (1962) supports this latter viewpoint.

In another study, the Oregon State Police (1977) increased its speeding citations by fifty percent during the month of May 1977. Radar detection equipment was used, and special emphasis was placed on freeways and peak periods of traffic volume. This increase in citations issued was reported to be accompanied by statewide reductions in speed. The report stated:

> One result was a 31 percent increase in rate of compliance with the 55 mph speed limit on all Oregon highways and a 50 percent compliance on the freeways. At the same time, the number of vehicles traveling at speeds in excess of 60 mph was substantially reduced. The 85th percentile speed decreased two mph on all highways (62 to 60 mph) and four miles per hour on urban freeways (64 to 62 mph). The most noticeable effect on higher speeds was in the range of 60 to 64 mph where nearly 25 percent of Oregon motorists were driving in April. By the end of May, almost half of those drivers had slowed down to speeds below 60 mph. (p. 4.)

Reinfurt, Levine, and Johnson (1973) have also reported success with the use of radar in multifaceted speed enforcement campaigns. These researchers used a complex experimental design in which presence of radar, visibility of patrol, ticketing, and media publicity were all manipulated. Speed data were collected in forty-three North Carolina municipalities. Results of the study indicated statistically significant reductions in the proportion of speeders and in the average speed of traffic. However, it was the combination of the above four factors carried out in the project that was important; when considered alone, each factor reflected only marginal evidence of effectiveness.

ENFORCEMENT PROCEDURES AND CRASHES

The effects of police enforcement procedures on crashes have been studied less frequently (and often less rigorously) than the effects of such procedures on traffic flow. Empirical studies of the quantitative effects of both general- and special-deterrence procedures on crashes are discussed below.

General-Deterrence Procedures

Most of the studies in this category cited here were concerned with the effects of enforcement intensity on crashes. Only a few dealt with the effects of patrol characteristics.

Intensity of Patrol. In general, studies suggest but do not prove that increases in patrol strength lead to decreases in crash rates. The California Highway Patrol (1972a) reported a significant reduction in reportable crashes when manpower was increased by 500 traffic-officer positions. For all four roadways in the California study, fatal crashes decreased 16.9% and fatalities decreased 19%. Injury crashes decreased by 2.5%. Persons injured with severe injuries decreased 11.2%, with minor injuries decreased 1.6%. Crashes involving complaint of pain, however, increased 9.4%. Unfortunately, no control groups were used in the study, and correlational studies of the data did not rule out the possibility of spurious correlations that would negate the hypothesis that police activity is negatively correlated with members of crashes.

An earlier study of intensity of enforcement by the California Highway Patrol (1966) also suggested a decline in crash rates. In this study, 150 additional traffic officers were assigned to one specific highway. Generally, accidents were fewer in number during the study year than in the prior three years (i.e., 792). The decline for injury accidents, however, was the only statistically significant decrease (264 versus 348). Property-damage accidents actually increased slightly (424 versus 414), but the authors speculated that this reflected more extensive reporting associated with the increase in available patrol units. The number of drivers involved in accidents decreased by 150 in the 1964 study year over the 1961-63 period average. Interestingly, drivers from age 16 to 36 showed the largest decrease in accident involvement. Again, no control group was used in their study, and the correlational analyses are inconclusive.

Other investigators reporting a reduction in traffic accidents with an increase in the quantity of patrol are Dougherty (1977); Ekstrom, Kritz, and Stromgren (1966); Jeffcoate (1950); and Shumate (1958). All are plagued by methodological deficiencies that make their finding inconclusive. Nevertheless, the study designs and findings are **not** incompatible with the hypothesis that increased patrol intensity reduces the number of crashes.

Only one study reviewed did not find an effect for increased levels of enforcement on accident rates. This was Michaels' 1960 reanalysis of Shumate's data. Michaels notes that regardless of level of patrol, the differences between the test and control routes were consistently small. He further points out that 1955 (the comparison year) was an abnormally high year for accidents on one of the test routes. "Consequently, ascribing a reduction in accidents to the increased patrol was probably unwarranted" (p. 111). Comparisons of the accident data on the test routes with those of the rest of the state and with all the control routes show a significant reduction in number of accidents for both test and control routes. Michaels concludes that there appeared to be little reliable effect due to enforcement.

Characteristics of Patrol. Southgate (1975) investigated the effect of police observation platforms on accidents. He found that during a twenty-eight-day study period, only four accidents occurred on the roadway in England where the platform was placed. That was half the monthly accident average.

No significant relationships of any kind were found for types of stationary patrol activity and accident rates by Joscelyn, Bryan, and

Goldenbaum (1971). Neither all accident types combined nor personal injury accidents in particular were significantly affected. These investigators report:

> In effect, stationary enforcement tests failed to stem normal three-year accident rate trends in any way, nor did the numbers of accidents during test months differ significantly from those occurring during non-test months during the test year itself. (p. 144.)

Special Deterrence Procedures

There are relatively few studies on the effects on crash rates of police procedures employing special deterrence procedures. Much more has been written about the methods of surveillance, detection, and apprehension than about their effects.

As part of its Operation 101, the California Highway Patrol (1972b) did evaluate the effects of increased manpower and enforcement actions on crash rates. The major finding of this study was: manpower was increased; enforcement actions increased; driver violations were reduced; and crashes decreased. While this decrease was not significant for weekday crashes, it was statistically significant for weekend crashes. As noted previously, weaknesses in study design make it impossible to attribute these effects to the procedure used.

With regard to detection methods, Milardo (1974) has reported successful results for the use of VASCAR. In January 1972, the city of Middletown, Connecticut, purchased its first VASCAR unit. Traffic division personnel were trained in its use. At the end of the first six months of 1972, enforcement activities increased, and a crash reduction of twenty-two percent was noted over the first six months of the previous year. Whether this reduction was due to the VASCAR unit or to some other coincident factor is not known.

Other studies in this area suffer from similar methodological deficiencies. For example, a study by Kunz (1950) reported:

> In April 1945, the Springfield, Massachusettes, Police Department inaugurated a rigid traffic control program. Prior

> thereto the accident rate had greatly increaed. The policy decided upon was to enforce all traffic laws on an impartial basis. Officers were not required to meet any arrest quotas, but they were expected to take appropriate police action whenever a violation was observed. The results of the program exceeded the expectations of the police officials. Accidents were greatly reduced. The number of persons injured in 1945 was reduced more than 40 per cent, and in 1946, despite a tremendous increase in traffic volume, injuries were reduced to only one third of what they were in 1944. During this corresponding period arrests for violations were increasing at a rapid rate . . . as the arrests for moving violations increased, the number of accidents decreased rapidly. When there was a relaxation in arrests for moving violations, accidents increased.

This study suggests an enforcement effort but does not rule out other hypotheses or explanations for the observed decreases in number of crashes.

A recent study by PRC Public Management Services, Inc. (1974) evaluated NHTSA's Selective Traffic Enforcement Programs (STEP) in Sacramento, California; El Paso, Texas; and Chattanooga, Tennessee. of the nine police countermeasures tested among these three cities, the study found:

> The police countermeasure that has power to be most effective in reducing traffic accidents is . . . Patrol and Cite. In the areas where this countermeasure has been properly tested, traffic accidents have been reduced. (p. iii.)

The patrol-and-cite countermeasure was defined as follows:

> Patrol within assigned STEP area and/or location and cite or warn for all hazardous moving violations. (p. 6.)

The STEP evaluation design employed quasi-experimental methods wherein number of crashes during the STEP activity was compared to the number of crashes in an equal time period immediately preceding STEP. The effect of time of day during which STEP was operative was also investigated, and where possible, non-STEP areas of a city were used as a comparison areas for the STEP areas. The conclusions about countermeasure effectiveness apparently represent the judgments made by researchers after subjectively considering all these effectiveness indicators.

No attempt was made by the STEP evaluators to determine the extent to which observed effects were due to general deterrence or special deterrence, although the description of the patrol-and-cite countermeasure implies that a special-deterrence effect was the primary objective of that countermeasure. It seems likely, though, that at least some of the effects were due to general deterrence, since each of the three cities had public information components designed to "advise the general public concerning the need, purpose, and operational plan of the STEP" (PRC Public Management Services, Inc. 1974, p. 23).

ENFORCEMENT PROCEDURES AND VIOLATIONS

If traffic crash risk is related to the behaviors proscribed by traffic laws, then reducing the incidence of those behaviors should reduce risk. Unfortunately few studies have evaluated the effects of specific enforcement procedures on traffic violations other than speeding (discussed as a traffic flow variable earlier in this chapter). Selected studies that have analyzed the effect of enforcement procedures on violations other than speeding are discussed below.

General-Deterrence Procedures

Most investigations of the effects of general deterrence procedures on traffic violations have focused on the intensity of patrol. In general, the results of these studies indicate that presence of patrol alone can reduce the incidence of certain driving violations. Cooper (1974) has reported significant effects on driver behavior with increased police enforcement. In his study, levels of enforcement were varied from zero to two officers at nine, selected urban intersections. Records of traffic behavior and other possibly relevant variables (e.g., weather) were maintained daily by trained observers for the duration of the study. Of special concern were two general types of traffic violations: turning violations and traffic signal violations.

A number of interesting results emerged from this study. First and foremost, the study found that increased enforcement brought about reductions in the number of violations committed by motorists and that this effect appeared to be felt almost immediately. Driver behavior, however, tended to revert to its original characteristic following cessation of the increased enforcement. Moreover, while the program was in effect, adherence to traffic laws was higher during periods of actual police presence than during hours of absence.

Reductions in the number of violations being committed by motorists have also been reported with increases in patrol level by the California Highway Patrol (1969, 1972b) and by Dougherty (1977).

Only two studies were reviewed that dealt with patrol characteristics and traffic violations. The effects of vehicle type were investigated by Booth (1978). Police motorcycles, marked patrol units, and unmarked patrol units were placed in highly visible positions at urban intersections. The results yielded significant differences among the three enforcement symbols, with the motorcycle producing the greatest effect on the motorists' behavior, followed by the marked patrol cars.

An experiment by Klebelsberg (1963) suggests that the presence of a marked patrol car may very well reduce the number of driver violations. Twenty-two test rides of one to one-and-a-half hours were made with marked and unmarked police cars in and near Vienna. Regular patrol cars, unmarked patrol cars, and a regular civilian car were used. An observer within the car noted all possible violations. In the downtown area, thirty-two violations were seen from a marked car and thirty-four violations were seen from an unmarked car. This difference was not statistically significant. It was suggested that the color of the unmarked car (same as the patrol car) made it appear suspicious. There was a large difference between patrol-car observations and civilian-car observations: thirty-two versus sixty-two violations. On a major artery, the relation between marked car versus civilian car was 18:107, and on a road outside Vienna, the relation was 80:288. No detailed data were given and no statistical tests were made in the report, but the Poisson index of dispersion calculated from the data indicates that these latter differences are significant at the .01 level.

Special-Deterrence Procedures

Very few studies are available on the effects of procedures directed at increasing the apprehension and punishment of traffic law violators. The California Highway Patrol (1969, 1972b) has reported that increases in manpower do lead to increases in citations for violations and subsequently to reductions in violations. Little else has been reported.

The effectiveness of police written warnings in deterring traffic law violations was evaluated by Fitts (1966). The evaluation was based on a comparison of the subsequent behavior of persons who initially received a written warning for a traffic law violation with the subsequent behavior of persons who initially received a citation for a traffic law violation. Data collected were limited to drivers of Tucson, Arizona, as of May 13, 1964, who received written warnings, citations, or both for moving vehicular traffic violations issued by the Tucson Police Department between May 13, and May 31, 1964. The subsequent behavior of these motorists was then observed until October 31, 1964. During the observation period, June 1 through October 31, 1964, both written warnings and citations were considered evidence of further traffic offenses.

In the written warning group, 229 subsequently committed additional offenses, for a repeat rate of 18 percent. In the citation group, subsequent offenses were committed by 206 motorists for a repeat rate of 14 percent. A chi-square test of expected frequences suggested that persons in the initial citation group committed fewer subsequent offenses than were statistically expected and that the initial warning group committed more offenses than were statistically expected. Unfortunately, no tests for other significant differences between the two groups were reported.

SUMMARY

A number of studies have examined the effect of police enforcement procedures on driving behavior. Most of these studies have been conducted at a high level of aggregation, so that it is impossible to say what element of a given procedure was responsible for an observed effect or, in many cases, whether the effect was due to general deterrence or special deterrence. Also, many of the studies used faultv or weak experimental designs, making it difficult to determine the validity of their findings.

Generally, three classes of variables have been used to measure enforcement effects: traffic flow variables, traffic crash variables, and traffic law violations. The literature indicates that increasing both actual and perceived levels of enforcement tends to have a favorable effect of **traffic flow variables**. Increasing the visibility and apparent "threat" level of enforcement symbols also affects flow variables positively. Older studies have found that moving enforcement symbols have a greater effect on flow, but recent, more rigorous studies indicate that stationary symbols are more effective in this respect. Studies of the effects of increased numbers of citations suggest a positive effect but are not conclusive.

For the most part the effects of warning notices on traffic flow have not been evaluated in the available literature. Field studies of automated detection devices indicate beneficial effects on speed-related flow variables, but one study also found that such effects may be short-lived. The only documented procedure for enforcing laws following too closely is of this genre, and one study suggests that it can be useful in increasing following distances between vehicles.

Studies of the effects of police enforcement on **traffic crash variables** indicate positive effects. However, the studies are not conclusive as a whole because of a lack of data, a poor design, or the use of inappropriate statistical methods in some of the studies. The literature suggests that increasing intensity of enforcement reduces crashes; only one study concluded that such a procedure had no effect. On the other hand, most studies have not shown that any particular patrol characteristic (e.g., marked cars) results in fewer crashes than any other characteristic. The STEP experience in several cities is an exception, suggesting that "patrol and cite" procedures do reduce crashes in some instances.

Finally, the literature provides fairly strong evidence that certain police activities reduce the incidence of a broad range of **traffic law**

violations. Increasing enforcement intensity has been found to decrease turning and traffic signal violations as well as speeding. Highly visible and threatening enforcement symbols also appear to reduce violations. However, studies have not found great differences among commonly used sanctioning actions (e.g., warnings, citations) with respect to their effects on subsequent violations.

CHAPTER FOUR
RESOURCE ALLOCATION

It is clear from the preceding chapter that some police procedures can help to reduce the incidence of some UDAs that are proscribed by law. A logical next question is how should an enforcement agency spread its resources among these alternative procedures so as to achieve the highest return as measured by reductions in overall crash risk.

This chapter reviews literature that addresses this question. First, the general nature of the resource allocation problem faced by the Traffic Law System as a whole and the police enforcement subsystem is defined. Following this, the general knowledge needs for solving this problem are set forth. Lastly, resource allocation strategies that have been used or suggested are described.

THE RESOURCE ALLOCATION PROBLEM

The proper management of highway crash risk requires "the combination of knowledge of the nature of the risk with knowledge of the expected effects of alternative risk reduction actions to determine overall resource allocation policies, strategies, and tactics" (Jones and Joscelyn 1972, p. 105). The same report describes the general traffic safety resource allocation problem in a given jurisdiction as:

> . . . to determine the operationally feasible mix of risk control forces and their point of application, both spatial and temporal, which minimize the total traffic risk in that jurisdiction. (Jones and Joscelyn 1972, p. 105.)

More specific to the concerns of the present report, however, is the allocation of **enforcement** resources to the minimization of traffic crash risk. In this context, the resource allocation problem becomes one of determining how best to assign available police resources among police procedures and of determining where and when such procedures are to be used.

As is noted by Franey, Darwick, and Robertson (1972), proper allocation of resources is among the most critical problems facing law enforcement organizations. Concerns over efficiency and economy are uppermost in such organizations, and one of the largest concerns is that of salary. The authors further report:

> The salary portion of the police budget is by far the greatest expense in a typical departmental budget, and since the police department is usually one of the largest of state and local governmental agencies, police salaries represent a major expenditure to the taxpayer. (p. 54.)

These researchers also state that optimization of police resources is achieved:

> . . . through the scientific, geographical/chronological assignment of personnel and equipment and the establishment of preventive patrol to deal with specific categories of unlawful driving behavior, according to needs which were based on accident statistics, enforcement activity records, traffic volumes, and other local traffic conditions. (p. 1.)

To accomplish such an optimization, however, it is necessary to determine the payoffs or utilities associated with a particular allocation of effort. Both the inputs and the outputs of these efforts must be specified. Ideally, such information would provide complete knowledge of the effects on traffic variables of any particular level or method of traffic law enforcement under all conditions. Shoup (1973) refers to this type of knowledge as a production function: the desired effects on traffic safety and flow are the outputs; the police resources employed are the inputs. Important to the decision-making process, this production function shows how output changes in response to changes in input. Shoup states that "This is important because most questions of resource allocation deal with marginal changes: how much additional output will result from additional expenditure, or how much reduction in output will result from a reduction in expenditure?" (p. 3).

A more specific statement of the police enforcement resource allocation has been set forth as follows:

> It is desired to determine the operationally feasible mix of enforcement control forces and their points of application both spatial and temporal, which minimize the total traffic risk in the enforcement agency's jurisdiction during a given time period. (Jones and Joscelyn 1972, p. 106.)

Regardless of how this problem is stated, its solution requires an understanding of the knowledge needed for resource allocation. It is also necessary to be familiar with techniques for maximizing the effective deployment of manpower and other resources. These are the topics of the following two sections.

KNOWLEDGE NEEDS FOR RESOURCE ALLOCATION

A fundamental premise underlying the police traffic services function is that appropriate police action creates general and special deterrence of UDAs and thus reduces traffic crash risk. For the police risk manager, "appropriate police action" must be specified in terms of on-the-road procedures; the times and places such procedures are to be used; and the personnel, equipment, and facilities to carry out the procedures. This specification is dependent upon the total traffic crash risk in the enforcement during a given time period, available police resources to deal with that risk, and the effects of available enforcement procedures on risk.

If sufficient knowledge about these three factors were available, the police resource allocation problem could be solved by any one of a number of well-known mathematical techniques. Ideally, such knowledge should include:

- traffic accident risk as a function of location within the jurisdiction, time, and enforcement control forces;
- enforcement control forces as a function of enforcement resources;
- total enforcement resources available in the jurisdiction as a function of time; and
- operational constraints in the jurisdiction. (Jones and Joscelyn 1972, p. 106.)

Unfortunately, much of this needed knowledge does not exist, and a wide variety of substitute resource allocation schemes have had to suffice. The next section discusses some resource allocation strategies that have been used in practice and identifies more sophisticated techniques that have been suggested for developing future strategies.

STRATEGIES FOR RESOURCE ALLOCATION

Strategies for the allocation of police traffic resources have ranged from simple reliance on past policy to the utilization of sophisticated computer technology. The former tack is frequently taken because police agencies have tended to develop as reactive organizations; police organizations are so busy reacting to demands for service that little time can be spent in assessing the appropriateness of the action that occurs or how resources are allocated. Jones and Joscelyn (1972) note:

> It is often stated that the police merely respond to the greatest immediate pressure and do not engage sufficiently in conscious management of their resources. Police are said to base their resource allocation decisions primarily on tradition and even folklore rather than on rational analysis of needs and capabilities. In fact, police administrators themselves have been among the strongest critics of police resource allocation procedures. (pp. 1-2.)

This section outlines the range of resource allocation strategies that have been suggested and/or used by police agencies.

The Quota System

One way of specifying the incidence of enforcement actions to be taken by police has appropriately come to be termed by disgruntled motorists as the "quota system." This term seems to imply indiscriminate enforcement, which the police administrator perceives as conducive to the generation of public resentment. How the "public" reacts on this issue has not, to our knowledge, been documented. In one of the truly rare articles on the use of the quota system (disguised under the term "minimum workload"), former Chief Roy Betlach of the Washington State Patrol (WSP) discussed this system and the results he feels it produces and the problems it causes. Chief Betlach attacked the problem directly when he stated:

> . . . we always come up with the age-old question, 'What should a traffic law enforcement officer do in a day, a week, or a month's time?' 'What do we expect of them?' If we are going to tell a man he isn't producing enough violator contacts, certainly we should be in a position to tell him what was acceptable as a day, a week, a month's work. (Betlach 1960.)

Under this system, the WSP assessed the traffic contacts that their men had made in 1957 and found that each man had averaged twenty-eight verbal admonitions, thirty-one written warnings, and twenty-two citations for moving violations each month. These amounts were then set as the performance standards for the department. While the statistics used to measure the effectiveness of the program, in terms of accident reduction, were not rigorous, this was an initial step in the establishment of a practical enforcement production standard. Another report discussed this problem as follows:

> To some, enforcement implies that each officer must make a certain number of arrests in a given period. We do not operate on such a 'quota system' but we do demand that every officer on patrol devote the time available to strict, impartial law enforcement against all violators of the law. Emphasis is placed at all levels on the officer on patrol stopping violators. We in Delaware are convinced that the officer who is high in the number of cars stopped compared to the number of hours he spent on patrol is an effective deterrent to the traffic violators. I am equally convinced that persistent stopping of traffic violators, followed by a trial and conviction, or written warning, is the most effective means at our disposal to reduce traffic accidents. (Delaware State Police 1965.)

Obviously, assigning a quota is not a complete solution to the resource allocation problem, since the procedures to be used in filling the quotas are not specified. Also, the quota system "strategy" does not specify where and at what times given resources are to be allocated.

Selective Enforcement

Theoretically, if the police were in the position to observe every violation and to take enforcement action in every case, they could effect a great reduction in accidents. Since this is clearly impractical, given the scarce resources available to a police agency, a concept known as "selective enforcement" has been introduced. Selective enforcement may be broadly defined as the application of enforcement effort at those times and places where accidents are occurring with enforcement stress placed on those specific violations of the traffic law which are causing them (Bankhead and Herms 1970). Implicit in this concept is the assumption (which is generally supported by available data) that traffic accidents occur in repetitive patterns over significant periods of time. Another assumption is that it is possible to predict the time, "cause," and location of accidents by examination of historical data.

Selective enforcement has also been defined more narrowly as proportional resource allocation. Franey, Darwick, and Robertson (1972, p. 1) define selective enforcement as "enforcement which is proportional to traffic accidents with respect to time, place, and type of violation." Jones and Joscelyn (1972) developed a theoretical justification for proportional allocation and the conditions under which it constitutes an optimal policy.

Proponents of selective enforcement maintain that such programs can encourage voluntary compliance with traffic laws (Franey, Darwick, and Robertson 1972; Rutherford 1971a), but it is not without its critics. Stinson (1961) comments:

> The 'speed cop' is almost as American as the 'hot dog.' To suggest that he has outlived his usefulness is to risk burning at the stake for heresy -- or at least banishment from the police community . . . . One of the most respected leaders of police thought, Bruce Smith, suggested in 1950 that we had reached the point of diminishing returns from special enforcement units per se. He was critical of conventional traffic law enforcement with its emphasis on specialization and selectivity, and he advocated its application on a more equal basis to everybody, everywhere. (p. 564.)

Several studies have investigated the effectiveness of selective enforcement programs in various jurisdictions. Some rules of thumb have been proposed, but they are difficult to apply to specific jurisdictions. For example, the California Highway Patrol (1972a) reports that, to effect a change in accident rates, the proper range for manpower deployment was 2.58 men per mile per 100,000 ADT (average daily traffic) to 3.73 men per mile per 100,000 ADT. Manpower, in this study, was deployed on the roadway based solely on the Field Commander's experience.

Cooper (1974) also investigated the effects of varying levels of enforcement in order to provide some usable guidelines to police forces as to cost-effective use of manpower. Patrolmen were assigned to seven intersection locations having a traffic volume of 20,000 to 30,000 ADT. Cooper suggests that the gains to be expected in employing a saturation type of program may be marginal over somewhat more modest procedures. Assigning one policeman to an intersection for an hour a day produced a significant improvement over a virtually no-enforcement situation. Unlike the California study, increasing this coverage to two policemen for three hours per day reduced violation occurrence only slightly over and above the first level of enforcement increase.

The most extensive evaluation of selective enforcement was the aforementioned study by PRC Public Management Services, Inc. (1974). The study found that several enforcement procedures could reduce crashes but made no attempt to determine how the effectiveness of the procedures varied with the intensity of the enforcement effort.

Indices

A common approach for assigning police patrol units is to use a hazard or a workload formula. Here, factors thought to be relevant for manpower allocation are identified; for example, accident rates, apprehensions, and requirements for enforcement activities are factors that could be used. The next step is to assign a weight to each factor. If a hazard formula is being constructed, the weights will specify the relative importance attached to each factor. Fatalities might be given a weight of five, injuries a weight of three, and other accidents a weight of two. This means that fatal accidents are judged to be two and one-half times as important as the "other" accidents. If a workload formula is being constructed, the weights reflect the number of man-hours required to handle each factor.

The next step in this method is to combine the weights and the factors to obtain a "hazard index" or "workload index" within a jurisdiction. The workload index is found by multiplying the weight for each factor by the amount of the factor in the jurisdiction and adding the products for all factors. To calculate the hazard index, the total amount of each factor for the entire jurisdiction is first determined; the fraction of the factor that occurs in the area in question is the calculated. This fraction is multiplied by the weight, and the products are added together as in the case of a workload index.

The final step is to determine the total hazard or workload index in the entire jurisdiction and to allocate patrol units among areas in direct proportion to their indices. Then, a location whose index is, for example, seven percent of the total index for the jurisdiction would receive seven percent of the patrol units.

When an index is used in this fashion, it becomes a part of a larger program of selective enforcement. It is also possible to use the index for allocating officers across time as well as across geographical locations by calculating the index separately for each hour or shift. This is sometimes necessary because many of the factors in a hazard or workload formula vary by time of day.

Also note that rule-of-thumb indices have been widely used in the past by police agencies for evaluating their performance. One of the most common of these, the Enforcement Index, is based on the assumption that convictions with penalties for hazardous moving violations should be greater (by some multiple) than the number of fatal and personal injury accidents. Suggested figures range from a ratio index of fifteen for rural areas to upwards to thirty for some urban and problem jurisdictions. The President's Highway Safety Committee states that the principal value of the enforcement index is that:

> . . . it provides a numerical measure of the relationship between accidents and enforcement. . . . Such an approach,

> while superior to mere opinion, must be used with caution. The level of enforcement required for optimum accident reduction often varies considerably from one place to another and from one time to another. (President's Committee for Traffic Safety 1963, p. 10.)

Ratio criteria such as the Enforcement Index have proved to be particularly misleading measures of effectiveness in many similar operational problems (see particularly Hitch !19531). For one thing, the index assumes the existence of a single objective for an enforcement safety program. It does not measure either the deterrent value of an enforcement symbol or the influence of enforcement on traffic flow, which may be of comparable importance. Further, the index does not provide any measure of the actual number of violations that occur, but only those violations against which police action is taken. Unfortunately, the Enforcement Index has been used by many agencies as almost the sole criterion against which police traffic performance is measured. This treats all other police costs and activities (traffic direction and control, motorist services, etc.) as if they were free goods, which, of course, they are not.

The enforcement index has, however, acquired a certain aura of validity. It does make a concession to the quality of enforcement by including only hazardous violations, but it ignores the total amount of police/driver contacts, including police activities connected with the issuance of written warnings. It also uses a measure (convictions) over which the police have no real control.

Algorithms

Computational procedures (i.e., algorithms) have been proposed and, in some cases, used for allocating police resources for enforcing traffic laws (Bankhead and Herms 1970; Byrd and Preston 1976; Darwick 1977; Rutherford 1971a). The algorithms are usually based on historical data on "demand" for police services rather than an analysis of risk per se.

For example, Franey, Darwick, and Robertson (1972) have provided a "cookbook" approach to manpower allocation and distribution.

Step-by-step instructions are given for determining the proper number of persons in a department, the number of patrol beats for each shift, the structure of configuration of a beat, and the assignment of officers for each beat. The following steps are suggested for any workload-staffing distribution study:

1. The total number of calls for police service (complaints, offenses, and other incidents) handled by the police department for a one-year period should be carefully examined. The number of calls for service used may represent an accurate and statistically correct percentage of the year's total workload such as a twenty-five percent sample.

2. A map of the community should be divided into small reporting areas designed and arranged to facilitate later consolidation into patrol beats. Reporting areas should represent a population of approximately one thousand persons. If an area is less densely populated, the reporting areas will be larger in size.

3. Each incident should be located geographiclly on the map, and the reporting area for each call determined.

4. Each incident should then identified--and at the time of day of the week of occurrence (or reporting) should be ascertained.

5. This information should be entered on specially designed workload-personnel distribution coding cards--one card for each incident. This coding card should include the month, day, time, event classification, and the location by reporting area.

The use of a computer analysis is recommended to assess the within-shift variations in workload and the day-of-week variance.

The authors note that the heaviest workloads will normally occur on Friday and Saturday and suggest that the maximum number of patrol officers be available for the heavy workload days. The algorithm continues with steps required to determine the staffing requirements to meet expected service demands. Unfortunately, it does not specify steps for determining what procedures should be used in providing the services.

Mathematical Models

Mathematical models have been developed for a wide variety of uses in allocating police resources in general (Avi-Itzhak and Shinnar 1973; Bard 1976; Belkin, Blumstein, and Glass 1973; Chaiken et al. 1975; Larson 1978; Larson 1972). Joscelyn and Jones (1972) presented a detailed model for allocating traffic law system resources. Jones and Joscelyn (1972) also have indicated how classical operations research models could be applied to the traffic law enforcement problems. More recently, Summers and Harris (1978) developed a computer simulation model for studying general deterrence processes vis-a-vis the drinking-driving problem.

There is little evidence that any of these models have been widely used by operational agencies for allocating resources for police traffic services. Undoubtedly one reason for their lack of use is that they have not been widely disseminated or explained to police agencies. Also, many agencies do not have the capability to put the models into operation. A more basic reason why such models have not been used is the lack of data to put into them. A quick perusal of the evaluation literature discussed in the preceding section shows that the most basic element of these data, traffic crash risk as a function of police enforcement activity, simply does not exist.

Shoup's (1973) survey of police traffic services reached a similar but somewhat darker conclusion:

> . . . there is no quantitative and objective evidence currently available that enables us to recommend any optimal or 'desirable' levels of traffic law enforcement or standards for police performance based on the material collected and analyzed in the course of this study. (pp. 1-2.)

Thus, a significant effort appears necessary to develop needed information before mathematical models can be used to any great extent in allocating police resources for enforcing traffic laws.

Information Systems

Another approach to allocating police resources is to use information systems

> . . . to provide decision makers with relevant and timely **risk information** for use in their own informal decision-making process. Such an approach places less emphasis on the allocation process itself, relying more on the user's experience in dealing with complexities and subtleties of real-world operations. Instead, it stresses the quality and availability of the information needed to make rational, if not mathematically optimal, decisions. (Jones and Joscelyn 1972, p. 3.)

The Indiana University Institute for Research in Public Safety (IRPS) developed and implemented a Computerized Highway Traffic Information System (CHTIS). The system provided risk information to an operational police agency for allocating traffic enforcement resources within its jurisdiction. The CHTIS used a computer-sensor system to gather, process, store, and retrieve information on traffic flow and traffic crashes at selected locations in Bloomington, Indiana.

Risk information generated by the CHTIS was provided to personnel at the local State Police post via cathode ray tube image and hard-copy computer printout. Thus, police were able to use the system to obtain on-line information concerning traffic behavior at any selected sensor location in either lane of traffic, and were provided daily summary reports on speeding violations and headways at all sensor locations. The police could then put this information to immediate use in allocating their manpower where they believed it would have the greatest impact on violators and, consequently, on accidents.

The user agency found the CHTIS to be a highly useful operational tool. The system was quickly incorporated into the regular police routine for scheduling and assigning personnel and for designing new tactics for enforcing traffic laws (Jones and Joscelyn 1972). However, the effect of the system on traffic crashes or crash-related behavior was not determined.

SUMMARY

An important aspect of police management is the allocation of police traffic resources among alternative enforcement procedures. Ideally, the resource allocator would like to minimize traffic crash risk in his jurisdiction by determining when to apply which procedures at which location. This, in turn, requires knowledge of the crash risk as a function of time and place, the availability of police resources, the effects of given procedures on crash risk, and the factors that constrain the use of the procedures in a given jurisdiction.

Several strategies have been suggested and/or used for allocating police resources for enforcing traffic laws. **Quota systems** have been used to set standards for enforcement activity by specifying (sometimes formally, but mostly informally) how many warnings or citations a patrol officer should issue in a given time period. Such systems are generally unsatisfactory solutions to the resource allocation problem because they do not specify the procedures to be used or their locations and times of application.

Selective enforcement (sometimes called proportional allocation) has been widely promoted by police analysts as a more rational approach to allocating scarce resources. Its basic tenet is that patrol units should be allocated as a function of the number of crashes of different types that occur in various places at different times in a jurisdiction. Sometimes, **indices** based on workload or fraction of a jurisdiction's total "hazard" at a time and place are used to determine patrol assignments in accordance with selective enforcement principles. Some of the more simplistic of these indices (e.g., the enforcement index) have been recognized as misleading and generally unsatisfactory by police authorities and are no longer recommended. Cookbook procedures (i.e., **algorithms**) have also been developed for allocating police resources to meet service "demand" given a fixed level of resources.

The more sophisticated **mathematical models** that have been used by some large jurisdictions to allocate police resources to a broader range of risks (including "crime") do not appear to have been widely used in the more specific case of traffic enforcement. The lack of use of these inherently more powerful tools is probably due to inadequate transfer of the technology to operational agencies, insufficient police capability to use them, and the lack of critical data needed to "feed" the models.

Information systems specifically tailored to the needs of police traffic enforcement have been developed and used experimentally for resource allocation. One such system provided real-time information on traffic flow and historical data on crashes to a state police post for use in assigning patrol units. This system was quickly incorporated into the regular operational procedures of the post, but its ultimate effect on traffic crashes in that jurisdiction was not determined.

In fact, few resource allocation schemes have been evaluated in terms of their impact on traffic safety. One exception is selective enforcement which was evaluated in three cities and found to have had a positive effect on crashes. However, it could not be determined from the evaluation whether the procedures or the allocation techniques were responsible for the observed effect.

CHAPTER FIVE
CONCLUSIONS

This literature review identifies and discusses documents on **police procedures** for enforcing laws related to three unsafe driving actions (UDAs): speeding, following too closely, and driving left of center. Associated procedures designed to reduce the incidence of these UDAs are also discussed (e.g., the deterrent effect of police presence).

SUMMARY OF FINDINGS

The literature on police traffic services is quite extensive. Many documents deal with speed law enforcement. However, only one document was found that dealt specifically with police procedures for enforcement of following-too-closely laws. No literature specifically dealing with police procedures for enforcement of driving-left-of-center laws was found.

The literature describing police procedures contains few surprises. Most procedures for enforcing speed laws are well known and could be described by any observant driver. When the objective is to apprehend and punish a driver (i.e., special deterrence), one or more officers must observe the driver committing the violation; measure the speed of the driver's vehicle; apprehend the driver; and arrest the driver or, more commonly, issue a traffic ticket.

Procedures that involve one officer using radar from a marked police vehicle are the most common. Procedures that require "advanced technology" (e.g., automated detection system) are uncommon. Table 5-1 presents a brief summary of the components of common police procedures for speed law enforcement as reported in the literature.

The other UDAs (following too closely and driving left of center) are not discussed at length in the literature. Enforcement actions for these violations tend to flow from the general police traffic function. Officers

TABLE 5-1

COMPONENTS OF COMMON POLICE PROCEDURES FOR ENFORCING SPEED LAWS

VEHICLES		Measurement Equipment	DEPLOYMENT		
Type	Marking		Solo/Team	Moving/Stationary	Overt/Covert
Automobile	Marked	Radar	Solo	Moving	Overt
Motorcycle	Unmarked	VASCAR	Team	Stationary	Covert
Aircraft*		Stopwatch			
		Speedometer/ Odometer			

* Usually uses stopwatch for measuring speed, works as a part of a team with autos and/or motorcycles.

on routine patrol may observe these violations and, at the officer's discretion, take enforcement action. This is in direct contrast to the procedures associated with speed law enforcement. Specific resource allocation strategies for speed law enforcement are frequently developed. Officers are equipped with specially designed measurement devices (e.g., radar) and assigned to specific locations at the times speed violations are believed to be most dangerous. Similar strategies for the other UDAs do not commonly appear in the literature.

SPECIFIC OBSERVATIONS

Another contrast is that traffic tickets are frequently issued to non-accident-involved drivers for speed law violations. Issuance of traffic tickets for following too closely or driving left of center frequently follows an accident.

Speed law enforcement is generally a proactive police traffic action intended to reduce the incidence of the speeding UDA. Enforcement of laws related to following too closely and driving left of center is usually a reactive police action occurring as part of the investigation of a traffic crash.

The speed UDA is deliberately addressed by the police by use of general- and special-deterrence strategies. Following too closely and driving left of center are addressed almost entirely by special-deterrence strategies, except to the extent that general police activity may be a deterrent.

GENERAL OBSERVATIONS

We have examined the literature on traffic law enforcement periodically over the last twelve years and have reported on the state of knowledge it reflects (Fennessy and Joksch 1968; Jones and Joscelyn 1972; Joscelyn, Bryan, and Goldenbaum 1971; and Joscelyn and Jones 1978). The present review does not reveal significant advances in the state of knowledge. Police departments have better trained and educated personnel and make more effective use of technology than they did twelve years ago. Today, more attention is given to deliberate resource allocation, officer productivity, and the development and implementation of traffic law enforcement strategies and tactics. Despite these improvements in the organization and delivery of police traffic services, there is not any clear evidence that new, effective risk-reduction strategies for the UDAs of interest have been discovered.

The literature, past and present, does support some general observations.

- Traffic flow behavior is influenced by police presence. In the immediate presence of a marked patrol vehicle, there is usually better compliance with traffic laws. This is referred to in the literature as the "halo effect." The effect dissipates when the police officer leaves.
- With the exception of the clearly demonstrated effect of overt police presence on traffic flow behavior (the halo effect), the effects of police procedures on reduction of the incidence of unsafe driving actions and, ultimately, on the reduction of the incidence of traffic crashes have not been objectively established.
- Existing police traffic enforcement procedures are based in the criminal law or quasi-criminal law. Personal identification of a violator and proof that the violator committed the offense are basic requirements for legal system action. These fundamental legal constraints greatly limit the strategies the police can implement. The legal constraints dictate a labor-intensive approach.
- The number of police officers needed for a large effect on traffic flow behavior through presence or to apprehend most violators, given present violation rates, is far beyond existing personnel levels.
- Driver behavior is governed, to a large extent, by the driver's perception of the likelihood of police action rather than the actual probability of apprehension. Public perception of police activity can be enhanced through credible public information activity. Over time public perception becomes more accurate so that the perception of enforcement will approach reality.
- The preferred police traffic strategy appears to be a

general-deterrence approach. Use of visual enforcement symbols (e.g., marked cars, conspicous patrol activity) to create the image of maximum police presence, coupled with a public information campaign, characterize this strategy. Actual apprehension and sanctioning (special deterrence) are limited to that thought to be absolutely necessary to create a credible perception of enforcement. Enforcement action is targeted at high-risk actions (e.g., reckless acts, deliberate violations, etc.).

APPENDIX A

DESCRIPTIVE LITERATURE ON ENFORCEMENT PROCEDURES AND THEIR EFFECTS

APPENDIX A

DESCRIPTIVE LITERATURE ON ENFORCEMENT PROCEDURES AND THEIR EFFECTS

Introduction

This appendix presents brief synopses of documents that describe police enforcement procedures for relevant traffic law violations. The documents are in general nonempirical and are more concerned with the nature of enforcement activities than with their effects. Conclusions about any such effects are to be interpreted as the opinions of the authors of the studies, since corroborating data are not always presented in the documents.

The synopses are presented in tabular form and in chronological order. Each synopsis lists the author(s) and title of the document, its topics, and a brief summary of its conclusions.

Obviously, not all descriptive literature could be included in the table. If a document was judged to provide a good description of police activity, or of a factor influencing activity, it was included. If the description was too vague or merely speculative, it was not included.

Author(s)	Title	Topics	Summary
Claybrook, J. (1978)	The 55 mph challenge.	1) resource limitation 2) technical activities underway or planned by NHTSA 3) need for compliance criteria 4) public information programs	currently, most effective means of voluntary public compliance is: 1) visible enforcement presence 2) mobile radar 3) unpredictable police movement 4) public information programs bold decisions about resource allocation will have to be made
Dadigan, L.S., and Ferguson, F. (1978)	Computer mapping aids pinpoint crime and accident trends.	1) limitations of traditional "pin maps" 2) ability of Synagraphic Computer Mapping (SYMAP) program to correlate information for accident trends, and use any variable that can be measured or observed	can be used for police resource allocation
Hirsch, T. (1978)	Police and speeders match wits in battle of electronics.	1) police tactics with VASCAR; helicopters; solar-powered devices that activate a motorist's detector unit. 2) fleet of nontraditional vehicles	1) Arizona Highway Patrol stopped using most radar units; average highway speeds and fatalities increased. 2) states need more stringent guidelines
Chaiken, J.M. (1977)	Patrol allocation methodology for police departments.	1) mathematical models to assist in allocating patrol resources 2) underlying principles of patrol allocation analysis 3) measures of performance	computer programs can meet objectives established by departments
Darwick, N. (1977)	National maximum speed limit (NMSL) enforcement practices and procedures. Final report.	examination of factors that affect police enforcement so that a resource document can be provided to all state police and highway patrols	within limits of available resources and personnel, agencies are enforcing NMSL
National Highway Traffic Safety Administration (1977a)	Manual for police traffic services personnel performance evaluation system. Management and implementation. Volume I.	a description of an evaluation system to provide measures of a patrolman's performance of police traffic services	no summary
Rasmussen, K. (1977)	"Bear in the air": Enforcement in Oklahoma.	1) aircraft program to increase "halo" effect 2) increase number of citations by ground units with air-to-ground communication 3) cost-effectiveness is comparable to conventional patrol	fixed-wing aircraft in conjunction with ground enforcement for selective and other enforcement tasks

Author(s)	Title	Topics	Summary
Spolander, K. (1977)	Traffic law enforcement. A review of the research on the effects of police law enforcement, and a problem analysis. (Summary only is in English.)	1) discussion of the three types of studies of police law enforcement: a) experimental b) nonexperimental c) effects on behavior 2) road user expectations of police enforcement 3) subjective probabilities of police detection, action, and sanction	1) due to restricted resources, future research should focus upon detecting the road user before being detected by him 2) the impact on road safety of police law enforcement depends on the validity of road rules
Swisher, R. (1977)	The Diamond Bar neighborhood/CHP traffic watch.	1) excessive traffic violations by community leads to citizens' traffic watch 2) some legal and enforcement training by CHP 3) possible legal and social problems	no summary yet; program still in the initial phase
Byrne, E.C. (1975)	Preventive and selective enforcement of traffic laws.	1) development of Enforcement Quotient (EQ): a formula to determine how well an agency is doing in enforcing traffic laws outside of accident situations	no summary
Jones, E.W. (1975)	The enforcement role.	1) external factors affecting police behavior 2) uniformity of laws and enforcement initiation of legislation from traffic law enforcement	no summary
Southgate, J.R. (1975)	Police observation platforms on motorways.	1) use of police observation platforms to improve surveillance of traffic flows and behavior, make police presence more conspicuous 2) data presented as to the danger of using the shoulder of the road on which to park a vehicle 3) data collected about use of platforms by patrols 4) general principles to be followed in the siting, layout, and construction of platforms	there is clearly a need for motorway observation platforms
York, R. (1975)	CHP ascends to higher levels of patrol capabilities with the STOL airplane program.	advantages and functions of Short Take-off and Landing (STOL) aircraft	STOL airplane has proven itself as useful, safe, and able to accomplish tasks that ground crews cannot.

Author(s)	Title	Topics	Summary
Milardo, D.T. (1974)	43.7% accident reduction.	1) a combination of tactics to reduce accidents including radar, VASCAR, videotape, support of administrators, new system of recordkeeping; arrests for nonaccident related violations	the direct relationship of increased non-accident related selective enforcement to accident reduction is apparent
Organisation for Economic Co-Operation and Development (1974)	Research on traffic law enforcement: Effects of the enforcement of legislation on road user behavior and traffic accidents.	1) psychological aspects of road user behavior 2) use of electronic equipment; cautionary letters; stationary v. moving enforcement symbols	extensive research is needed in most areas
Franey, W.H.; Darwick, N.; and Roberson, F.D. (1972)	Selective traffic law enforcement manual. Final report.	selective enforcement programs--personnel, implementation	opinion: intentional unlawful acts by drivers can be discouraged by fair, consistent enforcement
Rice, R.A. (1972)	A study of varying degrees of speed limit enforcement.	1) enforcement of speed limits and accidents in Australia 2) numerous factors other than enforcement might have contributed to accident trend; not controlled for 3) introduction of radar lowered the tolerance from 15 to 10 mph over the speed limit 4) use of radar warning signs and "Q" cars (unmarked cars; plain clothes officers)	no controls, no analysis: author states that certainty of apprehension is still the best deterrent against speeders
Newby, R.F. (1970)	Effectiveness of speed limits on rural roads and motorways.	a review of investigations into the effect of imposing speed limits on roads outside urban areas in the United Kingdom	1) speed limits as applied in practice have nearly always led to immediate reductions in vehicle speeds and in average accident rates 2) before setting limits, must take into account speed distribution, accident rate, features of road and environment
Witheford, D.K. (1970)	Speed enforcement policies and practice.	1) a survey of current speed enforcement practices 2) more uniformity needed for inter/intrastate regulations 3) need for diversity of enforcement to deter general population and target groups 4) concept of criminality as applied to traffic violations	1) most departments feel that a combination of open and concealed speed enforcement methods offers the best hope for effective speed enforcement 2) need for studies to demonstrate appropriate types of laws

Author(s)	Title	Topics	Summary
Coon, T.F. (1969)	Law enforcement and technology welcomes the chopper "copper."	1) equipped with radios, cameras, floodlights 2) can patrol in six hours what 15 patrol cars cover in 24 hours 3) need for new training and procedure programs	especially helpful monitoring traffic at large events, on major highways, vacation and holiday traffic flow
National Highway Safety Bureau (1969)	National Highway Safety Board priorities seminar. Proceedings. Volume 7. Enforcement.	1) how to measure police effectiveness (by using accident data) 2) need for scientific equipment 3) fiscal concerns 4) traffic records system	use of organizational, legislative, and procedural considerations to reduce accident risk
Pilot, J. (1969)	Instant re-play for the traffic violator.	use of video unit in the cars of state troopers to film traffic violations	video unit confirms officers' reports in event of civil action; "visual education" to those apprehended
Campbell, D.T. and Ross, H.L. (1968)	The Connecticut crackdown on speeding: time-series data in quasi-experimental analysis.	1) examination of the Connecticut "crackdown" on speeding 1955-1956 2) the methodology does not control for "six common threats to validity of experiments"	there is not sufficient evidence to prove that the heightened enforcement effort caused a decrease in highway fatalities
Fennessy, E.F., Jr., and Joksch, H.C. (1968)	Police traffic services and road safety: An evaluation of the literature. Interim report no. 1.	1) description of police traffic services 2) quantitative studies of police traffic activities 3) role of police in traffic services 4) recommendations for future research	critical review of studies about the relation of police traffic services to highway safety
Fennessy, E.F., Jr. et al. (1968)	The technical content of state and community police traffic services programs. Final report.	1) critical evaluation of empirical literature of police traffic services and its relation to highway safety 2) review of nonquantitative literature, including societal systems associated with police agencies 3) recommended program for police officer training and education; for research 4) field survey of 101 police jurisdictions, examination of services	1) Operation 101 is only quantitative study that clearly shows accident reduction due to enforcement efforts 2) currently, no objective evidence available that allows "optimal" or "desirable" levels of enforcement (a lengthy work that examines numerous areas of police traffic services)
O'Neal, R.A. (1967)	Here's VASCAR!	a desription of VASCAR; mechanics and operational principle	a simple, accurate and highly versatile device that vastly increases the effectiveness of the officer on patrol (measures vehicle speed)

Author(s)	Title	Topics	Summary
Pringle, S. et al. (1967)	The enforcement of traffic laws: Some current legal problems.	1) electronic speed-measuring devices 2) stopping motorists to inspect license or vehicle 3) implied-consent statutes	opinion: need a balance of safety and individual freedom
Bennett, W.W. (1958)	Radar in traffic enforcement.	1) statistics obtained from radar charts; observations, conclusions, and opinions of a chief of police 2) enforcement index: convictions penalty for hazardous violations; divided by the number of fatal and personal injury (P.I.) accidents	1) predictions of the ratio of vehicles traveling within the various speed minimum and maximum brackets, on any street, may be made with a reasonable degree of accuracy, providing several hours of study of vehicle speeds on this street and times of checks are obtainable 2) probability of being ticketed for speeding, even after detection by police, remains low

APPENDIX B

EMPIRICAL LITERATURE ON THE EFFECTS OF ENFORCEMENT

APPENDIX B

EMPIRICAL LITERATURE ON THE EFFECTS OF ENFORCEMENT

Introduction

This appendix lists and discusses a collection of empirical studies on the effects of enforcement on traffic. The appendix is presented in two parts. Part I contains brief synopses in tabular form of key studies published in the 1954-1978 period. The table lists the author(s) and title of each study, the dependent and independent variables examined, the measurement instruments used, and the author(s)'s summary of results. The studies are presented in chronological order.

Part II of this appendix contains more detailed reviews of studies published prior to 1973. The reviews include comments on methodological problems. The following sources cited in Part II were reviewed by Joscelyn, Bryan, and Goldenbaum (1971) in an Indiana University study: Baker (1954); Calica, Crowther, and Shumate (1964); Crittenden (1966); Council (1970); Huffman et al. (1961); Michaels (1960); Rowan and Keese (1962); Shumate (1958); Shumate (undated); and Smith (1962). The remaining critical reviews were taken from Fennessy and Joksch (1968) and Joksch (1972). The reviews in Part II were compiled by John H. Komoroske.

More detailed reviews of key studies in the 1973-1978 period are contained in Section 3.0 of the body of this report. The citations in both Part I and Part II of this appendix refer to the Bibliography section of the report.

Since traffic crashes are relatively rare events, many of the studies use a number of different "indicators" to measure the effects of enforcement. The effects of enforcement on travel speeds and speed law violations are frequently examined. While speed (principally deviation from average speed) is believed to be a major cause of traffic crashes, it appears that many of the studies have examined this variable because it is easier to measure than other traffic flow variables.

Many of the studies examined have methodological shortcomings that render the conclusions questionable. It is critical for the reader to grasp the methodological problems associated with research in this area. Such an understanding should allow critical review of future studies and enhance the quality of personal research efforts.

The relatively limited number of studies raises another methodological problem, that of validity. Only in a few cases have the research designs been replicated by other researchers with similar results. Thus, one is unsure of the degree to which the results of a particular study have been influenced by unique local conditions. Caution must be exercised in generalizing from the studies, particularly, those conducted in foreign countries.

APPENDIX B, PART I

TABULAR SYNOPSES OF KEY STUDIES ON ENFORCEMENT EFFECTS 1954-1978

Author(s)	Title	Dependent Variable 1	Independent Variable 2	Measurement Instrument	Author's Summary of Results 3
Booth, W.L. (1978)	Which vehicle: The Greensboro traffic enforcement vehicle experiment.	point at which brake lights come on, signifying recognition of enforcement vehicle	1) police motorcycle 2) unmarked police car 3) marked police car	1) observer 2) video film camera	1) motorcycle was recognized before either marked or unmarked cars 2) more CB broadcasts about motorcycle than either car 3) no traffic violations while cycle was visible
Brackett, R.Q., and Edwards, M.L. (1977)	Comparative evaluation of speed control strategies, vol. 2. Detailed description. Final report.	speed	1) reinforcement schedule 2) placement of patrol vehicle 3) type of highway	radar	1) patrol vehicles able to control traffic speeds on days when not present 2) effect noted only for commuter population
Cooper, D.F., and McDowell, M.R.C. (1977)	Police effects on accident risk at T-junctions.	gap acceptance	1) presence of police 2) presence of signs 3) neither	video camera	if warning signs are present, police have a significant effect on a junction without the commitment of continuous presence
Dougherty, D.A. (1977)	Illinois traffic safety programs: Report of evaluation or assessment. Selective traffic enforcement program, Champaign. Interim report.	1) accidents 2) citations 3) average speed 4) public awareness	patrolmen and marked vehicles	(not stated)	author states there is a disproportionate amount of time spent on speeding enforcement when causal factors of accidents continue to include disobeying red signal, improper turns, failure to yield and lane usage
New York State Police (1977)	Strike force for speed enforcement: Final evaluation.	speed	1) speed enforcement teams 2) publicity	radar and "other devices"	1) appears that speeds were significantly reduced at certain areas 2) author states that study design was not rigorous
Bensen, O.C. (1976)	North Dakota selective traffic enforcement program (STEP). Project director's report.	1) hazardous violations; accidents 2) speed and vehicle volume 3) accidents	1) STEP team 2) public information campaign; radar enforcement 3) manhours and number of enforcement officers	radar	selective enforcement may reduce hazardous violations/accidents in areas where traffic conflicts are not due to congestion
Byrd, R.N., and Preston, C. (1976)	Effect of highway patrol field strength on accident rates.	analysis of accident data: time available for traffic enforcement, accidents, road miles per patrolmen, number of drivers, field strength			1) each patrolman will decrease Property Damage Only accidents by five, and fatalities by one 2) a point will be reached where additional manpower will not result in the same benefits 3) author presents a method that can be used to determine size of force necessary to affect accident problems

Author(s)	Title	Dependent Variable 1	Independent Variable 2	Measurement Instrument	Author's Summary of Results 3
Dart, O.K., Jr., and Hunter, W.W. (1976)	An evaluation of the "halo" effect in speed detection and enforcement.	speed	1) visual speed indicator (VSI) on-off 2) type of static enforcement	radar	1) VSI had no significant effect 2) halo effect disappeared at 3.2 KM 3) police or speed check zone substantially reduced speeds in vicinity of enforcement unit
Lewis, S.R. (1976)	The effectiveness of police speed checks.	speeding over the speed limit	numerous kinds of speed checks: 1) radar and variation in police tactics 2) prosecution 3) written warnings 4) verbal warnings	radar	1) stopping of vehicles by police produces long-term effect on speeding motorists whatever subsequent action is taken 2) single radar check reduced mean speed of commuter traffic for two days afterward 3) two tactics, two days apart, showed an effect for more than eight days
Moncaster, M.E., and Southgate, J.R. (1976)	2001: Traffic policing in the future?	analysis given on these topics: 1) formulation of a resource allocation system 2) use of automated equipment and observational techniques 3) measurement of conflict rate in addition to injury/accident rate 4) resource allocation cycle		radar	1) radar checks can reduce speeding by 5-50%, and increase gap acceptance 2) serious conflicts occur at same points on junctions as accidents; there are as many conflicts in ten hours as injury accidents in three years 3) the combination of VASCAR plus warning signs is comparable to radar
Hunter, W.W., and Bundy, H.L. (1975)	A study of the effect of the speed check zone concept.	speed	1) roadway type 2) placement of warning signs and visible patrol car only 3) neither signs nor car 4) radar	radar	1) speed check zone sign had minimal effect 2) presence of patrol car reduced mean speed
Cooper, P.J. (1974)	Effectiveness of traffic law enforcement: A study to assess the effectiveness of different levels of police enforcement on driver behavior and safety at urban intersections.	commission of defined violation	1) number of enforcement officers 2) enforcement schedules	observation	increased enforcement may decrease number of violators, but not increase road safety

Author(s)	Title	Dependent Variable 1	Independent Variable 2	Measurement Instrument	Author's Summary of Results 3
Goetzke, R.E. (1974)	Reduction of accident severity through maximum enforcement effort.	accidents	1) electronic surveillance 2) public information program 3) personnel training 4) increased enforcement effort with marked cars	radar, "speed-gun"	1) conviction rate of 99.5% for speeding 2) injury reduction of 18% 3) accident reduction of 38%
PRC Public Management Services, Inc. (1974)	Evaluation of selective traffic enforcement programs. Interim report.	number of accidents	fourteen countermeasures	(not discussed)	summary is given in general terms, city by city; most effective police countermeasure is patrol of a designated area and citing all hazardous violations
Reinfurt, D.W.; Levine, D.N.; and Johnson, W.D. (1973)	Radar as a speed deterrent: An evaluation.	speed	1) visibility of patrol car 2) visibility of radar 3) ticketing 4) publicity 5) size of city	radar	1) combination of strategies caused a significant reduction in speed; each, alone, had marginal effect 2) city size was a confounding variable
California Highway Patrol (1972a)	Operation 500: A study of the effect of increased road patrol. Final report.	accidents	deployment of manpower	(not discussed)	on road susceptible to accident reduction, sufficient additional manpower will reduce accidents
Jones, R.K., and Joscelyn, K.B. (1972)	Computerized allocation of police traffic services: A demonstration study. Final report.	speed	one of numerous police/vehicle configurations: 1) civilian 2) unmarked state police 3) marked state police 4) marked state police with radar 5) marked state police in arrest configurations (lights, etc.) 6) two marked state police, one with radar	computer-sensor system	1) stationary patrol more effective than moving patrol 2) effects of enforcement extinguished within 3.2 miles 3) the information system is a highly useful operational tool for traffic law enforcement agencies and should operate in the real world for a multiyear period to help investigate nature of police decision-making process, assess countermeasures, etc.
Council, F.M. (1971)	Project report: Police traffic services.	1) speed 2) evaluation of new type of speed-measuring equipment	1) publicity campaign 2) data about speed-measuring equipment from selected cities	"new speed-measuring device"	inadequate response from those cities selected to be in the experiment; no analysis of the results can be made two recommendations: 1) present convincing information to police agencies concerning the "why" of evaluation 2) emphasis on police doing own

Author(s)	Title	Dependent Variable 1	Independent Variable 2	Measurement Instrument	Author's Summary of Results
Finkelstein, R., and McGuire, J.P. (1971)	An optimum system for traffic enforcement/driver control. Final report. Volume I.	analysis of data: 1) traffic citations, accidents, driver demographic and psychological characteristics 2) no measurement instrument; data gathering and analysis only			traffic officer is most effective part of traffic enforcement/driver control system (numerous summary statements)
Joscelyn, K.B.; Bryan, T.H.; and Goldenbaum, D.M. (1971)	A study of the effects of law enforcement on traffic flow behavior. Final report.	traffic flow behavior (speed, accidents, headway)	1) stationary and moving configurations: a) radar b) arrest configuration c) civilian d) marked vehicle e) unmarked vehicle f) two police vehicles in a "pack" configuration 2) time of day 3) traffic density	computer-sensor system	1) stationary symbols significantly reduce traffic speeds, extent of effects varies with respect to time of day, distances of traffic from symbol, side of road on which symbol is located 2) effects for moving enforcement less pronounced and dissipated rapidly
Bankhead, K., and Herms, B.F. (1970)	Reducing accidents by selective enforcement.	accidents	use of computer to develop "Collision Index" to provide basis for selective enforcement assignments		1) accidents decreased 12% in one year 2) accidents as related to traffic volume decreased 44% at specific intersections 3) various methods used to present information to officers: maps, videotape, booklets
Council, F.M. (1970)	A study of the immediate effects of enforcement on vehicular speeds.	speed	visibility of stationary and moving marked patrol cars	VASCAR	1) stationary more effective than moving patrol 2) moving patrol may not be effective at all
California Highway Patrol (1968)	Roadway characteristics and manpower deployment study. Phase II. Moving violation study.	analysis of accident data; observed violations: 1) speeding 2) following too closely 3) slow vehicle in left lane 4) changing lanes unsafely		1) trained observers 2) traffic counters (instruments) 3) accident reports	1) speed violations appear to decrease nonlinearly with volume; nonspeed risk violations increase with volume 2) accidents v. total violations shows no apparent relationship; accidents v. nonspeed risk violations shows a linear relationship

Author(s)	Title	Dependent Variable 1	Independent Variable 2	Measurement Instrument	Author's Summary of Results 3
California Highway Patrol (1966)	Operation 101. Final report. Phase I: Background and accident analysis.	1) all accidents 2) personal injury accidents	1) presence of police officers along highway 2) increase in arrests, especially citations for speeding	(not discussed)	saturation of enforcement can decrease fatalities and personal injury accidents (36 officers along 35 miles of roadway)
Roche, J.A. (1965)	Traffic accident reduction.	number of accidents	1) one-week training session for 100 police academy members 2) increased enforcement efforts at selected locations	observation	1) increase in arrests 2) decrease in accidents 3) serious deficiencies in individual drivers that cannot be offset by the police
Rowan, N.J., and Keese, C.J. (1962)	A study of factors influencing traffic speeds. (Includes six studies.)	speed	presence of enforcement officials and visible radar	radar	1) greatest effect of enforcement is upon traffic traveling in the direction opposite to the enforced direction 2) influence extends no more than four miles on either side of enforcement unit 3) communication among truck drivers may have confounded data for trucks
Smith, R.D. (1962)	The effect of enforcement of driving behavior.	speed	various configurations of marked and unmarked patrol units	roadside camera with timing clock; speed is calculated as travel time from camera to camera	marked enforcement symbol reduces traffic speeds
Novak, J.W., and Shumate, R.P. (1961)	The use of "control groups" in highway accident research.	1) number of fatal accidents 2) number of personal injury accidents	"line patrol" assignment (enforcement unit for each 15-mile sector; marked and unmarked; moving and off-street patrol during 18 peak hours of traffic)	accident reporting system of Wisconsin	authors state that methods in selection of control groups were not appropriate; before-and-after studies were not sensitive enough to detect enforcement level
Michaels, R.M. (1960)	The effects of enforcement on traffic behavior.	1) accidents 2) volume 3) speed	number of enforcement units is held constant (8 units=24 men); miles of highway patrolled was either 26, 52, 104, or 208	(not discussed)	(note: used same data as Shumate [1958] below) 1) no significant effects found for traffic volume or accidents that can be attributed to enforcement 2) passenger cars showed a significant reduction in the variability in speed in three of four test routes 3) effects of enforcement on behavior are quite indirect

Author(s)	Title	Dependent Variable 1	Independent Variable 2	Measurement Instrument	Author's Summary of Results 3
Shumate, R.P. (1958)	Effect of increased patrol on accidents, diversion, and speed.	1) accidents 2) traffic flow 3) speed	number of enforcement units is held constant (8 units=24 men); miles of highway patrolled was either 26, 52, 104, or 208	(not discussed)	1) addition of patrol units reduces frequency of fatal and personal injury accidents until ratio of 1 unit/13 miles of highway 2) proportion of speeding cars is reduced, average speeds are not significantly affected 3) no appreciable proportion of motorists chose alternative routes
Baker, J.S. (1954)	Effect of enforcement on vehicle speeds.	speed	enforcement configuration	(not discussed)	1) too few data to have statistical significance 2) "halo effect" (zone of influence exerted by an enforcement symbol) limited to 1000 feet ahead of and 200 feet behind the patrol car 3) average excess speed and death rate dropped with increased citations for speeding
Shumate, R.P. (undated)	The long range of enforcement on driving speeds.	speed	1) time of day 2) day of week 3) time of year 4) type of road pavement 5) speed limit of road 6) roadway width	radar	author states that enforcement may not decrease speed; but that this study did not maintain adequate controls

1 Dependent Variable: the action which is to be measured of changed.

2 Independent Variable: the actions that are manipulated or controlled so that the effect of the Dependent Variable can be observed or measured.

3 Author's Summary of Results: all information presented, including comments about procedures or methods of data analysis, is gathered from the original article.

APPENDIX B, PART II

DETAILED REVIEWS OF STUDIES ON ENFORCEMENT EFFECTS, CONDUCTED PRIOR TO 1973

APPENDIX B, PART II

DETAILED REVIEWS OF STUDIES ON ENFORCEMENT EFFORTS CONDUCTED PRIOR TO 1973

Wichita Police Department. undated. The driver.

The Wichita Police Department reports the effects of different enforcement follow-ups. For instance, due to a change in enforcement policies, punitive enforcement, as measured in total fines assessed, was 40% less in 1937 than in the previous year. During 1938 it was 56% less than in 1936. Individual fines remained roughly consistent, so these figures reflect approximately the number of fines. The number of accidents remained unchanged in 1937 compared with 1936 and was down 13% in 1938. "This was equal to the national decrease. Cutting the punitive enforcement pressure in half was not accompanied by any increase in the accident rate." However, since no collateral data are given, any conclusion is speculative.

More meaningful are the data on the effects of different kinds of "treatment" applied to traffic violations: arrest, warning, or traffic school. To eliminate possible differences in the characteristics of drivers being subjected to the one or the other treatment, the following procedure was chosen.

A group of 200 drivers was selected. Each driver had committed two violations for which the punishment (treatment) was one warning and one arrest, or vice versa. Drivers who did not commit any further violations in the 365 days following their latter offense are compared in Table B-1(a). From the table it can be seen that arrest is more effective than warning, and school more effective than either.

A second study, similar to the first, is summarized in Table B-1(b). Again it is concluded that arrest is better than warning and school is better than either.

A third study showed that 29% of drivers who were arrested

TABLE B-1

DRIVERS NOT COMMITTING FURTHER VIOLATIONS WITHIN 365 DAYS (Wichita Police Department, undated)

(a) First Study

No. Drivers	Treatment		
	Warning	Arrest	School
200	28%	32%	--
199	20%	--	42%
150	--	27%	29%

TABLE B-1 (Continued)

(b) Second Study

No. Drivers	Treatment	Percentage who did not commit violation in 365 days
100	Two warnings	25
100	Warning-arrest	42
100	Warning-school	51
100	Three warnings	11
100	Two warnings-arrest	39
100	Two warnings-school	54

committed another violation in one year, but only 24% of traffic school graduates. There were 1500 drivers in each group. No statistical analysis of the data was made.

Jeffcoate, G.O. 1950. Effect of motor patrols on accidents.

This experiment was performed in England from April 1, 1938, to September 3, 1939, and covered seven police districts in which additional motor patrols of specially trained men were used. They were to give advice, warnings, and safety education. The seven districts had a 4.5% reduction of casualties in 1938 compared with 1937, whereas the other 78 districts in England had an increase of 2%. The corresponding figures for fatalities are 7% and 3%. The reductions are statistically significant (the level is not given) if one uses the variation between districts for the comparison.

Some of the data are given in Table B-2.

No attempt was made to relate the numbers of additional men to the reduction in accidents due to the variations in strength of the patrols and their spheres of operation. The number of prosecutions in the seven test districts decreased by 12%, whereas in the rest of England it increased by 5%. This corresponds to the preventive purpose of the patrol.

Kunz, F.M. 1950. How enforcement affects the driver's behavior.

> In April 1945, the Springfield, Mass., Police Department inaugurated a rigid traffic control program. Prior thereto the accident rate had greatly increased. The policy decided upon was to enforce all traffic laws on an impartial basis. Officers were not required to meet any arrest quotas, but they were expected to take appropriate police action whenever a violation was observed. The results of the program exceeded the expectations of the police officials. Accidents were greatly reduced. The number of persons injured in 1945 was reduced more than 40 per cent, and in 1946, despite a tremendous increase in traffic volume, injuries were reduced to only one third of what they were in 1944. During this corresponding period arrests for violations were increasing at a rapid rate . . . as the arrests for moving violations increased, the number of accidents decreased rapidly. When there was a relaxation in arrests for moving violations, accidents increased.

TABLE B-2

NUMBER OF FATALITIES (Jeffcoate 1950)

	Extra forces operating			No extra forces operating		
	1937	1938	Change	1937	1938	Change
County	535	503	-6%	2652	2767	+4%
Metropolitan, City, or Borough	1239	1152	-7%	1278	1296	+1%
Total	1774	1655	-7%	3931	4063	+3%

A chart showing monthly accident numbers in 1944-47 (all accidents) and moving violations prosecuted in court supports all but the last of these statements. The average number of accidents decreased from 80-90 to about 30-40 (however, with an increasing trend); the average number of prosecuted violations increased from 200-300 to 700-800. The statement "when there was a relaxation in arrests for moving violations, accidents increase" did not appear substantiated. Other possible causes of accident reduction were not mentioned.

Therefore, though strongly suggestive, the information given in this report does not give conclusive evidence for the effectiveness of the police activities.

Lefevre, B.A. undated. Relation of accidents to speed habits and other driver characteristics.

Lefevre describes a study performed by the New York State Department of Public Works. Drivers' speed habits and accident records were studied on a rural two-lane highway five miles east of Albany, New York. Speed information was gathered for eight summer weekdays in 1950 and six in 1951. Only data for New York-registered passenger cars were used in the analysis.

The analysis was conducted by observing and recording speeds of the cars and, after the observations were recorded, sending the drivers a questionnaire and obtaining their records from the Motor Vehicle Bureau. The observations were made at two checkpoints, one at a straight portion of the road and the other at a curve. Data were collected on cars inbound in the morning and outbound in the evening. 1,393 observations could be evaluated.

The data were presented in both tabular and graphic form, but no statistical analysis was presented. The number of accidents, drivers' speed (below or above median), headway, age, car, and miles driven were all given.

Some of the results are compiled in Table B-3. Since the locations are only 600 feet apart, the data in the first and third and second and

TABLE B-3

ACCIDENTS PER DRIVER (Lefevre undated)
(1950-1953)

DRIVERS	Location 1 (straight)		Location 2 (curved)	
	Morning Citybound	Afternoon Outbound	Morning Citybound	Afternoon Outbound
Slower half of all at the	0.41	0.32	0.32	0.34
Faster location	0.37	0.43	0.42	0.42

fourth columns are based, to a large extent, on the same drivers. Therefore, the fact that the slower half had significantly lower accident rates in the third and fourth columns is not independent. In the first column this relation is reversed, but the difference between rates is not significant. The level of significance used in the study is not mentioned.

Another analysis divides all drivers into "accident" and "nonaccident" groups. The observations show that, in the afternoon, "nonaccident" drivers have lower speeds than accident drivers, this being reversed in the moving. However, the difference is not statistically significant.

The analysis of headways gives the surprising result that, for drivers observed in the morning, the accident rate is increasing with shorter headways, whereas for drivers observed in the afternoon it is decreasing with shorter headways.

The accident rate per driver increases with miles per year (information obtained from drivers' estimates of their mileage), but less than proportionally. Since the mileage was broken down into only five groups, the information is only summary.

These results show no clear-cut relation between accidents and speed habits or headway habits. Moreover, it is possible that systematic differences in the drivers' characteristics or traffic composition make the comparison meaningless.

Baker, J.S. 1954. Effect of enforcement on vehicle speeds.

Baker conducted a pilot study to look into the following questions:

> What is the effect of a patrol unit on the speed of nearby vehicles?
>
> What is the effect of increased enforcement on vehicle speeds in Chicago?

Since this was a pilot study, fewer than fifty vehicles were observed for each condition—too few to give statistically significant results.

As a measure of the effects of enforcement, the average excess speed was chosen; that is, the sum of speeds of the observed vehicles above the limit, divided by the total number of vehicles.

To answer the first question, speeds were observed on a stretch of road with a standing patrol car, first with an officer at the wheel and then with the officer apparently writing a ticket. This was also done with a patrol car moving at the speed limit and then five mph under the limit. One conclusion was that the "halo" effect, as he calls the zone of influence exerted by an enforcement symbol, was limited to about 1000 feet ahead and less than 200 feet behind the patrol car.

To answer the second question, observations were made day and night at eight points before enforcement increased and then repeated one and three years afterwards. Average excess speed and registration death rate dropped with increased speed arrests. Night speeds responded to enforcement more than day speeds. Again, the data were too few to have statistical significance.

Vickrey, J.W., and Israel, R.J. 1955. Safer highways: Study shows roles of enforcement and freeway construction.

We are concerned only with those parts of the paper related to police activities. In some parts, data for accidents and various measures of enforcement are discussed for: California rural state highways 1948-53; Pennsylvania Turnpike 1950-53; Chicago 1948-51; and New Jersey Turnpike 1951-54. All show a decreasing trend of accidents and some variation, usually an increasing trend, in enforcement. We can draw no conclusions from these data.

More relevant is the part which reports activities of special enforcement units of the California Highway Patrol in different locations for short time-periods during 1953-54.

For eight areas, patrol hours and accidents are compared for one month during the period of special enforcement and for the same month of the preceding year. The data were presented as in Table B-4 without analysis. However, the author discusses the data without realizing that one cannot attach much meaning to differences of a few percent, but rather that one has to consider orders of magnitude only. We plotted the data and found some suggestion of a correlation between the percentage increase in the number of patrol hours and the percentage decrease in

TABLE B-4

CALIFORNIA HIGHWAY PATROL
Special Enforcement Unit Activities-Comparative Data
(Vickrey and Israel 1955)

Area	Month & Year Compared	Without Special Enforcement Unit		With Special Enforcement Unit		Percent Increase, Patrol Hours	Percent Reductions, Accidents
		Patrol Hours	Accidents	Patrol Hours	Accidents		
Bakersfield	Jan. 1953- Jan. 1954	4,750	232	8,376	167	77	28
San Leandro	Nov. 1952- Nov. 1953	3,032	227	3,384	189	12	17
Sacramento	Mar. 1953- Mar. 1954	5,228	214	8,543	142	82	33
Stockton	Apr. 1953- Apr. 1954	3,387	137	4,591	143	36	9
Redwood City	July 1952- July 1953	2,803	135	3,001	121	7	10
San Bernadino	July 1952- July 1953	3,851	204	4,507	191	17	6
San Diego	Mar. 1953- Mar. 1954	4,641	213	5,261	183	14	9
East Los Angeles	Oct. 1952- Oct. 1953	3,237	311	4,013	217	24	30
Totals		30,889	1,693	41,676	1,363	35	19

accidents. A gross description would be that a fifteen percent increase in enforcement would reduce accidents by ten percent, a thirty percent increase by twenty percent, and a seventy percent increase by thirty percent. Since the correlation is at best weak and comparison data are not given, one should draw conclusions from these data with caution. Also, one has to note that the percentage of change of patrol hours is not necessarily an adequate measure of the change. For example, the same percentage increase in a sufficiently policed community can be expected to have less influence on accidents than in a community with insufficient police activities. The total additional effort of 11,000 patrol hours corresponds to about five man-years.

Bennett, W.W. 1958. Radar in traffic enforcement.

Bennett describes a traffic enforcement campaign in Edina, Minnesota, where 130,000 vehicle speeds were checked by radar. Twenty-two percent of all vehicles exceeded the speed limit, 4.3% of which were ticketed. Only vehicles exceeding a tolerance limit, which was not given, were ticketed; however, nineteen percent of the speeding vehicles exceeded the speed limit by more than 6 mph. Of those speeders exceeding the speed limit by more than 6 mph, only twenty-three percent were ticketed.

These data do not give the overall probability that a speeder will be apprehended; however, they indicate that even the conditional probability that a speeder who has been clocked by the police will be apprehended might be fairly low.

Campbell, B.J. 1959. The effects of driver improvement actions on driving behavior.

Campbell describes a study of the effects of advisory letters sent to drivers who had accumulated more than a certain number of violation points. 2880 drivers were sent letters, 3814 were not. To test the comparability of these groups, the frequency of different types of violations prior to the action was compared. Though the differences were significant at the 1% level, the general agreement of the data was so good that the groups were assumed to be comparable. Some of the results are presented in Table B-5.

The difference in the proportion of drivers with subsequent violations and the differences in the time to the next violation are statistically significant at the 1% level. Campbell also mentions that advisory letters do not beneficially influence drivers whose records finally reached suspension levels.

Another part of this study deals with drivers who accumulated enough points to receive notices that their licenses would be suspended. Some drivers did not respond to the notice and their licenses were suspended, others requested a hearing and their licenses were suspended or they were put on probation. These groups all showed improvement in their accident records compared with those of a control group that received no notices. Differences between the different types of actions and their variants are difficult to interpret, since they depend partly on the drivers' actions, and partly on the hearing officers' evaluations of the drivers' actions, and the chances of improvement.

<u>Ross, H.L., and Campbell, D.T. undated. The Connecticut speed crackdown: A study of the effects of legal change.</u>

The effects of the famous Connecticut "crackdown" on speeders, started in January, 1956 were examined for the period 1951 through 1959.

The authors hypothesize that there was no "appreciable reduction in traffic fatalities" (p. 7) caused by the Connecticut crackdown on speeding and accept this hypothesis on two separate bases:

> (1) On the basis that the decrease in fatalities might be explained by nonpolice effects that were not measured; namely, history, maturation, testing, instrumentation, "regression," and instability. Their argument is made in terms of plausibility and is therefore not assessed here.
>
> (2) On the basis of statistical analysis.

The second test the authors apply is to use a time series analysis of the data, comparing it with combined data for New York, Rhode Island, Massachusetts, and New Jersey. They conclude that Connecticut's rate was rising, compared with other states, before the crackdown, but falling

TABLE B-5

PARTIAL RESULTS FROM STUDY BY CAMPBELL (1959)

	No. of drivers	Proportion with Subsequent violations	Lapse between letter and next violations for drivers with subsequent violations
Drivers sent letters	2880	0.12	10.0 months
Drivers not sent letters	3814	0.19	8.7 months

afterwards. However, they state that "statistical tests" show the difference to be not significant. The authors do not report the type of time series that was fitted to the data or, since monthly values were used, whether or not seasonal variations were eliminated, and they do not state the tests used for comparison.

Therefore, the conclusion of the authors that there is insufficient evidence to prove that the crackdown caused a decrease in highway fatalities is not convincingly demonstrated.

Some corollary observations of the authors are also of interest: the crackdown resulted in a large increase in the suspension of licenses for speeding in the years 1956-1959 compared with the years 1951-1955. Speeding violations as a percentage of all violations showed a decline; however, this might have been caused by a reluctance of policemen and prosecutors to pursue minor speeding violations, rather than by an actual decrease in speeding violations. The arrests for driving without a license, nearly zero before the crackdown, went up rapidly. The percentage of speeding violations judged not guilty went up. These last two facts suggest that the punitive effects of the crackdown are not completely effective and tend to be mitigated in a society that is dependent on automobile transportation.

The first statistical analysis the authors apply is to measure the possibility that the change in fatalities is due to chance. Although they do not state their method of procedure, it is possible from their references to reconstruct some of their analysis. They fit regression lines to the precrackdown and postcrackdown data and then test whether there is a significant difference between the regression line fitted to the entire population of fatalities.

The reason that the authors' test does not yield significance is that the test they used requires an assumption that is false for the data they apply it to. The test requires that the subpopulations have the same variance. However, the residuals of the regression should be unbiased estimates of the variance. When this criterion is used on their data, there is a significant difference between the precrackdown and postcrackdown variances. Thus, there is a discernible difference between the two populations. The reason the authors' test showed no significance is that the high variance in the precrackdown data dominated both the sum of squares of the differences and of the regression based on all the data. Thus, the authors' conclusion that there is no significant difference is not justified.

Irby, T.S., and Jacobs, H.H. 1960. An epidemiological approach to the control of automobile accidents: Experimental patrol intensification at a military base.

Irby and Jacobs studied the causes of off-duty, private motor vehicle accidents at a U.S. Marine Corps base, and evaluated the effectiveness of a countermeasure. Their study of the records at Camp LeJeune indicated that younger, unmarried Marines in the lower three grades were involved in a higher percent of accidents than their numbers would justify. As a countermeasure, two Marine patrol cars stopped private automobiles having Camp LeJeune base tags identifying the owners as enlisted men with the rank of sergeant or lower. The patrolmen stopped cars at random and asked each driver for various personal information. The purpose of this action was to remove hazardous drivers and to create a feeling of ever-present surveillance. Accident data were obtained before, during, and after the nine weeks that the patrols were conducted, from December 16, 1957 to February 24, 1958.

The measure for accident frequency was taken to be the number of drivers involved in private car accidents per 10,000 men present for duty on the base. The effect of the action became evident only during the latter half of the patrol period, and for two and a half months after its termination. The difference in accident rates between the average for nine weeks following the test (36 per 57,600 man-months) and the remaining 23 months (excluding the nine weeks, weeks 51-60) (501 per 486,800 man-months) was tested.

Although apparently making some doubtful simplifications, the authors derive from plausible arguments that the statistic

$$Z = \frac{X/P_x - Y/P_y}{\sqrt{X/P_x^2 + Y/P_y^2}}$$

is approximately normally described, where X and Y are the numbers of drivers involved in accidents in the test period and the control period respectively, and P_x and P_y are the man-months of exposure during the test period, and during the control period. They obtain Z = -3.0 and find it smaller than the critical value of -1.6 for the one-sided normal distribution at the 5% level. A correct test uses the statistic

$$W = \frac{X/Px - Y/Py}{\sqrt{(X + Y)\ /P_x P_y}}$$

which is approximately normally distributed. We obtain the value W = -2.9, which is, as Irby and Jacob's Z = -3.0, statistically significant.

However, even if the reduction is statistically significant, it is possible that it might be due to the well-known seasonal variation of accidents. To illustrate this we take data published by the National Safety Council for 1959, the year closest to the time of the experiment described. For the entire USA, there was a monthly average of 2,755 fatalities for the months of March and April, which corresponds roughly to the test period used by the authors, and a monthly average of 3,190 for the months which correspond to their apparent contol period. This alone would give a "reduction" of 14%, due solely to the seasonal fluctuation. Though these data cannot be directly compared with those of the authors, they have to be borne in mind if one wants to evaluate their claim of a 42% accident reduction.

The authors also discuss other factors that might influence the accident rate and find that there is no reason to assume that these factors have an influence.

<u>Sieben, H.A. 1960. Saturation patrols work in Minnesota.</u>

Sieben reports on a program of concentrated enforcement on Minnesota highways where high accident rates had been observed. The goal was to reduce accidents while maintaining a favorable public image.

For the selected areas, state, county, city, town, and village police agencies cooperated in an enforcement plan. Advance publicity for the concentrated enforcement plan was given, and newspaper representatives were invited to the briefing and actually to accompany the patrols on the operation. Emphasis was placed on courtesy to the motorists and avoiding unnecessary delay. Approximately 50 officers patrolled a short section of highway for ten hours, and driver's license checks and motor vehicle checks were also made during the operation.

The patrols were considered successful primarily because there were almost no accidents in the paqtrolled sector. However, only very few figures on accident reduction were given:

> An average of 40 accidents are reported for any Friday-Saturday night period on the 20-mile stretch selected. During this operation only one 'fender-bender' was reported. On another comparable road section, a 10-hour operation reduced the tally to zero . . . Two stretches of highway under surveillance have an average of 30 accidents per weekend, but on this patricular weekend only one property damage accident occurred . . .

Due to the extremely scanty quantitative information, we would usually not consider this report worthwhile for presentation. However, the few data on results are so spectacular that they show convincingly the possibility of a beneficial effect of police traffic supervision. This does not mean that this conclusion can be carried over to routine police activities. The circumstances of these activities were highly unusual. The publicity could have been a deciding factor, one which is likely to be quite shortlived. Also, much could be due to diversion or reduction of traffic, factors that will work only during short and locally concentrated activities. The number of policemen involved appears to have been far beyond what would be possible on a routine basis; therefore, one would have to check whether such short-term campaigns have a worthwhile long-term influence.

<u>Michaels, R.M. 1960. The effects of enforcement on traffic behavior.</u>

<u>Shumate, R.P. 1958. Effect of increased patrol on accidents, diversion, and speed.</u>

The Traffic Institute of Northwestern University, in cooperation with the Wisconsin State Highway Patrol and the U.S. Bureau of Public Roads, performed a large-scale experiment. Four test routes were selected by one criterion: the frequency of accidents. Attention was paid to the problem of adequately measuring the intensity of enforcement. As a measure for the intensity of enforcement, the average number of patrol units that a driver passed per mile was chosen. Different intensities of enforcement were used on the four test routes. On test route 1, patrols were assigned in January, 1956. On test route 2, patrols began in April, 1956, on route 3 in August, and on route 4 in November. No information is given about the previous intensity of policing. Accident experience was gathered from 1947-55 data for the test routes. Reports were required for accidents causing $100 or more damage, and the study data were taken from these reports, filed by drivers. It was recognized in the study that the stronger presence of police might lead to a more complete reporting.

Shumate fitted a trend to the accident data available for this area; however, he did not analyze this trend. Then he compared the accident data after the initiation of patrols with what was to be expected from the trend. Some of the results are given in Table B-6. The level at which he calculated the changes to be significant is also given. This was apparently done by comparing the deviation of the observed numbers from those predicted by the trend with the standard deviation of the data from which the trend was calculated, and testing this with a normal distribution. This, however, is not a correct procedure, but since not enough data are given to repeat the analysis, we have to use Shumate's results, which at least appear to give an estimate of the order of magnitude of the variation.

The results are that the fatal and injury accidents for 1957 decreased significantly on test routes 1, 2, and 3, whereas they did not significantly

TABLE B-6

RESULTS OF SHUMATE'S COMPARISON (1958)

Route	1956		1957	
	Deviation of actual from trend	Level of statistical significance	Deviation of actual from trend	Level of statistical significance
Test 1	-25%	< 0.001	-32%	< 0.001
Control 1	-8	> 0.77	-6	> 0.83
Test 2	-9	> 0.34	-22	< 0.02
Test 3	--	--	-28	< 0.007
Control 3	--	--	+14	> 0.63
Test 4	--	--	-14	> 0.26
Control 4	--	--	-8	> 0.56
Total, Test Routes	-11	> 0.06	-24	< 0.001
Remainder of State	+4%	> 0.80	+1%	< 0.96

TABLE B-7

PERCENTAGE OF VEHICLES EXCEEDING SPEED LIMIT
(Shumate 1958)

Year	Test Route		Control Route	
	Passenger Vehicles	Trucks	Passenger Vehicles	Trucks
1955	15	65	8	55
1956	9	45	4	38
1957	2	32	3	33

decrease on the control routes. Data for 1956 are not discussed here; we think it inappropriate to judge them by the same statistical test, since the patrols were working only part of the year on some test routes. Because the total time leapsed since the beginning of the increased enforcement might have some influence on the effects of the enforcement, this might also affect the 1957 data. Therefore, the author's conclusions, not reported here, about the different effects of different levels of patrol should be taken cautiously.

To study the effects of enforcement on traffic volumes, and the possibility of diversion, two routes were selected that are parallel to, and alternatives to, two test routes. Volume counts from 1950 through 1956 were used for both the test routes and the alternate routes. A trend was fitted to the data and the expected values were compared with actual counts for 1956 and 1957. There were no significant diversions.

To study the effect of enforcement on vehicle speeds, a sample of 3000 vehicle speeds were obtained on test routes in 1955, 1956, and 1957, and compared with a similar sample from six similar highways far away. Speed limits were 65 mph, and data were taken in periods of free flowing traffic. Both on test routes and control routes, the percentage of vehicles exceeding the speed limits decreased during 1956 and 1957 compared to 1955 as can be seen in Table B-7. A chi-square test showed that the reduction for passenger vehicles in 1957 was significantly greater (at the 2% level) than on control routes.

However, it is difficult to draw conclusions from these data. There was no obvious influence on enforcement on average speeds, and there were some indications that speeds tend to group more closely around the average.

The overall effort involved in this experiment can be estimated from Shumate's data to be 150 man-years.

Michaels reanalyzed Shumate's data (see Table B-8). He uses different assumptions and statistical techniques, and comes to the conclusion that there were no effects on accidents. However, this would not invalidate Shumate's conclusions; it would just show that Shumate's tests are, in this case, more discriminating than Michaels'. Michaels criticizes Shumate's

TABLE B-8

MICHAELS' ANALYSIS OF SHUMATE'S DATA (1960)
(Totals presented only for fatal and personal injury accidents)

Route	1955	1957	
Test 1	94	72	not significant
Control 1	24	18	
Test 2	144	102	$p = 0.05$
Test 3	69	52	not significant
Control 3	29	36	
Test 4	184	170	not significant
Control 4	92	97	
Total, Test Routes	501	396	$p < 0.05$
Total, Control Routes	145	151	
Total, Test Routes	501	396	$p < 0.01$
Total, Rest of State	3,788	4,222	

use of linear trends as "an extremely strong assumption which could not be wholly validated from the data" (p. 111). He claims that

> . . . use of the chi-square test does not require such strong assumptions. On the contrary, the chi-square test is a conservative test which uses the control route data as basic determinant of any significant changes in accident frequency on the experimental route. (p. 111.)

However, we think that the hypothesis used by Michaels implied in the application of the chi-square test on a 2 x 2 table makes no less strong an assumption. He assumes, implicitly, that accidents on test and control routes would have the same percentage of change between two years if there were no influence of police activities.

Whether Michaels' assumption of an equal percentage change on test and control routes, or Shumate's assumption of a linear trend for test routes and control routes, is more realistic is a question that can be answered only on the basis of empirical evidence.

Of the four test routes, Michaels finds a significant reduction of the number of fatal and injury accidents on only one. However, he cautions

> it should be noted . . . that 1955 was an abnormally high year for accidents on this route. Consequently, ascribing a reduction in accidents to the increased patrol was probably unwarranted. (p. 111.)

The "abnormally high year" implies the use of a trend of the data, which he rejected previously. Also, we do not consider it acceptable to qualify a statistically significant result, after a test, on the basis of information available prior to the test.

The combined figures of all test routes, or all control routes and all test routes, or all routes in the state for fatal and injury accidents, show significant reductions at 5% and 1%. Michaels comments

> These results indicate that for the more discriminating comparison between the matched test and control routes there appeared little reliable effect due to enforcement. Regardless of level of patrol the differences between test and control routes were consistently small. Also, the significant differences found on comparing test routes with the state as a whole had to be interpreted with caution. (p. 112.)

We agree that the comparison between individual test routes and control routes can be more discriminating, but only if there is a strong influence from the individual characteristics of the roads. However, if all test routes show consistent though not individually significant reductions, it is possible that the reduction in the total becomes significant. This is due to the fact that random fluctuations can be expected to better cancel out in the totals, whereas improvements add up.

Instead of this argument, the author presents two possible explanations: One is that the base year had an abnormally high number of accidents, which we refuted above, and the other is a fairly sophisticated statistical argument that we think is inappropriately used.

Summarizing, both Shumate's analysis and Michaels' analysis (different from his interpretation) of Shumate's data suggest a beneficial influence of law enforcement activities on traffic accidents.

To study the influence of enforcement on speed, Michaels analyzes the variance of speed distributions using the F-test. for passenger cars he finds a significant reduction on three of the test routes and on none of the control routes. For trucks, he finds a significant reduction for two test routes and for one control route. The effect is most pronounced for the highest level of enforcement, 0.31 patrols passed per mile of driving. There is no obvious relation between speed reduction and enforcement at lower levels.

<u>Huffman, W.J. et al. 1961. The effectiveness of an emphasis patrol by the Illinois State Highway Police in district 10 on a selected highway.</u>

This study deals with the effects of increased enforcement in Illinois. Accident and arrest statistics for Route 45 in Champaign County, Illinois, were gathered for 1956, 1957, and the first five months of 1958, to plan the following experiments.

Increased patrols were used for the last six months of 1958. The number of police used during the period of increase was based on an estimated enforcement index computed as the ratio of arrests for moving violations to the number of accidents. Before the emphasis patrol, 15 patrol cars were assigned to Champaign County; during the emphasis patrol, 6 patrol cars were added, for an estimated 3 man-years of additional effort. The accident data for 1957, 1958, and 1959 were analyzed to evaluate the effect of the emphasis patrol. Some of the results are presented in Table B-9.

Using the Poisson index of dispersion (which tests whether the change in accidents from one year to another can be explained by the chance variability of a Poisson distributed variable), the reductions in accidents from 1957 to 1958 are significant at the 5% level, whereas from 1958 to 1959 no significant reduction occurred. Though the figures look impressive, they have to be interpreted with considerable caution since no basis for comparison is given and the authors state:

> There has been a downward trend in severe accidents on the highways in Illinois during the past two years. This may account for much of the differences between 1957 and 1959, but it is believed that the emphasis patrol did have a continuing effect into 1959 and was responsible for some of the favorable results.

Since this belief is not substantiated, the conclusions must be accepted only with reservations.

The authors tried, further, to establish a relationship between the enforcement index and accident frequency. However, their result that "as the enforcement index goes up the accident rate goes down" is tautological, since accidents enter in the denominator of the enforcement index.

The authors also analyzed differences in the numbers of violations for 1958 and 1959. They conclude that there is no significant change in the total number of arrests, though there is a significant increase in the number of arrests for speeding, which they ascribe to increased use of radar.

Novak, J.W., and Shumate, R.P. 1961. The use of "control groups" in highway accident research.

To examine the problems raised by the different interpretation of the

TABLE B-9

ACCIDENT DATA FOR CHAMPAIGN COUNTY, ILLINOIS
(Huffman et al. 1961)

Data for the last 6 months of	Accidents		Year	Poisson index of dispersion	
	Fatal	Personal Injury		Fatal	Personal Injury
1957	10	50			
1958	2	32	1957-58	5.3	4.0
1959	1	34	1958-59	0.3	0.6

same data and the use of control groups, Novak and Shumate performed the following study in October, 1958. One hundred and ten miles of highway in Wisconsin, previously having only minimal enforcement, were put under concentrated and systematic enforcement patrol. For comparison, a total of 95 miles was chosen as a "random control group," and 125 miles as a "matched control group." These roads were as similar to the experimental roads as possible, but were not subject to systematic enforcement. Accident data from October 1956 through September 1957, October 1957 through September 1958, and October 1958 through September 1959 were used (see Table B-10). The 1957-58 and 1958-59 data for fatal and injury accidents were compared with the 1956-57 data by 2 x 2 tables. The conclusion was that the fluctuations from year to year for both random and matched control groups were too large to allow any evaluation of the influence of the control activity.

From the data given in the description, the effort for this experiment can be estimated to be from 7 to 20 man-years.

Rowan, N.J., and Kesse, C.J. 1962. A study of factors influencing traffic speeds.

In a study of the factors that influence traffic speeds, Rowan and Keese investigate also the effects of radar enforcement on the traffic. A radar unit on a tripod is placed on the shoulder of the roadway, with the monitoring vehicle 150-200 feet beyond. A "catch" unit is located one-fourth to one-half a mile further down the road, but still within sight of the monitoring vehicle.

The study finds that this activity has a greater effect on traffic in the opposing direction than in the enforced direction. Trucks slow down more than other vehicles, again especially in the opposing direction. Further, a conclusion is stated that the enforcement operation loses influence within a distance of approximately four miles on either side of the enforcement unit.

Shumate, R.P. undated. The long range effect of enforcement on driving speeds.

TABLE B-10

FATAL AND PERSONAL INJURY ACCIDENTS
(Novak and Shumate 1961)

	1956-57	1957-58	1958-59
Experimental road	127	96	118
Random control group	40	39	46
Matched control group	79	43	67

TABLE B-11

AVERAGE SPEED OF PASSENGER CARS AND TRUCKS
BEFORE AND AFTER ENFORCEMENT
(Shumate undated)

Location	Passenger Cars			Significant level	Trucks			Significant level
	Average speed		Change		Average speed		Change	
	1958	1959			1958	1959		
2	46	50	4	0.001	43	45	2	0.001
3	52	54	2	0.001	46	43	3	0.001
6A	57	56	-1	N.S.	49	50	1	N.S.
6B	57	57	0	N.S.	47	47	0	N.S.

In September 1958 a series of speed samples was taken at five selected locations on a highway network that was to be placed under concentrated enforcement patrol in October 1958. From 79 to 1611 vehicles were observed for five to ten hours in one day at each location. In November 1958, measurements were taken at a control location outside the area of enforcement, but on the same route (US 14) that two of the original locations were on. In September 1959, eleven months after the start of increased enforcement, a second set of samples were taken at the same locations, under the same weather conditions, during the same hours of the day and the same days of the week as the first set. Each set was matched with its before counterpart, and formed the basis of subsequent analysis and interpretation of the effects of enforcement on speed. Speeds were measured by radar hidden in mailboxes at the highway, usually set among a group of real boxes.

Shumate concludes that: (1) there is no evidence that enforcement at the levels (One enforcement unit per 15 miles of highway. Marked and unmarked enforcement units in ratio 5:1. On duty during the 18 peak hours of accident experience for several days a week.) used in these series of tests causes the average speed of vehicles to decrease significantly, (2) the number of drivers exceeding the legal speed limit does not decrease after the application of enforcement, and (3) the variance of vehicle speeds about the mean is not significantly affected by an increase in enforcement activity.

This study was criticized by Tamm (1961). He reports a check of the data gathered on US 14 and states

> It was found--and this was not mentioned in the report—that the test site used in 1958 had to be moved in 1959 because of the possible influences of construction work in the area to a site at which no construction work was under way. (p. 14.)

About the control site he states

> The 1958 data was collected on November 11 and the 1959 data on November 3. Since November 11—Veterans Day--is a legal holiday in Wisconsin, Minnesota and Illinois, the probability exists that an abnormal factor, holiday traffic, could have influenced the data. (p. 14.)

Though Tamm does not state which of the three locations on Route US 14 was moved, his comments cast doubt upon the care with which the study had been conducted in general. Tables B-11 and B-12 show those of Shumate's data which are not affected by the change in location. From these data it is apparent that the reductions in average speeds, even if they are statistically significant, are so small that they are likely to have little practical relevance. Moreover, reduction of speed per se—without regard to speed limits or circumstances—is not a legal objective of police activity. Therefore, it is more appropriate to test the influence on drivers exceeding the speed limits or driving at unreasonable speeds. This is reflected in Table B-12. The speed limit in location 2 is 50 mph; in locations 3 and 6 the limits are 65 mph in daytime, and 55 mph at night. Location 6 is 1-1/2 miles north of a 50 mph zone. Even if we disregard the changes in prevailing speeds, it is remakrable how large a percentage of cars at location 2 and trucks at location 6 are exceeding the speed limit even in the presence of concentrated enforcement.

Because Shumate finds no significant changes in vehicle speeds and no trend is apparent in these changes, the data are not reproduced here. This experiment apparently used the same data on enforcement activities as described in the previous paper.

Smith, R.D. 1962. The effect of enforcement on driving behavior.

Smith reports a series of experiments conducted by the IACP on the influence of enforcement on speed.

In these experiments, speeds were measured as travel time per mile. Time was measured within one second, and in one instance, within two seconds. Since the average travel time was about 60 seconds, this is an error of about 1.7% and 3.3% respectively. The observations were restricted to free-flowing passenger vehicles, those with 15 second or longer headways.

In the control situations there were no police vehicles in sight. In the eight test situations there were marked or unmarked police vehicles in different activities and positions.

TABLE B-12

PERCENTAGE OF VEHICLES EXCEEDING THE LEGAL SPEED LIMITS
(Shumate undated)

(a) Passenger Cars

Location	%1958	%1959	Change	Chi-square	Significant levels
2	50	83	33	27.9	0.001
3	4	8	4	6.6	0.001
6A	15	15	0	0.02	N.S.
6B	17	16	-1	0.04	N.S.

(b) Trucks

Location	%1958	%1959	Change	Chi-square	Significant levels
2	29	46	17	10.4	0.001
3	57	35	-22	22.4	0.001
6A	78	69	-9	1.85	N.S.
6B	72	70	-2	0.03	N.S.

Three sites were chosen and traffic in each direction was treated differently. All arrangements were randomized. A total of 5000 measurements was taken. The travel times in front of and behind an enforcement symbol were analyzed by an analysis of covariance. It was found that the only significant single factor is the presence of an enforcement symbol. The combined factors of direction-site and flow-direction-site also have an influence at the same level of significance. However, the reduction in mean travel for the most influencing symbol is equivalent to a reduction of speed from 58 mph to 56 mph, or less than 4%. This has to be evaluated in comparison with the potential errors of measurement mentioned above. Also, it is questionable whether the mean speed is an appropriate measure for the effects of enforcement, because the speed limit was 65 mph, and the majority of vehicles, being below this limit, should not be affected.

More interesting is the effect of vehicles moving faster than the speed limit. At some sites, significantly more (at the 0.05 level) vehicles changed speed from above to below the speed limit than vice versa, but there was no consistent pattern. However, again it is not apparent that this is the right criterion. Though it was tested whether the assumption of 0.5 probability for increase and decrease across the speed limit in the control situation was acceptable (with a 0.05 significance level), the difference between test and control situations was not tested. Also, the absolute speeds of vehicles above the speed limit should be considered.

The last part of the study was just briefly described: A police vehicle was stationed at the beginning of the test range. The average spot speeds for this three-mile range were compared, for both traffic directions, with and without a police car present. The author concludes that the effect of the enforcement symbol is maintained for a distance of at least three miles. However, we find it difficult to draw such a conclusion from the two graphs he presents, except that the average point speed is lower (up to 8 mph) in the presence of a police car.

<u>Klebelsberg, D. 1963. Versuche mit getarner verkehrsueberwachung, kuratorium fuer verkehrssicherheit.</u>

Klebelsberg reports experiments on the effects of marked and unmarked police cars. Twenty-two test rides of one to one-and-a-half hours were made with marked and unmarked police cars (the same color, make, and model, but without a light dome and with plain license plates, and luggage rack on roof) and a regular civilian car were used. An observer within the car (sometimes not knowing in which car he was) had to note all violations he could observe. In the downtown area there was no difference between marked and unmarked cars: 32 violations seen from a marked car and 34 violations seen from an unmarked car were explainable by the fact that the color of the unmarked car made it appear suspicious. There was a marked difference between patrol car observations and civilian car observations: 32 versus 62 violations. On a major artery, the relation between marked car versus civilian car was 18:107, on a road outside Vienna, 80:288. No detailed data are given and no statistical tests are made. However, it is easy to compute the Poisson index of dispersion, which shows that the latter differences are significant at a level less than 1%. Since the comparability of the test rides (time of day, day of week, weather, etc.) is not reported, it must be noted that the differences might be due to other factors than the presence of a marked police car. However, this does not appear likely, since the ratio of observed violations always favors the unmarked cars.

Sheehe, G.H. 1963. Factors influencing driver attitudes, skill, and performance.

In a panel discussion, accompanying the presentation of his paper, Sheehe presented, in part, the following:

> Two undergraduates got so interested that they wanted to make a special study. First they had too grandiose ideas. Finally they limited their study to one violation on three-quarters of a mile section of a highway adjacent to the campus on which we had good traffic volume data and which was in an area where police attention to violators was good. These students clocked traffic (determined speed of vehicles) for 84 hours in all, doing so on different days of the week and at various hours, and got a real good measure of what traffic was doing. They obtained data from the highway department on the volume of traffic in a year on this section

> of highway and the violation tickets issued in this area. They found that the odds of getting a ticket for violating the speed limit in excess of ten miles over the limit was one in approximately 7,600. Thereafter I had this bit of information concerning the odds of getting tickets for one kind of violation under certain circumstances.
>
> The point I am making is this. Up to that time I knew of no study of the odds or likelihood of getting tickets or what the driver behavior of a large sample of drivers was like. I think this points out the need of finding out more about day to day driving behavior if we are going to determine what is good and bad driving and what should be changed.

<u>Calica, A.B.; Crowther, R.F.; and Shumate, R.P. 1964. Enforcement effect on traffic accident generation.</u>

In the context of a more comprehensive theoretical study, which we will not review here because it lacks empirical verification, Calica, Crowther, and Shumate report an experiment where a patrol car was stationed between recording points with the officer inside the car, beside the car, beside an occupied passenger car, and driving. Measurements were taken both with the patrol car and without it. There were eight field sites, each four miles long, with instrument locations at the beginning, after 1-1/2 miles, after 2-1/2 miles, and at the end. Eighty-eight tests and 109 control samples were taken, and the results presented in 24 tables. The result of the authors' statistical evaluation is that there are some statistically significant influences of enforcement symbols on speed, headways, and the frequency of passing, but that the magnitude of the changes are of no particular importance.

<u>Solomon, D. 1964. Accidents on main rural highways related to speed, driver, and vehicle.</u>

This is a large study in which the speeds of 290,000 drivers were measured, traffic volume counts were made, 10,000 accident reports were analyzed, and drivers were interviewed. Of interest to us in the wealth of information contained in the study, is the relationship between speeds before an accident and the accident rate. The author's conclusion that

> . . . the differences in involvement rate at the various speeds are substantial enough to suggest that relatively high speed driving is, on the average, safer than either low speed or high speed driving on main rural highways, (p. 11.)

is supported by an impressive graph. However, the speeds before accidents are obtained either from estimates by investigating police officers or information provided by the driver involved in an accident. The author discusses the possibility that drivers tend to give lower than actual speeds, but contends that this will not materially change his results. He also mentions that accidents at low speeds might have occurred at intersections. Another possibility is that accidents may happen more frequently at times when all vehicles are driving slower due to weather, traffic conditions, or other factors. These points should be sufficient to cast severe enough doubts that the conclusions relating accidents and speed cannot be trusted.

Coppin, R.S. et al. 1965. The effectiveness of short individual driver improvement sessions.

The California Department of Motor Vehicles presently uses the Negligent Operator Informal Hearing whereby a negligent operator is informed of his record and is allowed to state his case in a 30-40 minute contact with a driver improvement analyst. Section 12810 of the California Vehicle Code defines a negligent operator as any person whose driving record shows a violation point count of four or more points in 12 months, six or more points in 24 months, or eight or more points in 36 months. It was the object of this study to analyze the effect of these informal hearings on the subsequent driving records of first-time negligent operators.

From a pool of 9000 first-contact hearings held in the first eight months of 1961, a group of 3,500 subjects were selected for the hearing group eliminating drivers with point counts of 5 or more in the preceding 12 months. 2000 subjects were selected for a control group.

Statistically significant differences were found between the two groups, on each relevant variable, indicating that the two groups were not representative of the same underlying population and were, therefore, not comparable in a direct group comparison approach. (The relevant variables, age, sex, marital status, prior accidents and prior traffic citations, were selected on the basis of known driver record relationships.) Therefore, the two groups were matched by pairing individuals from each group by the following variables: age, sex, marital status, and the number of accidents and countable traffic citations in the 12-month period prior to their hearing of control assignments. The experimental group was split by season of hearing assignment, nonsummer (January-May) and summer (June-August), to minimize seasonal effects, since control subjects could only be drawn from the summer months.

The number of exact matches was small; therefore, the matching requirements were relaxed to pair subjects who were not more than two years apart in age, but who were identical on all other matching variables. 501 summer-hearing matches and 466 non-summer-hearing matches were derived from the data.

Partial results from an analysis of the data are shown in Table B-13. The authors conclude that:

> (1) The overall individual hearing program is an effective means of reducing subsequent citation frequency, but the effects diminish with time.
>
> (2) The overall hearing program does not reduce subsequent accident involvement or reduces it to such a small extent that it could not be detected.
>
> (3) Receipt of the hearing notice and/or initial action probably constitutes an important factor in the hearing program effects, apart from face-to-face interaction with a hearing analyst.
>
> (4) The subsequent accident and citation frequencies of the hearing groups were approximately twice as high as a similarly stratified sample from the overall California driving population, indicating that the hearings did not reduce the point count of the negligent drivers to the state average.

<u>Gates, G.G., and Hand, N.E. 1965. Policing of motorways.</u>

TABLE B-13

PARTIAL RESULTS FROM STUDY BY COPPIN et al. (1965)

Season of hearing	Citation Frequency*				Accident Frequency			
	First Year		Second Year		First Year		Second Year	
	Hearing	Control	Hearing	Control	Hearing	Control	Hearing	Control
Summer	1.06	1.43	0.93	1.01	0.25	0.24	0.18	0.16
Non-summer	1.21	1.44	0.99	1.02	0.25	0.23	0.19	0.17

* The differences in citation frequency are statistically significant at < 0.01 for summer, < 0.05 for non-summer.

We report on two aspects of this report from Britain. First, Gates and hand studied in Britain the probability that an incident of a certain duration will be detected by a police patrol. The event consisted of either a car parked on a hard shoulder, or a pedestrian walking on a hard shoulder. Different durations from 1 to 40 minutes were chosen for incidents. A 15 mile stretch of divided limited access highway (M6) was patrolled by a patrol car and a motorcycle. The speed of patrolling, which influences the theoretically expected probabilities, was not mentioned. The probabilities of detections estimated from 117 incidents are shown in Figure B-1, together with those theoretically expected for a patrol moving at 45 mph. They agree fairly well.

Experiments were also conducted with stationary patrols, either on the shoulder or on bridges and access roads. However, it was not mentioned whether the patrols were stationary for longer periods, or whether they changed their locations at shorter intervals. Since this influences the theoretically expected probability of detection, no comparison is possible.

From this, one can conclude that even on a well patrolled road, the probability of detecting a short incident is quite small (e.g., in this case, 3% for an incident of 1 minute duration).

In the second part of the report, the relation between police activities and accidents was explored. Between the periods of March 9-June 6, (phase 1) and June 7-July 19 (phase 2), the level of police activities was changed. The average number of patrol cars per shift on three stretches of the road in different counties is given in Table B-14.

The number of accidents for these areas and periods was normalized for traffic volume change (the method is not described), and phase 1 was split in two to obtain comparable intervals. The figures obtained by the authors (without giving a definition of their dimension) are given in Table B-15.

The authors perform several statistical analyses with these figures and the totals for all counties. (Reconstructing their tests we found that the authors had tested the Poisson-Index of dispersion (chi-square distributed) for the totals of accidents obtained from Table B-15. This, however, is inadmissible since the "normalized" figures are no longer

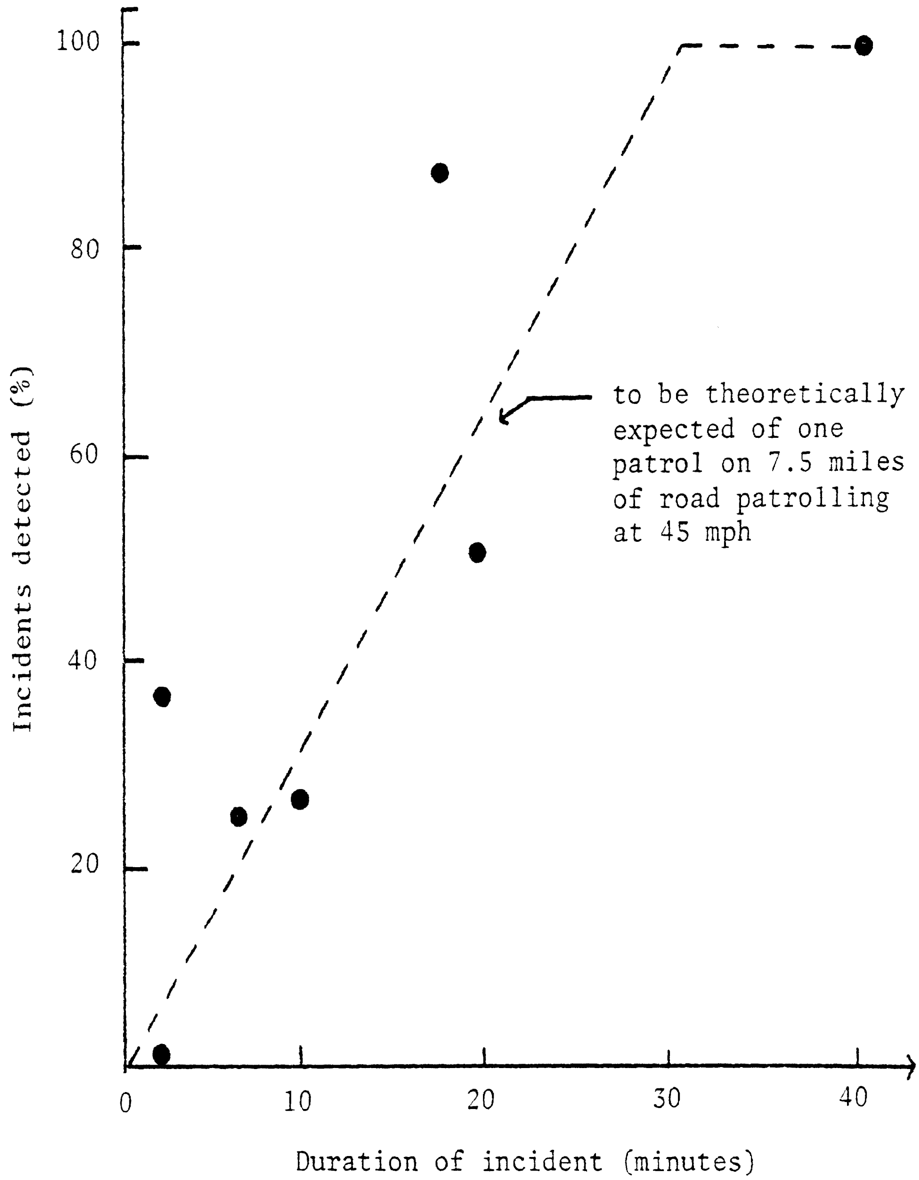


FIGURE B-1

PROBABILITY OF DETECTING INCIDENTS
(Gates and Hand 1965)

TABLE B-14

AVERAGE NUMBER OF PATROL CARS ON THE ROAD
(Gates and Hand 1965)

Shift	Phase	Time Period 8-16	16-Midnight	Midnight-8
Cheshire	1	3.48	3.24	0.93
	2	3.56	2.92	0.95
Lancashire	1	3.42	3.46	0.83
	2	4.05	3.76	1.00
Staffordshire	1	3.74	3.47	0.98
	2	2.82	2.87	0.99

TABLE B-15

NORMALIZED PERSONAL INJURY ACCIDENTS
(Gates and Hand 1965)

Phase	Cheshire	Lancashire	Staffordshire
1A	4	4	5
1B	8.1	7.9	6.4
2	8.9	4.7	9.5

Poisson-distributed.) Their conclusion is "It was not possible to show any relationship between levels of policing or the organization for policing and accident rates during the experiments." Their conclusion is based on totals for all counties. We think that this conclusion cannot be properly drawn from totals for the counties, since the patrol activity increased in Lancashire from phase 1 to phase 2, whereas it decreased in Staffordshire. Thus, any effect is likely to cancel out in the total. On the other hand, accidents were decreased in Lancashire and increased in Staffordshire as one would intuitively expect.

<u>Recht, J.L. 1965. Multiple regression study of the effects of safety activities on the traffic accident problem.</u>

This study examined, on a statistical basis, how the various safety-related activities (engineering, safety education, police traffic supervision, etc.) contribute directly or indirectly to accident prevention. Since some of the variables examined by Recht concerned police traffic activities, the study was selected for detailed review. The stated purpose of the investigation, of relevance to this review, was to determine

> . . . those items, or activities, of greatest relevance to motor vehicle death rates. Specifically, the purpose of the study was (1) to find out which of some 218 program and non-program items had statistically significant associations with motor vehicle death rates . . . (p. 3.)

A second objective of Recht's study, "to study ways of refining and improving the methods of evaluating activities which are intended to contribute to accident prevention" (p. 3), was considered to be outside the scope of this literature review and is not considered here.

Recht performed a total of 110 multiple regression analyses using data for 45 states, mostly from the National Safety Council's 1960 State Motor Vehicle Inventory. As dependent variables he used total death rates, non-pedestrian death rates, "residual rates," bodily-injury-claim frequency rates, property-damage-claim frequency rates, and "death ratio" (see below). (Residual rate was defined as "the difference between the actual death rate computed on the basis of the regression equation derived using only non-program items.") The independent variables are chosen from a list of 285 items, among them eight items about traffic law enforcement, four on intoxication enforcement, and seven on accident investigation. Twenty variables are demographic, geographic, etc., and include such data as rural road mileage, daylight hours, crime rate, maximum speed limit, and precipitation.

Among the police traffic supervision items, Recht finds significant negative association of mileage death rates and death ratio only with traffic conviction rate, selective enforcement, and the enforcement index. Only the enforcement index has a significant negative association with total death rate, bodily-injury rate, and property-damage rate.

However, while we think that Recht's approach is appropriate for an exploratory survey of the field, we must object to his use of rates, which are computed by dividing the number of accidents in a state by the total miles driven. A potential correlation between the total mileage and the independent variables may be reflected in the accident rate, and thus influence the correlation between the accident rate and the dependent variables. Without investigating this possibility, one cannot distinguish the contribution of this spurious correlation from a genuine influence of independent variables on traffic fatalities. This consideration is even more pertinent to his "death ratio," which is supposed to "equalize" the states in terms of size, population, etc.; it is defined (with the figures rounded by us) as

$$\frac{\text{Number of deaths}}{(\text{population})^{0.25} \times (\text{miles traveled})^{1.56} \times (\text{miles of road})^{0.38} \times (\text{cars})^{-1.10}}$$

in which the exponents were determined by a regression analysis. It seems quite possible that the variables in the denominator are correlated with some of the independent variables.

Our suspicions are reinforced by Recht's findings that the enforcement index is the only police-related variable that consistently shows an association. He defines the enforcement index as the ratio of "hazardous traffic violations with penalty per fatal accident" (p. 67). Since the number of fatal accidents is very closely related to the number of traffic deaths, practically the same quantity is used in the variable to be explained and the explaining variable. This can create a correlation between these variables due merely to a variation in the number of fatal accidents, for whatever other possibly unrelated cause. That the number of fatal accidents appears in the numerator of one variable explains the negative correlation.

A careful analysis of this possibility is necessary before any conclusion can be drawn from this study, since it appears not only possible, but likely, that Recht's results are affected by spurious correlations.

Roche, J.A. 1965. Traffic accident reduction.

Roche reports a program of the New York State Police to investigate and reduce accidents. Two troopers attended Accident Investigation Courses at the Traffic Institute, Northwestern University. Upon their return, these men devoted their attention to two selected high accident locations within their patrol areas--It was reported that "these efforts, during the summer of 1963, on two sections of highway led to accident reductions of 50 per cent and 53 per cent respectively." However, since no absolute figures and no corollary data are given, the significance of these data cannot be evaluated.

To investigate and prevent accidents, one hundred troopers attended a one week advanced accident investigation course conducted by "our academy." Seven high accident locations were selected throughout the state.

The study reports that

> two of the specially trained men were assigned to each of these locations . . . We have pointed out to our members that an arrest is far more appropriate after the violation has led to an accident, than an arrest for the same violation when no accident resulted . . . The two men assigned to each of these locations were directed to concentrate their efforts on increased enforcement and investigation of accidents within their specific pilot areas. In addition they were instructed to

> develop data on the cause of accidents and effects of increased enforcement . . . These men were part of our patrol force and, of necessity, had to participate in the routine police functions of their entire station patrol area. . . (pp. 3, 4, 5.)

Extra patrol hours were spent in the area beyond that of normal coverage. The selection of locations was based on accident experience. All roads were state highways, except one location with town and county roads as well. Traffic violations were increased (no data given). There were routine changes such as the installation of signals, but no major reconstructions. Physical changes that occurred in this area could be considered identical to the usual changes that occurred on any other road in the state.

At the end of 12 months of the study, there had been 979 accidents, compared with 1177 in the preceding 12 months, a 17% decrease. The 12,706 extra hours of enforcement (no figure for the hours of enforcement before this action is given) resulted in 8935 traffic arrests. During the same period, total accidents in the rural areas of New York increased in 12% and accidents investigated by the state police increased by 9%.

In the first six months of the following year, there was a 2% increase in accidents above the first six months of the program, whereas there was a 10% increase in accidents investigated by the state police; no number for all reported accidents was yet available.

However, one has to be careful when using the figures on investigated accidents for comparisons, since the two additional men were directed to conduct investigations on "as many fatal and serious personal injury accidents as possible" (p. 3).

One of the conclusions of the author is:

> Our detailed accident investigation led us to believe that there are serious deficiencies in individual drivers. These deficiencies are not necessarily in the area of "driver attitude" but are much more predominant in the area of the driver's ability to respond to emergencies . . . The preponderance of cases though have been those in which the driver failed to recognize the developing problem or upon recognizing it took no action or the wrong action. (pp. 11, 12.)

Though the data suggest a reduction of accidents, no definite conclusion should be drawn since other potential factors (volume, changes in roads, and traffic conditions) are only summarily discussed.

Ekstrom, B.; Kritz, L.B.; and Stromgren, K.L. 1966. Experiment with reinforced traffic supervision on Europe highways 3 and 18, summer 1965.

This Swedish experiment deals with the effects of quantitatively increased but otherwise unchanged traffic patrol. The control period (regular patrol) was May-June 1965, the experimental period (increased patrol) was August-September, 1965. Except for a few press articles long before the beginning of the experiment, there was no publicity.

Two sections of highway were selected. One was used as a control while the other received increased enforcement. The highways were selected for similarity of weather, traffic volume, and road conditions. The experiment consisted of recording accidents and some traffic parameters, both pretrial and trial periods, on both the test and control portions of the highways. The average daily pretrial staff was 28 policemen in 15 patrol cars and 10 policemen on motorcycles. For the trial period the staff was tripled. On the control highway, the staff consisted of 16 policemen in 9 cars and 6 policemen on motorcycles.

To ascertain if the reporting system or, equivalently, the number of accidents detected on the trial stretch was the same in both the trial and pretrial periods, a record was kept of the number of vehicles towed.

To study the effects of increased patrol, data were collected on the observance of traffic regulations, overtaking, entering the highway, and speed, partly before and partly during the trial period. The corresponding study of the control stretch was made during the same hours of the same days, to minimize the influence of the uncontrolled factors. Some of the results are given in Table B-16. The numbers in parentheses are from the statistical reports, the others from police authorities. The difference illustrates the difficulty of obtaining reliable and comparable accident data. An idea of the seasonal increase in accidents for 1964 is given by Table B-17. Also, observations were made of the behavior of cars when entering this highway and on the observance of speed limits. The data

TABLE B-16

RESULTS FROM STUDY BY EKSTROM, KRITZ, AND STROMGREN (1966)

	Experimental roads		Control roads	
Period	Injury Accidents	Serious injury and fatal accidents	Injury Accidents	Serious injury and fatal accidents
Control	45 (39)	19 (16)	43 (21)	9 (9)
Experimental	35 (27)	10 (8)	48 (38)	14 (11)

TABLE B-17

SEASONAL INCREASE IN ACCIDENTS
(Ekstrom, Kritz, and Stromgren, 1966)

	Experimental roads (May-June)	Control roads (August-September)
Control period	58	81
Experimental period	63	90

suggest, sometimes strongly, a favorable effect of the increased enforcement on driver behavior.

No statistical analysis was made of the data. The only analysis of the recorded results was to apply the rate of increase from pretrial period to trial period on the control stretch, to the pretrial figures on the trial stretch. It appeared that the numbers of accidents predicted on this basis were consistently higher than actually observed. The conclusion was that since this happened uniformly, increased supervision had a favorable effect on traffic safety. This may indeed be the case, but more analysis may be needed since the uniformity may result from dependence of the events.

Fitts, G.L. 1966. An evaluation of the effectiveness of police written warnings as a deterrent to traffic law violations in Tucson, Arizona.

Fitts evaluates the effectiveness of written warnings issued by the City of Tucson, Arizona, Police Department between May 13 and May 31, 1964. The evaluation is based on a comparison of the subsequent behavior of persons who initially received a written warning for a traffic law violation with the subsequent behavior of persons who initially received a citation for a traffic law violation.

Data collected were limited to drivers of Tucson, Arizona, as of May 13, 1964, who received written warnings and/or citations for moving vehicular traffic violations issued by the Tucson Police Department between May 13, and May 31, 1964. The subsequent behavior of these motorists was then observed until October 31, 1964. The restrictions placed on the experiment, in an effort to control the observation period, similarity of treatment, nonmoving vehicular traffic violations, outside traffic enforcement action, continuity of law enforcement personnel, and the five months of observation are considered adequate for this study.

Data on written warnings were acquired from the Records Section of the Tucson Police Department. Data on citations were obtained from the Traffic Violators Bureau of the Municipal Court.

During the observation period, June 1 through October 31, 1964, both written warnings and citations were considered evidence of further traffic offenses.

The data were grouped by sex and age. The null hypothesis that there was no difference between the effects of initial actions on subsequent behavior was applied for each sex and age category to be studied. Two-by-two contingency tables were established, containing observed frequencies of initial and subsequent behavior. Statistically expected frequencies were computed and tested by computing the chi-square using a significance level of 0.05. The experimental group contained 1,255 persons; the control group, 1,502 persons. Data were analyzed for all persons in the two groups, by male and female, males by age category, and females by age category.

In the experimental group, 229 subsequently committed additional offenses, for a repeat rate of 18%. The male segment committed the greater proportion; offenders in the 18-24 year age class predominated. In the control group, subsequent offenses were committed by 206 motorists for a repeat rate of 14%. Males and the 18-24 year class again predominated. In summary, persons in the control group (initial citation) committed fewer subsequent offenses than were statistically expected. The experimental group (initial warning) committed more offenses than were statistically expected.

Hooker, R.W. 1966. Traffic accident costs and the effectiveness of highway safety expenditures in Wyoming.

The purpose of this study was to determine:

> . . . which highway accident prevention programs were most effective in reducing the number and cost of traffic accidents in Wyoming. (p. 1.)

Since the effectiveness of police activities was also evaluated in this study, Hooker's study was selected for detailed review.

Hooker studied accidents and traffic safety activities in Wyoming by multiple regression analysis of yearly data from 1953 (in some cases 1951) to 1964. His dependent variable is the total number of traffic accidents; his independent variables are:

- motor vehicle registration
- motor vehicle mileage
- number of hours worked by the Wyoming Highway Patrol
- total safety expenditures by the Wyoming Highway Patrol
- expenditures by municipalities for traffic police
- fines and forfeitures incurred as a consequence of traffic violations
- expenditures by the State Highway Department for
    - total maintenance
    - guidelines
    - snow, ice, and sand removal, and for ice control
    - traffic services, and
    - construction of miscellaneous facilities
- number of days each year in which 0.10 inch or more of snow and/or sleet fell

Hooker calculated "several hundred regressions" and selected for further analysis those variables whose regression coefficients consistently showed the same sign. The measures of highway patrol activities showed a consistent negative relation to accidents when lagged one or two years. Hooker selects the average number of hours of work of the Wyoming Highway Patrol in the two preceding years, traffic engineering expenditures, the number of days each year during which 0.10 inch or more of snow and/or sleet fell, and motor vehicle registration as variables for his final regression analysis. He determines several regression equations, the most important of which, together with the standard error of the regression coefficients shown in parentheses, is:

$$Y = 75.1x_1 - 30.4x_2 + 26.2x_3 - 6.0x_4$$

$$(105)\ \ (4.1)\qquad (2.5)\qquad (6.7)\qquad (1.0)$$

where Y is the number of accidents, x_1 is vehicle registrations in thousands, x_2 is hours of work of the Highway Patrol in thousands, x_3 is the number of snow or sleet days, and x_4 is traffic engineering costs in thousands of dollars. (To give an idea of the order of magnitude, Y varies between 7,000 and 11,000, the annual hours worked by the Highway Patrol between 165,000 and 219,000.) Hooker finds that the regression coefficient for the hours of Highway Patrol work is significantly different from zero. Although he notes that, "If several hundred different regressions were run, then chance alone should yield some significant independent variables" (p. 55), he concludes

> The findings show that additional dollars allocated to the Wyoming Highway Patrol were most effective in reducing the number of accidents and accident cost. An additional dollar spent on the patrol resulted in an average reduction in accident costs of over ten dollars . . . If the budget of the Patrol were increased by 50 percent, it is doubtful that these extra expenditures would be any less effective than they have been in the past. (p. 2.)

The conclusions are too sweeping--especially the extrapolation—and cannot be sufficiently substantiated. However, the results--a multiple correlation coefficient of $R^2 = 0.9999$--suggests that there is some relation and that a deeper analysis of the matter is warranted. It appears doubtful whether standard tests can properly be applied to a regression using variables selected as these are. If, out of fourteen potential independent variables, several hundred combinations were formed and then those variables were selected that showed consistently the same sign of the regression coefficient, it is not unlikely that their combination will result in a high correlation coefficient. We found the following points that should further warn against too precipitous conclusions: a large component of accidents can be explained by a trend alone, which explains 79% of the variance, and we found no significant correlation between the number of accidents and the "lagged" hours worked by the Highway Patrol alone. Further, the (non-significant) regression coefficient that was determined has a positive sign, implying a positive correlation between Highway Patrol activities and number of accidents. This suggests that the influence of the police activity is rather subtle, especially if one looks at the variable, "number of days with snow and/or sleet." Even though the latter variable alone is not significantly correlated to accidents (due to the trend in the accident figures), the graphical presentation of accident numbers and number of days with snow show an obvious parallelism in the small variations. Another argument suggesting caution is that the author finds no consistent influence on accidents by the municipal expenditures for traffic police.

It should be possible to test the hypothesis that Hooker's results suggest. For example, one might distinguish between accidents occurring in the domain of the Highway Patrol and those occurring in municipalities. The first should show a stronger correlation with total expenditures than the latter. Also, the hypothesis of a lag might be tested by combining the actual patrol hours for periods other than the calendar year. If there is a build-up of effects of increased enforcement, this should be recognizable from the shifts. However, the average of data for the two preceding years is not the same as the data lagged by 18 months, which, since it introduces an auto-correlation in the independent variable, might cause statistical problems.

Summarizing, we can consider Hooker's results, at best, as suggestions of relations, but cannot attach any confidence to them.

California Highway Patrol. 1972b. Operation 101: An accident and enforcement study. Condensation..

California Highway Patrol. 1972c. Operation 101: Final report. Phase Iv, part 2. Relationships.

Operation 101 was a study conducted by the California Highway Patrol that was designed to answer the question: "Can you design a study that will prove that traffic law enforcement is or is not effective in reducing accidents?" (California Highway Patrol 1972b, p. 1).

The basic finding of the CHP researchers is that:

> The results of operation 101 can be stated very simply. Manpower was increased, enforcement actions increased, driver violations were reduced, and accidents were reduced.

(California Highway Patrol 1972b, p. 4.)

This is an ex post facto study of the effect of significantly increasing police manpower on a specific segment of roadway. No control sites were used in the study. Further, as the CHP author states, "No research design was built into the actual deployment by hour of day, day of week, or month of year. Manpower was deployed on the study roadway based solely on the Field Commander's experience."

The study began on January 1, 1964 and ended in 1965. The actual location of Operation 101 was a 36-mile stretch of U.S. Highway 101, which was divided into two 18-mile segments, the "Northern Beat" and the "Southern Beat." The Northern Beat consisted of 18 miles of 4-lane conventional roadway running between the Pacific Ocean and the Marine Corps Base at Camp Pendleton. This segment of roadway had an average daily traffic of 27,000 vehicles. The Southern Beat consisted of 18 miles of a variety of roads going from full freeway near the City of Oceanside to the city streets of Delmar, California. The average daily traffic on the Southern Beat was computed at 36,000 vehicles.

Manpower was doubled from 18 to 36 officers during the study period. A total of 55 officers participated in the study. Table B-18 shows the percentage increase in traffic arrests during the study period. The major change was on the midnight shift and on the weekend. The day shift did not show as much of a change.

The violation surveys conducted in this study involved speeding and other moving violations. The surveys were conducted by CHP observers from highway overpasses. The CHP authors concluded that the manpower increase resulted in statistically significant decrease, in almost all cases, for the category of other moving violations. Speeding violations showed no overall statistically significant decrease. Violation volume was plentiful, averaging 73 per hour during the 224 hours of the violation surveys.

A summary of changes in accidents during the Operation 101 is shown in Table B-19.

A more detailed analysis of accidents was performed as follows:

TABLE B-18

PERCENT INCREASE OF ARRESTS BETWEEN 1963 AND 1964
(California Highway Patrol 1972b)

	Northern Beat	Southern Beat
Midnight Shift	+250%	+385%
Day Shift	+ 53%	+ 62%
Swing Shift	+102%	+ 78%
Weekday	+ 92%	+ 82%
Weekend	+132%	+109%

TABLE B-19

CHANGES IN ACCIDENT EXPERIENCE DURING OPERATION 101
(California Highway Patrol 1972c)

	Fatal and personal injury crashes	Total accidents
Midnight Shift		
Northern Beat	-12%	-22%
Southern Beat	-43%*	-26%*
Day Shift		
Northern Beat	-10%	+ 2%
Southern Beat	-19%	0
Swing Shifts		
Northern Beat	-35%*	-39%*
Southern Beat	-16%	- 7%

* Significant changes.

Information was collected on all traffic officer activities in the Oceanside area, both on and off the study road, for one year (1964). Hourly data were used for 1964 as data points for regression analysis. They were also accumulated on a daily basis, by workshift, and weekday or weekend. Reportable and total accidents were used as dependent variables. Correlations of various degrees were found between accidents and independent variables, selected from arrests, verbal warnings, parking arrests, mechanical warnings, services, traffic, rainfall, manhours scheduled, hazardous arrests, total stops, in-view hours. Arrests nearly always had significant (at 5%) negative regression coefficients, verbal warnings also. Hazardous arrests, however, had nearly always positive, sometimes significant, regression coefficients. In-view hours had nearly always negative, usually significant regression coefficients.

We consider the value of these regression equations questionable: some independent variables, like arrests, verbal warnings, manhours scheduled and in-view hours are likely correlated, also arrests and warnings are likely to be correlated to traffic. Arrests include hazardous arrests, and are therefore correlated to each other. On the other hand, no distinction is made between arrests resulting from accidents and others, which generates a correlation, which is probably responsible for the positive regression coefficient of hazardous arrests. These likely correlations between the independent variables can create correlations which makes an interpretation of the regression equations hazardous.

Changes in arrests and accidents between 1963 and 1964 by shift and beat, were described, and the relations between percent change in accidents and percent change in the "enforcement index" shown in a figure: approximately linear, negative, relations appeared. We have earlier criticized the enforcement index as an unsuitable measure of police traffic law enforcement. A comparison of the arrests and accidents per shift does, however, show fewer accidents related with the more arrests. Since no control group was used, and the regression analyses are based only on the year with experiments, thus not allowing a before and after comparison, no conclusions beyond that drawn previously, that there appears to be beneficial influence on accidents, can be drawn from this analysis, but Tables B-18 and B-19 add support by suggesting some relation between increased arrests and decreased accident numbers.

Also compared was how manpower in terms of men/100,000 vehicle miles of travel, by shift and beat, related to change in total accidents. The conclusion was that where more than 3 men/100,000 VMT were assigned, accidents decreased, though not always significantly. We do not see, however, how an absolute level of manpower for a time period might be functionally related to a change in accidents.

The greatest weakness of this report is the lack of control groups. The regression analysis used is, as discussed, not a convincing substitute. Therefore, though the data are compatible with the hypothesis that the increased police traffic activities did beneficially affect accidents, they do not suggest this except in an intuitive way. The external validity is limited at least by the highly unusual situation of the highway studied.

Fraser, H.D.G., and Hills, P.M. 1967. Hampshire and the Isle of Wight: Assessment of motorcycle traffic patrols.

In this British study, a system of motor cycle patrols, beginning with 12 in 1964 and adding up to 37 (actually, only 36 since two were combined) in 1966, was established for the "purpose of reducing accidents and encouraging the force movement of traffic."

Accident data for 1964, 1965, and 1966, broken down by patrols and with information on the beginning of the patrol and the length of road covered (between 3 and 30 miles), are presented. The only comparison done by the authors is inconclusive, showing about as many increases in accidents as decreases; however, we think that their comparison of accidents between years with full patrol coverage is improper for an evaluation of the effects of patrols on accidents (it might be appropriate for checking build-up degrading effects).

A rigorous statistical analysis would be quite difficult, since the different starting dates of the patrols and lengths of patrols should be considered. Some gross tests did not show any clear-cut patterns. Therefore, the results of this program appear inconclusive.

Gates, G.G., and Hand, N.E. 1967. Policing of primary routes. Part II, results of no. 7 police district traffic experiment.

From August 1 to December 31, 1965, an experiment was conducted in Police District No. 7, in the southwest of England. 541 miles of primary roads were selected and divided into 25 sections as close as possible to 20 miles each. Personnel from police forces in District No. 7 were reassigned to these selected primary roads so that there was one patrol car and one motor cycle or two motor cycles per 20 miles during the day and one patrol car per 40 miles during the night.

Among other things, changes in accident numbers were examined. Accident numbers for the period from August 2 to December 31 of the experiment and the preceding year are shown in Table B-20.

TABLE B-20

TOTALS OF SERIOUS AND FATAL ACCIDENTS
(2 August-31 December) (Gates and Hand 1967)

	1964	1965
Selected Primary Roads	530	444
Non-selected Primary Roads	675	707
Rest of No. 7 District	2,320	2,435
Total for No. 7 District	3,525	3,586
Total for Great Britian	38,914	38,747

Testing the data as 2 x 2 tables, the difference between the Selected Primary Roads and the Total for Great Britian and also that between the Selected Primary Roads and the Non-selected Primary Roads are significant at the 0.1% level.

It is noticeable that the total for District No. 7 was nearly unchanged; this might lead to the speculation that the shift of policemen to the Selected Primary Roads reduced accidents there, but increased accidents in those parts which had reduced numbers of policemen.

The author discusses the changes in accidents for different parts of the time period and for different police forces within the experiment. Whereas there was a reduction, under two different assumptions, in all periods, there were reductions, again under two different assumptions, in 7 out of 10 areas.

Traffic volume data were known for two places only, insufficient to draw any conclusions.

Since the 541 miles were chosen from the "more important" primary roads, one has to be careful with comparisons. The only point which gives some weight to the data is the difference in accident numbers between the roads with increased patrol and those with reduced patrol.

No reliable data on the levels of patrolling during 1964 were known, but it was estimated that the level of patrolling on the related primary roads in 1965 may have been on the order of six times the level obtained in 1964; the effective decrease in patrolling on other roads was very much smaller.

The level of patrolling did not vary strongly over time or between the districts; from a graph we estimate an average of 4,700 patrol hours per week. This gives a total of about 100,000 man-hours or 50 man-years.

Kaestner, N.; Warmoth, E.J.; and Syring, E.M. 1965. Oregon study of advisory letters: The effectiveness of warning letters in driver improvement.

The Oregon Department of Motor Vehicles, Drivers License Division conducted a study of its overall driver improvement program to evaluate the effects of warning letters, differing in form and content, as deterrents to future traffic involvements. From a pool of records of drivers who were eligible for warning letters, four groups were formed: (1) a control group of drivers who received no warning letter, (2) a standard form-letter group, (3) a personalized letter group, and (4) a group who received personalized letters that were less threatening and more encouraging ("soft-sell"). Each grouping was made on a random basis.

The basic assumption for this study is that, if the subsequent driving records differ among these four groups, this is presumably the result of the different treatments (forms of letter used) of the four groups, and not to other extraneous factors. The study included only male drivers with valid licenses who had no prior contact with the driver improvement program in Oregon. Approximately 52% of the drivers involved were less than 25 years old. The number of records in the final evaluation of the four groups was 240, 241, 233, and 233, respectively.

Subsequent driving records for the four groups were evaluated for periods of six months and one year. If a driving record included no entries, minor violations or nonchargeable accidents, it was classified as a "success." If a record included a moving violation of a relatively serious nature, it was classified as a "violation failure." If a record included a chargeable accident, it was classified as an "accident failure." Proportions of success and failure were determined for each of the four groups, and the deterrence of the warning letter was assessed by comparing these proportions with those for the control group. The results after a full year are presented in Table B-21.

TABLE B-21

RESULTS OF OREGON STUDY
(Kaestner, Warmoth, and Syring 1965)

Classification	Control (no letter)	Standard (form)	Standard (personal)	Soft-sell (personal)
Accident failure	8%	6%	6%	3%
Violation failure	41%	47%	41%	41%
Success	51%	47%	52%	56%

The results of this study indicated that those receiving the standard letter and those receiving no letter had very similar subsequent driving records. By contrast, those who received the personalized standard letter and the personalized "soft-sell" letter did, in fact, respond more favorably during the next six- and twelve-month driving intervals. This better subsequent driving record is attributable almost entirely to the more favorable response to personalized letters by drivers who were under 25 years of age. None of the letters sent to drivers 25 or older had any appreciable effect on subsequent driving.

Although the assignment of records to each of the four groups was made by random selection, which resulted in a median age of approximately 24 years for each group, it is presumed that the years of driving experience, prior conviction and accident records, and special restrictions are also equivalent among the subgroups. It has also to be assumed that the violation records reflect the driving behavior, which is obviously only true if the probability of apprehension remains unchanged. No statistical analysis of the significance of the results is made. Since the number of accidents is small, one must interpret the data carefully.

<u>California Highway Patrol. 1968. Roadway characteristics and manpower deployment study. Phase II. Moving violation study.</u>

The objective of this study was

> . . . to determine possible stable relationships (1) between highway traffic volume and the frequency of certain traffic law violations and (2) between traffic law violation frequency and motor vehicle accidents. (p. 1.)

Discussed here are only those parts relating to passenger cars and freeways, the main body of the study. Thirteen locations on US 101 were used, all being four- and six-lane freeways with average daily traffic volumes ranging from 8500 to 130,000 vehicles. Officers in civilian clothing using unmarked cars counted violations and measured speeds. The observers distinguished between "speeding violation," meaning exceeding 70 mph and "non-speeding risk violations," of which the following were observed:

- slow driver, left lane
- not passing or driving in designated lane
- changing lanes unsafety
- following too closely
- passing unsafely
- turning upon roadway unsafely
- interfering with driver or mechanism
- passing on right unsafely
- parking on roadway
- stopping on freeway
- starting parked vehicle unsafely
- divided highway crossing
- speed contest on highway
- not yielding for passing
- towed vehicle swerving
- passing without sufficient clearance or unsafely
- slow speed, impeding traffic

For each location, data for a total of 24 hours (comprising two 12-hour periods, one on a weekday, one on a weekend) were used. The volume is referred to as "survey volume," to distinguish it from the "average daily traffic" (ADT) which was taken from the 1965 Annual Traffic Census.

The most obvious step in analyzing data is to plot them. A plot of total violations versus survey volume shows no obvious relations; however, separate plots for speeding and for non-speed risk violations versus survey volume suggest such relations. Speed violations appear to decrease nonlinearly with volume, whereas non-speed risk violations increase with volume (the correlation-coefficient of 0.72 is significant at the 5% level).

As the "final link in the logic chain," the author examines the relation between accidents and violations. A plot of accidents versus total violations shows no apparent relationship. However, a plot of accidents versus non-speed risk violations shows a fairly good linear relationship.

Such a relationship suggests that one could assume an underlying causal relation between non-speed risk violations and accidents. However, a closer inspection of the diagrams shows some similarities that suggest the relation might be due to a common dependence of both violations and accidents on one basic variable, namely traffic volume. A plot of accidents versus either survey volume or average daily traffic volume showed good linear relationships.

To eliminate the influence of volume, we calculated the regression of accidents versus ADT (because both relate to an entire year), and used the regression of non-speed risk violations versus survey volume (since both refer to the same period of observation). We expect the residuals of the data against the regressions to reflect a more specific picture of the accident and violation situations, since the influence of the numbers of vehicles and opportunities for accidents should be at least reduced by this regression. A plot of the residuals versus each other (see Figure B-2) suggests no relation at all. Thus, we feel that there is no indication of a causal relation between "non-speed risk violations" and accidents. Of course, if there were also a contribution of speeding violations to accidents, this might obscure such a relation. Therefore, with each point in Figure B-2, the corresponding number of speed violations is given. No

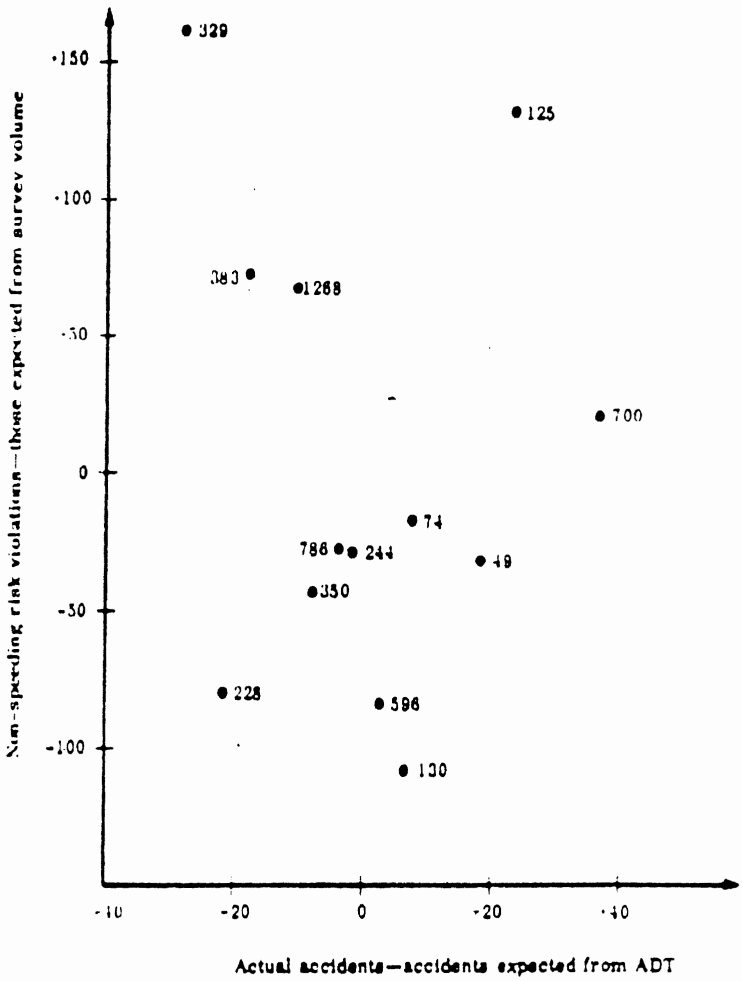


FIGURE B-2

RELATION BETWEEN RESIDUALS OF ACCIDENTS
(numbers at points are speed violations)
(California Highway Patrol 1968)

pattern is recognizable in these figures either. Of course, it is also plausible that the absolute number of speeding violations is not the important factor, but rather the excess over the corresponding average. We could not test this exactly since we had no basis for assuming a specific non-linear function to calculate a non-linear regression. However, an attempt to do this graphically was not successful.

Thus, the data of this study do not suggest any relationship between traffic violations and accidents. This, however, does not mean that there might be none. There might be either a subtle influence of speeding violations, or some of the "non-speeding risk violations" might actually not be risky, which is likely to be the case, for example, "slow driver, left lane," which might only be a nuisance and traffic impediment. An analysis with a finer breakdown of violations appears to be worthwhile.

Council, F.M. 1970. A study of the immediate effects of enforcement on vehicular speeds.

In March 1970 the results of a study conducted by the University of North Carolina Highway Safety Research Center was published. Although somewhat limited in its overall scope, its conclusions tend to support the results of most other research. The study examined the short term or immediate effects of two enforcement symbols on vehicular speeds: (1) a single North Carolina Highway Patrol vehicle parked adjacent to the roadway and (2) a single patrol vehicle moving in the stream of traffic. Data was then collected at three points along the test site--at the location of the enforcement unit. The experiment was conducted on four separate but similar segments of roadway varying from 10 to 18 miles in length and during four time periods between 9:00 a.m. and 4:00 p.m. Mean speed, speed variances and percentage of vehicles traveling above the speed limit were the measures for evaluation of the effects.

The study based its analysis only on speeds of vehicles approaching from a single direction, when the patrol vehicle was stationary, and only on speeds of vehicles meeting the enforcement unit when it was moving. Speed data came only from free flowing vehicles (a subjective evaluation was made) and analysis was further limited to pairs of "matched" speeds, i.e., before and after speeds for the same vehicle.

The results indicated that all vehicles passing an enforcement symbol were affected by its presence; however, the effects were differed according as to whether the symbol was moving or stationary. The stationary symbol produced a decrease in mean speeds, a decrease in speed variance, and a decline in the number of violators between the before and after measurements. A moving enforcement symbol produced either no effect on speeds or the opposite effect--that is, mean speeds, speed variances and number of violators often increased.

<u>Jorgenson, N.O. 1970. The application of speed regulations in Denmark.</u>

Up to 1953 there were in Denmark general speed limits of 40 km/hr in urban and 60 km/hr in rural areas for all vehicles (and limits for special types of vehicles). In 1953, general speed limits for cars were removed. The trend in the number of persons injured, separate for motor vehicle occupants, motorcycle riders, moped riders, bicycle riders, other vehicle riders, and pedestrians was compared. The data suggested an increase in personal injury and fatalities for two-wheel vehicles and pedestrians. Comparing the accident experience for 3 and 6 year periods before and after 1953 showed that before 31% of accidents happened in rural areas, after 36%. Before 1953, 60% of all fatalities occurred in rural areas, after 1953, 65%. No statistical analyses are performed, nor was any other factor quanwitatively considered.

At dangerous curves, advisory speed signs have been posted, the speed dètermined by driving experiments. At 16 of these curves, accidents dropped from 60 during the year before to 24 during the year after; at 8 others, from 76 during the two years before to 40 during the two years after. Most of the reduction, however, is due to a few locations, the others showing little improvement. No statistical test was performed. Due to the lack of consideration of other factors, the results are at best suggestive. The external validity is limited since Danish experience cannot be directly transferred to the United States.

<u>Newby, R.F. 1970. Effectiveness of speed limits on rural roads and</u>

motorways.

Experience with a 40 mph speed limit is reported which was imposed on 120 miles of road in the suburbs of London. Seventy-two miles of road had no previous speed limit, but 46 miles had had a 30 mph limit. An analysis by Newby (1962) showed a statistically significant (5%) reduction of injury accidents by 19%, and about 28% fewer fatal or serious injury accidents, during the six months after. An analysis of the next 17 months showed almost unchanged effects. However, on those roads where the limit was raised from 30 to 40 mph, there were increases in injury accidents by 2%, and by 8% in fatal and serious injury accidents, statistically not significant. Since this is a secondary source, the validity cannot be determined.

Between 1959 and 1964, temporary speed limits were imposed on summer weekends (June through August) on certain sections of busy main roads, many of them holiday routes. During 1961 through 1962 accidents decreased by 27%, whereas they decreased by 21% on similar roads without speed limits. Casualties decreased by 24%, but only to 18% on control roads, and 3% on all other roads. No statistical analysis was attempted.

Instead of the 50 mph limit during summer weekends, a permanent 50 mph limit was imposed on 400 miles of busy main roads, mainly chosen because of their high accident rate. Comparing the accidents on these roads with those of other roads in the same police districts (but excluding the summer months to exclude the effects of the summer speed limits) shows a reduction from a ratio between .050 and .069 to .046 and .048. No statistical analysis is performed.

The results of a preliminary evaluation (Road Research Laboratory, 1966, 1967) of the imposition of a general speed limit of 70 mph on roads not previously subject to a lower limit, are briefly reported. On a 100 mile sample of dual roads with high-travel speeds before imposition of the limit, fatal and serious casualties were 21% fewer, the reduction being statistically significant at the 1% level. On the entire no-travel or motorways, there was a reduction of 20% in casualties.

This report is too sketchy to allow critical evaluation of the reported results; e.g., it is not mentioned to what extent the speed limits were enforced, though some data on vehicles exceeding the speed limit are given.

A bibliography with short abstracts is appended to this paper. Those abstracts which contain quantitative information are summarized here without evaluation.

Bitzel, F. 1966. The accident risk on motorways.

A study is mentioned, comparing accidents and casualty rates per vehicle miles traveled (VMT) on two German Motorways, and with no speed limit, and one with a 100 km/hr speed limit. The death rate was 18% lower, the casualty rate 42% lower than on the unrestricted motorways.

Harrinen, S.; Leinonen, K.; and Ratilainen, L. 1966. Research on speed limits in highway traffic in 1962.

A general speed limit of 90 km/hr was imposed during June-September 1962 in three Finnish counties. One main roads outside the local speed limit areas, the number of fatalities was reduced by 17%, the number of injuries by 13%, mainly in accidents involving cars.

Prisk, C.W. 1967. Accident rates on motorways especially with reference to: (a) speed restrictions (b) minimum and maximum speed limits.

Accident numbers and VMT for all United States toll roads in 1965 are compared. Grouping according to the speed limit shows the results in the data shown in Table B-22.

Wehner, B. 1966. Considerations of safety in road design.

Casualties on the Autobahn, Cologne-Bonn (four lane, undivided) before and after imposition of a 80 km/hr speed limit are shown in Table B-23.

Joscelyn, K.B.; Bryan, T.H.; and Goldenbaum, D.M. 1971. A study of the effects of law enforcement on traffic flow behavior. Final report.

The general objective of this study was to evaluate the effect of

TABLE B-22

ACCIDENT AND DEATH RATES ON U.S. TOLL ROADS BY SPEED LIMIT (Prisk 1967)

Speed Limit (mph)	Accidents per 100,000,000	Deaths VMT
60	95	1.7
65	117	2.2
70	118	2.7
80	102	7.1

TABLE B-23

CASUALTIES ON THE AUTOBAHN COLOGNE-BONN BEFORE AND AFTER IMPOSITION OF A SPEED LIMIT OF 80 km/hr

	Before	After
Killed	21	3
Seriously Injured	72	31
Slightly Injured	127	79

various methods of enforcement on traffic flow behavior. While the effect of law enforcement in general was the major concern, special attention was also paid to distinguishing the different effects of several basic types of enforcement symbols and activities. Thus, the collection and analysis of data concentrated on documenting the manner in which both moving and stationary police activities affected a series of different measures of traffic flow.

To measure the effects of enforcement, data were obtained by a computer-sensor system which monitored traffic at 14 separate locations on State Route 37 in Monroe County, Indiana. At each site, traffic was measured in both directions by means of strategically located loop detectors which were coupled via rented telephone transmission lines to an IBM 1800 Process Controller Computer located within the physical plant of the Institute for Research in Public Safety. Eight such sites were located within a 1.4 mile section of highway where the stationary sampling activity was conducted.

To test the stationary vehicle effects on traffic flow behavior, four test locations were selected within the 1.4-mile segment. The four sites were located to stimulate differing degrees of awareness in a driver as he overtakes stationary enforcement stimuli, with long or short periods of warning. The sites also provided for the varying capabilities of the enforcement vehicle operator to observe traffic once it had passed by him. Four time slots within the 24 hour day were selected to represent flow, including moderate and heavy daytime traffic and light and moderate night-time traffic. Finally, six different enforcement vehicle configurations were employed during the four different times at the four separate locations. The six vehicle types were:

1. Civilian
2. Unmarked State Police
3. Marked State Police
4. Marked State Police with Radar
5. Marked State Police in an Arrest Configuration with

Lights, and Stopped Civilian Vehicle

6. Two Marked State Police, One with Radar

The effects of moving enforcement vehicles were measured by a slightly different method. Nineteen Indiana State Police marked vehicles were equipped with low-power transmitters. Concomitantly, at 12 sensor sites, a receiver was installed to notify the computer of the presence of the police vehicles. Appropriate software was written to identify each police vehicle and label its data as they were placed into permanent storage. Since the computer-sensor system operates on a 24-hour-a-day basis, all varieties of traffic density and times of day were sampled.

Findings concerning the comparative effects of stationary and moving enforcement symbols upon traffic flow behavior may generally be summarized, as:

1) Stationary enforcement symbols significantly lowered traffic speeds and percentages of speed limit violators, but did not significantly affect overall traffic headways, percentages of headway violators (i.e., of "tailgaters"), nor the standard deviation of traffic speed distributions. Moving enforcement symbols lowered traffic speeds to comparable, although somewhat smaller, degrees.

2) Actual decreases in traffic speeds and percentages of speed limit violators produced by the various stationary symbols varied under different traffic density conditions, extending for clearly demarked distances in each lane of traffic, but no farther than 3.2 miles in either lane for any symbol under any density level. Moving enforcement symbols also were observed to lower traffic speeds for measurable distances ahead and behind in both lanes. Unlike stationary symbols, moving enforcement symbols demonstrated maximum effects upon traffic speeds at some distance ahead of the enforcement vehicle, rather than immediately adjacent to it. In all, the effects of moving symbols extended for shorter overall distances.

3) Stationary enforcement symbols lowered the speeds of, and percentages of speed violators in, nearby traffic, in direct proportion to the "severity" of such symbols; i.e., to the extent to which passing

motorists might be expected psychologically to interpret such symbols as posing an arrest "threat." At extended distances, however, these effects were inversely proportional to symbol "severity."

4) The effects of both stationary and moving symbols were generally greater in the same, rather than in the opposite, lane of traffic.

5) The shapes of spot speed distributions at roadway points of maximum effectiveness were generally "normal"--i.e., Gaussian—before, during, and after the periods when stationary symbols were introduced. In other words, the normality of such distributions was on the whole unchanged by the enforcement symbols during overall shifts to lower speeds in both lanes of traffic. Although infrequent, changes in the presence of stationary symbols appear to have been in the direction of non-normality, rather than toward increased normality.

6) The effects of both stationary and moving enforcement symbols upon traffic speeds dissipated rapidly after these symbols were removed.

Finally, due to the relatively low level of accidents and non-significant change in the overall level of enforcement, no statistically significant relationships could be established between enforcement activity and local accident occurrence.

<u>Rice, R.A. 1972. A study of varying degrees of speed limit enforcement.</u>

The author discusses enforcement of speed limits and traffic accidents of Brisbane, Queensland, Australia, from 1960 to 1970.

Changes in speed limits, enforcement practices, and the number of moving hazardous violations are discussed and related to road deaths, pedestrian deaths, number of persons injured, number of persons seriously injured, and the casualty accident rate per 10,000 vehicles.

The results, somewhat simplified, are that there was an increasing trend in traffic injuries and fatalities until 1964, a decrease to 1968 and an increase afterwards. From the middle of 1963, warning signs for speed control by radar units were no longer required; from 1969 on, they were again required. The author admits that factors other than enforcement--such as better street lighting, better roads, etc.—might have contributed to the decreasing trend from 1964 on, but that the only factor changed in 1969 and 1970 was the speed limit enforcement method, which considerably decreased the apprehension of speed offenders.

No statistical analysis was attempted, no control groups were used (except when commenting that a reduction in deaths in 1961, a recession year, occurred in all of Australia). The author's conclusions are at best suggestive, and by no means convincing.

Rutherford, J.W. 1971a. Flint's selective enforcement unit proves successful.

Systems Research, Inc. 1971. Interim analysis of the selective enforcement project.

The Flint Police Division began a major test of the concept of selective enforcement on July 1, 1969. The program lasted three years, ending on July 1, 1972. No final evaluation of this project has been completed as yet. However, the two articles referenced above report on some of the preliminary results of the project.

Rutherford describes the objectives of this program as:

> (1) . . . The reduction of serious accidents involving physical injury or death
>
> (2) . . . The reduction of all traffic accidents, and
>
> (3) . . . Better implementation of accident investigation data. (pp. 9-10.)

In this program, Flint hired 29 men especially to work in the Selective Enforcement Unit. They were supervised by experienced officers and specially trained to perform this function. The men were assigned primarily to 15-18 one-man, semi-marked cars of which 10 are VASCAR-equipped. The remaining cars are operated as two-man cars and are used primarily for transporting prisoners who have been arrested by other Selective Enforcement Officers. This program actually became operational on November 23, 1969. All operations are confined to one eight-hour period. Initially, this time period was 2:00 p.m. to 10:00 p.m. The city was divided into 32 grids of equal size and the Selective Enforcement Team generally saturates the four grids with the highest daily frequency of accidents. However, all grids must be adjacent to each other for assignment purposes.

Rutherford's article presents some glowing preliminary reports on the success of this program. His evaluation is based on the following approaches.

A "trend" line was computed by averaging the number of accidents per month for each month of the year 1966 to 1969 (prior to the start of the program), and calculating the change from month to month in percent. Month-to-month changes in accidents during the program were compared with the corresponding changes in the base period. Compared with the base "trend," the first month of the program showed a decrease of 21.8% in all accidents in the entire city, of 59.9% in the area of the selective improvement unit's deployment and a 25.1% decrease in injuries and fatalities. Similar statistics are noted in the article but no absolute numbers are presented.

An independent study of the Selective Enforcement Unit was performed by Systems Research, Incorporated. Again, their interim report does not present any absolute numbers that could be used to perform more detailed analyses of the effectiveness of this program. However, this report does point out some major problems in the design of the project:

> The fundamental limitation of this technique (the use of a trend line) is that it assumes that any and all differences between "expected" and the actual trends is entirely attributable to the activities of the SEU. Using this approach, no consideration can be given to changes in weather conditions, traffic densities, driving behavior, and a host of other factors which may have had an influence on the number and severity of accidents which were occurring . . . (In short), its "true" effectiveness being "masked" by the adverse intervention of "other" factors.

SRI used the following approaches to evaluate the effects of the Selective Enforcement Units: the seven most heavily patrolled grids in the city were selected. The average daily numbers of accidents were calculated, month by month, per days on which the unit was patrolling and for days on which it was not patrolling. This could be done for a seven-month period only. Linear regressions between the average daily accident number and the number of the month were calculated, separate for patrol days and non-patrol days. The purpose was to determine whether there were fewer accidents on patrol days than for non-patrol days. This report finds that accident frequency over the period was decreasing more rapidly on patrol days on one grid, increasing less rapidly in four grids, decreasing at the same rate in one grid, and increasing more rapidly in one grid, and concludes that the SEU was apparently effective. A similar analysis was performed on accident numbers weighted by severity. No significance tests were performed; however, a visual inspection of the graphs of the report suggests that many of the differences discussed are probably not significant.

The report, however, mentions basic problems with the design of the experiment: Scientifically defensible analysis of the Unit's effectiveness is severely confounded by the policies governing deployment of the Unit. Selective enforcement units were assigned for a given day of the week for an entire month to four adjacent grids; that combination of grids which had the highest numbers of accidents on this day of the week in the preceding month. The rationale for doing this was that on these days, based on past history, the expected number of accidents would be highest.

This hypothesis, however, was not tested. An alternative hypothesis would be that the high accident numbers in the preceding month were chance fluctuations, and that therefore in the following months a more probable lower number of accidents would occur. If this hypothesis were true, the SEU would have been operating in grid squares where lower accident numbers were to be expected. Thus, SRI's approach to the evaluation of the effectiveness of the SEU is not only not convincing, but possibly misleading.

Nor is Rutherford's approach to the evaluation convincing: his use of average month-to-month changes assumes a steady post-trend which was not tested. The use of relative (percentage) changes instead of absolute numbers, is possibly confounding the effects of chance fluctuations. The fact that the nationwide traffic fatality trend started to change in

November 1969, the same month the Flint program started, suggests strong caution against any trend comparison without a control group. The possible influence of the GM strike, which considerably affected Flint's economy during the experimental period was considered in neither study.

Therefore, we can conclude that the data presented are compatible with the hypothesis that the SEU did beneficially affect traffic accidents in Flint, but that they do not suggest such an influence. Therefore, the question of external validity does not arise.

Michigan Office of Highway Safety Planning. 1972. Selective traffic law enforcement projects in Michigan.

In this report, accident data for 17 jurisdictions in Michigan, in which selective traffic law enforcement projects were conducted, are presented, usually from 1969 to 1971. In most areas, the number of accidents in some categories (fatal, personal injury and property damage) declined. However, all but one project was started in either 1969 or 1971, so either not enough "before," or enough "after" experience was available. No control groups were used, therefore it is possible that the changes are part of a general trend, since nationwide traffic deaths declined between 1969 and 1970, and remained nearly constant to 1971. Neither is the potential influence of other factors considered. Therefore, the author's conclusions, "The overall . . . effect of these selective enforcement activities . . . resulted in a total of 71 fewer deaths during the period 1969-1971" (pp. 1-2) is not justified. The data are, however, compatible with the hypothesis that the program reduced accidents. The question of external validity does not arise.

Schiro, B.J. 1972. Sacramento Police Department selective traffic enforcement program. First annual report.

In this program, 18 officers were specially trained and equipped and assigned to STEP. The cooperation of the traffic engineers, the courts and the prosecutor was enlisted, and considerable publicity for STEP had been generated.

As results, accident data for city streets (excluding freeways) are reported in Table B-24. They are compared with nationwide increase in fatalities of 16% in unincorporated, and 2% incorporated data. The portion of Sacramento County excluding Sacramento shows an increase of 80%. No analysis was attempted. (This is surprising, since one might expect a "spillover" effect of the police activities into neighboring areas.)

Since factors other than police activity are not measured, and no comparable control group is used, therefore, no conclusion on the effects of the program can be drawn, though the data are compatible with the hypothesis that the program has an effect. The question of external validity does not arise.

<u>California Highway Patrol. 1972a. Operation 500: A study of the effect of increased road patrol. Final report.</u>

The overall purpose of this study—an outgrowth of Operation 101—was to devise an objective method for determining manpower requirements. This was a major and large-scale study of the effect of increased patrol manpower (an additional 500 troopers) on traffic accidents and other related traffic safety factors.

The study dealt with the state highway system and involved the collection of data on the activities of over 1,250 CHP troopers over the period January 1966 to February 1968. At first glance the findings of this study are impressive. The basic conclusions relating to traffic safety are listed below:

1. On U.S. 50 a statistically significant relationship obtained between
   a. manpower and moving violations
   b. moving violations and reportable accidents
   c. reportable accidents and manpower

2. The analysis of U.S. 50 and comparisons with Operation 101 supports the conclusions that:
   a. a significant increase in manpower will result in a significant reduction of reportable accidents
   b. more than 2.0 men per mile per 100,000 vehicle

TABLE B-24

COMPARISON OF ACCIDENTS IN 1971 AND 1972
January 1 to June 30
(Schiro 1972)

	1971	1972	Change (%)
Total accidents	5,149	4,604	-11
Injury accidents	1,403	1,204	-14
Fatal accidents	26	20	-23
Hazardous driving violations	19,576	28,455	+95

miles of travel is required for non-metropolitan roadways to effect accident reduction

c. beyond 4.2 men per mile per 100,000 miles of travel on a non-metropolitan roadway the benefits of accidents decreases.

3. For all roadways in Operation 500, fatal accidents were reduced by 31 (16.9%) and fatalities were reduced bv 42 (19.0%). Injury accidents decreased by 172 (2.5%). Persons injured with severe wounds decreased by 188 (11.2%), with minor wounds decreased by 73 (1.6%) and with complaint of pain increased by by 428 (9.4%).

In terms of manpower actually used on the study roadways, a calculation shows that 757.6 positions worked the study roads in the study year. This is 339.8 positions higher than the pre-study year. The actual deployment of these men was determined by the area commander. However, only the roadway designated as part of the study was allocated additional manpower. The actual before and after crash experience of the roadwavs included in this study is shown in Table B-25.

The study authors note that there was a slight manpower buildup 1 year prior to the study year on the designated roadway. However, their interpretation of the data in this table was as follows:

> It can be seen that fatal accidents for the study period were significantly below the two year prior total but that injury accidents continued very close to long-term trends. (p. 15.)

Carrying this logic further the CHP states that the number of accidents that occurred were compared with the number which was "expected to produce the results shown in Table B-26. The CHP concludes from this data that: . . . 'fatal accidents were nearly 17% less than would have been expected if operation 500 had not been carried out' (p. 16). Before discussing this finding in more detail it will be useful to describe the study methodology.

There were six primary roadways involved in this study: U.S. 50; U.S.

TABLE B-25

ACCIDENTS BY ROADWAY
(California Highway Patrol 1972a)

Roadway	Fatal Accidents			Injury Accidents		
	2 Years prior	1 Year Prior	Study Year	2 Years Prior	1 Year Prior	Study Year
U.S. 50	11	6	10	255	314	233
U.S. 101	72	44	56	1,986	1,954	2,252
SR-17	44	32	32	1,159	1,021	1,032
I-80	28	17	20	709	954	1,105
I-5	12	14	11	946	933	985
I-10	39	31	24	1,178	1,236	1,000
Total	206	144	152	6,233	6,412	6,607

TABLE B-26

TOTAL STUDY ACCIDENTS VERSUS EXPECTED ACCIDENTS BY TYPE
(California Highway Patrol 1972a)

Occurrence	Fatal Accidents	Injury Accidents
Actual	152	6,607
Expected	183	6,779
Percent change	-16.9%	-2.5%

TABLE B-27

STUDY TIME PERIODS
(California Highway Patrol 1972a)

Roadway	Prestudy period	Study period
U.S. 50	1/61--12/65	7/66--6/67
U.S. 101	6/61--6/66	7/66--6/67
SR-17	9/61--8/66	10/66--9/67
I-80	9/61--8/66	10/66--9/67
I-5	1/61--12/66	3/66--2/67
I-10	1/61--12/66	3/66--2/67

101; SR-17; I-80; I-5; and I-10. Data was collected for each roadway. However, the data was collected for different time periods. Table B-27 shows the pre-study and study periods for each road. These are the baseline years for which the CHP constructed "expected" values with respect to fatal and personal injury crashes. Trends were used to fit the pre-study data using up to a third degree polynomial and the best fit was selected. If a polynomial fit was not significant, then the arithmetic mean was used. . . After the curve of fit was selected, an expected value was established and this value was used for major comparisons.

An important factor was that no direct "before" period could be used for this study because, in the words of the CHP: " . . . since traffic officers were phased into a patrol area prior to the study so training could be carried out. Therefore, the pre-study, if only the prior 12 months was to be considered, would be biased and not be truly comparable" (p. A-4).

It was the original intent of the CHP study team to use "reportable" accidents as the measure of effectiveness in this project. However, it was found that the number of reportable crashes is highly dependent on the number of officers available for accident investigation. For example, during the first two months of the study, there was a 300% increase in the most minor type of crashes—those involving "complaint of pain." The study team determined then that decrease of severity of injury would be made part of the evaluative criteria of the project.

The relationship between men per 100,000 vehicle miles traveled (VMT) and reportable accidents was also analyzed by regression analysis for each of the areas. Data for roadway, weekday and shift combinations were used as sample points. In all cases negative correlation coefficients were found: in two cases non-significant, in one case significant at 90%, in 5 cases significant at 95% up to 99.9%.

The greatest weakness of this study is that no control groups are used. The use of accident trends is not a sufficient substitute, except if the stability of the trend is well established. The fact that on a nationwide basis traffic deaths in 1967 dropped slightly compared with 1966, whereas there was a strong increasing trend from 1961 to 1966 should caution against assuming a stable trend.

More detailed analysis would have to be performed before the statistically significant correlations between the numbers of reportable accidents and men per 100,000 VMT can be accepted as evidence for the effects of police traffic law enforcement. The reason is that the sample points--differing by weekday and shift--represent situations which are likely to be different. The influence of factors like light conditions or traffic volume has not been considered. The greatest danger, however, is the possibility of spurious correlations. If, for example, accidents are increasing with VMT, but the number of men per sample point were constant, then one could obtain a negative correlation between accidents and men/100,000 VMT.

Thus, we have to conclude that the information presented in this report does not convincingly suggest a beneficial influence of police traffic activities on accidents, though it is well compatible with such a hypothesis. The question of external validity does, therefore, not arise.

APPENDIX C

LITERATURE ON THE 55 MPH NATIONAL MAXIMUM SPEED LIMIT

APPENDIX C

LITERATURE ON THE 55 MPH NATIONAL MAXIMUM SPEED LIMIT

This appendix summarizes the results of our review of literature relating to enforcement of the 55 mph national maximum speed limit (NMSL). The review was supported by the police enforcement project and a comparison NHTSA project entitled "Identification of General Deterrence Countermeasures for Unsafe Driving Actions" (Contract number DOT-HS-7-01797).

At the Highway Safety Research Institute Information Center between 100 and 150 documents pertaining to the 55 mph NMSL were located. The vast majority of these discussed the 1974 speed limit either as an energy law, as a law responsible for a dramatic decrease in highway fatalities, as a focus for Public Information and Education (PI&E) campaigns, or as a subject for another public opinion poll. If the articles mentioned enforcement, it was usually to state that speeding citations had increased nationwide, and that public compliance with the NMSL would be determined primarily by the level of police enforcement.

Less than twenty-five articles described specific police activity. These documents were examined in order to answer four questions.

- What specific enforcement activities have been carried out or are presently being used to detect speeding violations or deter drivers from speeding?
- What other activities were undertaken to encourage compliance?
- What are the results of the enforcement and other activities?
- What are the advantages, disadvantages, and/or problems associated with these activities?

Available information pertaining to each of these questions is presented for each document reviewed. Any speed-measuring instruments used by the police are also noted when such information was contained in a document. Neither PI&E campaigns nor any other nonenforcement countermeasures that were identified are described in the appendix.

The documents indicate that some state agencies have implemented strategies that are innovative. We have described these in as much detail as possible. More often, however, we found only vague references to a statewide plan to enforce the 55 mph NMSL or encourage 55 mph compliance via other activities. The problems mentioned most often in the documents were of a general nature--a lack of manpower and equipment. There was little or no evaluation of specific police strategies to determine problems or advantages with certain techniques.

Adams, B. 1977. Report to the president on compliance with the 55 mph speed limit.

A. **ENFORCEMENT ACTIVITIES**

None were cited.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

1. DOT conducted a public information campaign.
2. Six states conducted public information campaigns.
3. Michigan, Indiana, Ohio, and Illinois undertook a joint program over the Labor Day weekend.

C. **FINDINGS**

1. Since 1974, nine states have increased their penalties for speed violations; seven states have prescribed less severe penalties.
2. There has been a trend by state legislatures toward imposing less severe penalties for NMSL violations.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

In the face of fixed or decreasing budgets, uncooperative state legislatures and increasing demand for police services, police have had difficulty sustaining enforcement levels necessary to obtain acceptable speed limit compliance levels.

American Association of State Highway and Transportation Officials. 1974. Effects of the 55 mph speed limit.

A. **ENFORCEMENT ACTIVITIES**

1. Enforcement efforts have been shifted to speed, especially in rural areas.
2. No specific enforcement techniques were detailed.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

None were cited.

C. **FINDINGS**

1. The number of speeding citations was ten to twenty percent greater in 1974 that in 1973.
2. Excessively high speeds have virtually been eliminated.
3. Travel speeds were found to be more uniform.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

None were cited.

Bishop, H. et al. 1974. A special report on highway vehicle speeds 1973-1974.

A. ENFORCEMENT ACTIVITIES

1. Standard enforcement procedures were used; there were some shifts in emphasis, such as reassignment of patrols to heavily travelled roads.
2. In opinion of Highway Department officials there was: a high level of enforcement effort in eighteen states; about the same level of enforcement as before and fairly effective enforcement in sixteen states; and little enforcement in four states. There was no response from officials in other states.
3. No specific enforcement techniques were detailed.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

None were cited.

C. FINDINGS

1. Georgia was the only state to show no increase in citations.
2. Operators of trucks violated the NMSL more frequently than did automobile drivers; independent truckers were more flagrant violators than common carriers.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

While the level of effort was high and relatively effective, many state highway patrols lacked sufficient manpower to adequately enforce the 55 mph limit. This was especially true in the Western mountain states where traffic volumes were lower, distances greater, and highway patrols so undermanned that a violator's likelihood of being apprehended was slight.

Clark, W.E. 1976. The use of the mass media by the Maryland State Police in support of strict enforcement of the 55 mph speed limit.

A. Enforcement Activities

Specific tactics used by the Maryland State Police included:

1. Strict enforcement of 55 mph limit with no tolerance.

2. No warnings issued in lieu of citations.
3. Use of nontraditional vehicles.
4. High visibility of marked State Police cars.
5. Unmarked State Police cars with MSP tags.
6. Use of four-way flashers on State Police cars.
7. Use of running roadblocks in areas of continuing noncompliance.
8. Use of helicopters to spot speeders.
9. Use of stationary radar, moving radar, and VASCAR.
10. Special supplemental enforcement force.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

1. An advertising campaign publicized enforcement activities, stressing that any vehicle on highway could be a police vehicle.
2. "55" stickers were given to drivers.

C. FINDINGS

None were cited.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

None were cited.

Croke, J.A. 1977. Report on results of NHTSA public information and education focus group study.

A. ENFORCEMENT ACTIVITIES

None were cited.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

None were cited.

C. FINDINGS

1. The majority of drivers sampled indicated that they only observed the 55 mph limit some of the time, and that was when they believed that police might be present. Those who speeded did so at 58 to 60 or 65 mph. Drivers were convinced police allowed tolerances of 5 to 10 mph in enforcing the NMSL and they took these perceived tolerance levels into consideration in deciding how fast to drive.
2. The drivers' main reason for observing the 55 mph limit was fear of being apprehended and cited. The reason most often given for

disobeying the 55 mph limit was that it was inconveniently slow; in addition, the participants in the discussion said they felt safe at speeds above 55 mph **under normal driving conditions.**

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

Not applicable.

<u>Dart, O.K., Jr. 1977. Effects of the 88.5-km/h (55-mph) speed limit and its enforcement on traffic speeds and accidents.</u>

A. **ENFORCEMENT ACTIVITIES**

1. Enforcement levels more than doubled in Mississippi.
2. In Louisiana, enforcement levels increased by sixty-two percent, mostly on interstate and other divided highways.
3. No specific enforcement techniques were detailed.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

None were cited.

C. **FINDINGS**

1. Except for interstate highways, vehicle speeds have recovered to pre-NMSL levels.
2. Speeds became more uniform after enactment of the NMSL, and very few vehicles were found to exceed 65 mph.
3. An Institute of Transportation Engineers study found that no new manpower was assigned to speed enforcement, and that the likelihood of a speeder being apprehended was only fair.
4. Most agencies used moving radar as their principal enforcement tool and most unofficially allowed tolerances of 6 to 10 mph.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

None were cited.

<u>Darwick, N. 1977. National maximum speed limit (NMSL) enforcement practices and procedures. Final report.</u>

A. **ENFORCEMENT ACTIVITIES**

1. Specific NMSL enforcement tactics included:
   a. Speedometer pacing, in which a patrol officer gauges the speed of the target vehicle by checking both his

speedometer and the change in distance between the patrol vehicle and the target vehicle. The officer can either hold his own speed constant or adjust his speed to that of the target vehicle.

b. Odometer pacing, in which a patrol officer uses his speedometer to hold a steady speed and the odometer to determine the change in distance between his vehicle and the target vehicle as they pass checkpoints. The distance between vehicles as they pass checkpoint #1 is compared to the distance between them as they pass checkpoint #2.
c. Moving radar.
d. Stationary radar.
e. VASCAR.
f. Stopwatches.
g. Marked and unmarked patrol cars, visible or concealed.
h. Aircraft (fixed wing and rotary).
i. Disguised civilian vehicles.
j. Automated violation recorders that determine speed (using pavement sensors or radar), automatically photograph violators and their vehicles, and record their speeds and the date, time, and location of the violation.
k. Camouflaged patrol vehicles.
l. Motorcycles.

2. Enforcement tactics used in a number of selected states were detailed. States examined by the authors included:
   a. **Arizona.** Arizona used a variety of speed measuring devices and vehicles. Marked and unmarked cars were used, twenty-six percent of the fleet was radar equipped, and VASCAR was used. Most important, however, the Arizona Highway Patrol is the only such agency in which stopwatches were used by officers in surface units as speed measuring devices (although departmental directives indicated that the stopwatch

was intended to "supplement" speed determination by other means, usually speedometer).

b. **Arkansas.** The Arkansas State Police patrol fleet was 100% radar equipped and aircraft were used for speed enforcement.

c. **California.** California law prohibits "speed traps," meaning speed determinations using time-distance measurements (such as VASCAR and stopwatches); the legislature has consistently refused to permit the Highway Patrol to use radar; and officers enforcing traffic laws are required by statute to be in uniform and operate marked patrol vehicles. These restrictions notwithstanding, the Highway Patrol has conducted a vigorous campaign of NMSL enforcement. Enforcement tactics include "escorting" traffic to prevent violations; this tactic is either rare or unique among other state enforcement agencies. Additionally, the CHP was the only agency that operated a considerable number of motorcycles for enforcement. Finally, the Highway Patrol consistently used two-officer cars at night; this was found to be uncommon among other such agencies.

d. **Colorado.** Colorado used a variety of speed measuring devices and vehicles. Devices in service included moving and handheld radar, VASCAR, and stopwatches operated from aircraft. Vehicles operated included marked and unmarked patrol cars, motorcycles and aircraft.

e. **Georgia.** Georgia used a variety of speed measuring devices, including stationary radar, moving radar, and aircraft.

f. **Iowa.** Iowa used a variety of speed measuring procedures and devices, including stationary, moving, and handheld radar, VASCAR, and aircraft. Important considerations affecting NMSL enforcement included: repeal of the statute requiring license suspensions for three speed convictions in twelve months; fining violators only ten dollars for speeding 10 mph over the limit; the practice, of some courts, of deferring sentencing in speeding cases; and the difficulty of convincing patrol officers that the NMSL should be enforced.

g. **Maryland.** Maryland used a variety of speed enforcement practices and devices, including stationary, moving, and handheld radar, VASCAR, and disguised civilian vehicles. The latter tactic is considered unique. Maryland is also conducting a speed enforcement program/study.

h. **New York.** New York used a variety of speed measuring devices, including stationary radar, moving radar, and VASCAR. New York is one of the few states in which the use of radar detectors is prohibited by law.

i. **Ohio.** Ohio used a variety of speed measuring devices including radar, VASCAR, and aircraft. One consideration affecting NMSL enforcement in Ohio is that no violation points can be assessed against a driver for conviction of a speed above the NMSL but below the previous limit.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

None were cited.

C. FINDINGS

1. Driver compliance in some states was better during the 1973-1974 gasoline shortage than afterwards.
2. Extremely high speeds (80 mph or higher) were less frequent after passage of the NMSL.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

1. Speed devices were found to be cost effective and accurate, and

they eliminated long and speedy pursuits.

2. Radar could be moved from one patrol vehicle to another
3. Maintenance costs and downtime for radar and VASCAR equipment were found to be very high.
4. Moving radar was found to be accurate and capable of measuring speed in both directions.
5. VASCAR required more training and servicing than did radar.
6. Some prosecutors dismissed prosecutions involving speeds less than 10 mph over the limit.
7. Laws in some states prohibited the use of VASCAR, stopwatch, or radar.
8. The Massachusetts State Police reported that the courts experienced difficulty in handling the increased volume of NMSL cases. In some instances, courts took months to report NMSL convictions to driver licensing authorities. In other states, some courts refused to find accused speeders guilty even when the evidence of their guilt was clear.

<u>Davis, B.O., Jr. 1976. The 55-mph speed limit.</u>

A. ENFORCEMENT ACTIVITIES

None were cited.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

None were cited.

C. FINDINGS

After the passage of the NMSL, it was found that:

1. Average vehicle speeds declined from 60.3 mph in 1973 to 55.8 mph in 1975.
2. The speed variation between cars and trucks declined from approximately 5 mph to less than 2 mph.
3. Speeds ranged from 50-60 mph, as compared with a range of 60-90 mph previously.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

1. Some states penalized NMSL violators with token fines or no fines at all, and others assessed no violation points against

drivers convicted of NMSL violations.

2. Some courts and prosecutors refused to take any action against violators whose speeds did not exceed 65 mph.

Demeter, J. 1975. Can we learn to drive 55?

A. **ENFORCEMENT ACTIVITIES**

Enforcement techniques included:

1. Five man teams working in five-mile stretches along California interstate highways
2. A variety of tactics in Massachusetts, including: putting more police on road patrols; increasing the visibility of patrols; adding forty police cruisers; and using pace cars and radar traps to apprehend violators.
3. The use of electronic and photographic devices.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

None were cited.

C. **FINDINGS**

1. The number of speed citations increased.
2. 85% of drivers complied with the NMSL.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

None were cited.

Elliott, S.A. 1977. Communications plan supporting 55 miles per hour statewide public information education campaign "55 m.p.h. We can live with it."

A. **ENFORCEMENT ACTIVITIES**

Enforcement tactics included:

1. Electric speed monitoring.
2. Monitoring of citizens band (CB) radios.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

The author cited an ongoing public information and education campaign.

C. **FINDINGS**

None were cited.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

Information campaigns were found effective only within a state; they produced less compliance from out-of-state drivers.

<u>Hirsh, T. 1978. Police and speeders match wits in battle of electronics.</u>

A. **ENFORCEMENT ACTIVITIES**

None were cited.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

Two techniques for encouraging NMSL compliance were identified:

1. Strong public information and publicity campaigns
2. More severe penalties for NMSL violations. For example, a speed violation in Maryland is punishable by a fine of thirty to fifty dollars, and the assessment of violation points as follows: one point for speeds of 55-65 mph; two points for speeds of 65-85 mph; and three for speeds above 85 mph. (Accumulating eight points within two years triggers license suspension; accumulation twelve within that period revocation.) Since the NMSL became law, nine states have prescribed more serious penalties for NMSL violations.

C. **FINDINGS**

1. The average vehicle speed in California was 60-62 mph.
2. The average vehicle speed in Arizona was 62-63 mph.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

Seven states have reduced the penalties for NMSL violations. For example, the penalty in Idaho is a five dollar fine.

<u>Institute of Transportation Engineers, Technical Council Committee 4M-2. 1977. Ramifications of the 55 mph speed limit.</u>

A. **ENFORCEMENT ACTIVITIES**

1. Strict enforcement directed at speeds of 60 mph and above was reported.
2. Virtually no new manpower has been assigned to speed enforcement; rather, most enforcement agencies changed their priorities from apprehending drunk drivers and patrolling

secondary roads and high accident locations to enforcement of the 55 mph limit.

3. The principal enforcement tool was found to be radar.
4. No specific enforcement techniques were detailed.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

None were cited.

C. FINDINGS

1. In Indiana, Maine, and Michigan, driver compliance with the NMSL was higher during the mandatory than during the voluntary period.
2. In Utah, there occurred a significant speed reduction on roads where the previous limit was greater than 55 mph.
3. In West Virginia, measurements at one site showed that average speeds decreased after the enactment of the NMSL.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

Difficulties in enforcing the NMSL resulted from personnel and equipment limitations.

Milebrandt, T.H. 1975. 55 - it's working.

A. ENFORCEMENT ACTIVITIES

1. Enforcement tactics included:
   a. The use of traditional speed enforcement techniques.
   b. Concealing radar in bales of hay along highway and in pickup trucks.
   c. Rotary and fixed wing aircraft.
2. The following enforcement guidelines were reported: at speeds of 56-65 mph, the violator was stopped and the patrol officer took "appropriate action;" at speeds of 65 mph and above, the violator was cited.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

Public information campaigns

C. FINDINGS

Average vehicle speeds declined approximately 10 mph after passage of the NMSL.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

Officials were assigned to enforce the NMSL on interstate system even though the number of fatalities and injuries on two-lane highways had risen.

New York State Police. 1977. Strike force for speed enforcement: Final evaluation.

A. ENFORCEMENT ACTIVITIES

1. Speed enforcement teams (three consisting of four state troopers and one sergeant and one consisting of six troopers and one sergeant) were assigned to enforcement duties.
2. Enforcement was directed at the observation and apprehension of high speed vehicles.
3. Radar and other devices (not described) were used from 7:00 a.m. to 11:00 p.m. seven days per week, for one to three months.
4. After completing the strike force program at one location, the team would move to another.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

News releases concerning the enforcement program were distributed to radio and television stations and newspapers.

C. FINDINGS

1. It appears that speeds were significantly reduced at most strike force locations while teams were operational, and those effects usually lasted from four to six weeks after the team had left the location.
2. Intensive enforcement plus media coverage were found to increase compliance significantly.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

Certain data (such as traffic volume trends and seasonal influences) necessary to evaluate entire program were lacking.

Oregon State Police. 1977. 55 mph compliance campaign.

A. ENFORCEMENT ACTIVITIES

1. Increased enforcement action was directed toward lower violator

speeds.

2. The decision whether to issue the violator a citation or warning was left to the officer's discretion.
3. A selective increase in use of radar occurred, with special emphasis placed on freeways and peak traffic volume periods.
4. The previous level of patrol manhours was maintained.
5. No specific enforcement techniques were detailed.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

A public information and awareness campaign also was carried out.

C. **FINDINGS**

1. An increase in citations, for speeds under 65 mph occurred.
2. Proportionately more drivers of trucks than automobiles were cited for speeds between 55 and 60 mph.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

None were cited.

Rankin, W.W. 1974. 55 mph: What happened to speed, travel, accidents, and fuel when the nation's motorists slowed down.

A. **ENFORCEMENT ACTIVITIES**

1. An increased number of speeding citations was issued.
2. No specific enforcement techniques were detailed.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

None were cited.

C. **FINDINGS**

Traffic was found to travel at more uniform speeds.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

None were cited.

Schecter, H.B. et al. Impact considerations of the national 55 mph speed limit. Interim report.

A. **ENFORCEMENT ACTIVITIES**

1. Most highway patrol officials indicated that their departments were enforcing the 55 mph limit as they would any other speed limit.

2. No specific enforcement techniques were detailed.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

Cooperation by courts was cited as a supporting factor.

C. **FINDINGS**

1. Nine of fourteen state patrols reported "very little" current compliance by drivers.
2. Increases in speeding arrests were reported by all states.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

One stated difficulty was inadequate manpower.

<u>Staats, E.L. 1977. Speed limit 55: Is it achievable? Report to the Congress by the comptroller general of the United States.</u>

A. **ENFORCEMENT ACTIVITIES**

1. Enforcement levels remained relatively constant.
2. Disguised patrol cars, cruising in teams and equipped with radar, were used.
3. In Oregon, state police devoted approximately one-third of traffic patrol time to freeways (however, only six percent of Oregon traffic fatalities occurred on freeways).
4. No specific enforcement techniques were detailed.

B. **OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE**

Two Department of Transportation public information campaigns, and a number of state campaigns, accompanied the enforcement effort.

C. **FINDINGS**

1. Average vehicle speeds decreased.
2. Uniformity of speeds increased.

D. **STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS**

1. Enforcement was difficult because of the increased use of citizen's band (CB) radios and radar detectors by drivers.
2. Enforcement agencies have requested additional personnel and equipment; however, state legislatures generally have not provided the necessary funds.
3. State officials maintain that responsibilities other than NMSL enforcement require a higher priority of their limited resources.

4. States with many miles of sparsely traveled roads were reluctant to assign many officers to these low volume areas.
5. Penalties for violations (fines and points) differed from state to state.

U. S. Department of Transportation. 1977a. Organizing a 55 mph campaign.

A. ENFORCEMENT ACTIVITIES

Enforcement activities included the use of radar and aircraft, and monitoring citizens band (CB) radio. Details of specific enforcement techniques were not given.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

Specific activities included:

1. Publicity campaigns.
2. Appearances by police officers before civic organizations.
3. Enlisting the support of trucking organizations.
4. Demonstrations, by police officers, of speed monitoring devices to judges and prosecutors.
5. The use of "chaperones" (state police cruisers with all lights on) setting a 55 mph pace.

C. FINDINGS

None were cited.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

None were cited.

U.S. Department of Transportation. 1976. 55 mph fact book.

A. ENFORCEMENT ACTIVITIES

Enforcement tactics included:

1. The use of stationary radar, mobile radar, and VASCAR.
2. The use of aircraft patrols.
3. Parking patrol vehicles alongside the roadway in conspicuous locations.
4. Conducting selective enforcement programs.
5. Using unmarked and private vehicles equipped with radar,

accompanied by several "chase" vehicles.

6. Concentrating enforcement on freeways and other highways where the previous speed limit was higher than 55 mph.
7. Using fixed-wing aircraft adjacent to interstate highways near interchanges; flying aircraft simultaneously along 40-60 mile segments of interstate system between two state lines; and using stopwatches operated from aircraft to clock vehicle speed, then summoning radio ground units to apprehend violators.
8. Using nontraditional police vehicles, including foreign cars and trucks, to detect violators.
9. Activating four-way flashers on state police cars to increase their visibility.
10. Using running roadblocks in areas of continuing noncompliance.
11. Using helicopters to detect speeders.
12. Using special supplemental enforcement forces.

B. OTHER ACTIVITIES TO ENCOURAGE COMPLIANCE

1. Conducting public information campaigns.
2. Increasing the likelihood of sanctioning a driver after apprehension to deter other would-be speeders.
3. Placing roof-mounted speed reminders on police vehicles
4. Deploying "assistance patrols" to remind drivers of the speed limit.
5. Giving extensive media coverage of enforcement activities.

C. FINDINGS

In Maryland, within weeks after a publicity campaign resulted in extensive press coverage of enforcement activities, the majority of speed violators apprehended were out-of-state drivers.

D. STATED ADVANTAGES, DISADVANTAGES, AND PROBLEMS

None were cited.

APPENDIX D

LITERATURE ON MEASUREMENT TECHNIQUES AND INSTRUMENTS USED IN RESEARCH ON UNSAFE DRIVING ACTS

APPENDIX D

LITERATURE ON MEASUREMENT TECHNIQUES AND INSTRUMENTS USED IN RESEARCH ON UNSAFE DRIVING ACTS

This appendix lists and describes measurement techniques and instruments used in past research on speeding and following too closely. No literature on driving left of center was found. The source documents for this information were primarily empirical studies of police enforcement procedures, but also included articles and other documents that dealt specifically with measurement.

Each source document is summarized separately in terms of:

- characteristics measured,
- measurement instrument(s) used, and
- measurement method(s) used.

The documents are presented alphabetically by author.

Bensen, O.C. 1976. North Dakota selective traffic enforcement program (STEP). Project director's report. Final report.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar.

MEASUREMENT METHOD: Concealed radar was placed at five locations within the 15.5 miles of designated highway, and carried in unmarked vehicles. In addition, radar equipment was placed in visible marked radar units whose locations varied.

B. **MEASUREMENT:** Speed

MEASUREMENT INSTRUMENT: Traffic Data Recorders, which recorded vehicle speeds, traffic volumes, other various information for all lanes in both directions of travel.

MEASUREMENT METHOD: Two Traffic Data Recorders were used to measure and record vehicle speed data. One was placed on each highway. Units were placed on open highway, away from interchanges, rest areas or inclines. Vehicle data were recorded on magnetic tape.

Booth, W.L. 1978. Which vehicle: The Greensboro traffic enforcement vehicle experiment.

A. **MEASUREMENT:** Driver response to police vehicles (specifically braking, as indicated by activation of brake lights).

MEASUREMENT INSTRUMENTS: Trained observers and enforcement officers; monitoring of citizen's band (CB) radio.

MEASUREMENT METHOD: Each test vehicle parked at an intersection for two hours, in a location visible to traffic. The street on which the vehicles were placed was marked off in 25-yard lengths, from 75 to 250 yards away from the intersection. An observer, stationed 250 yards from the intersection, marked the point at which drivers applied their brakes. When brake lights did not show, the distance was recorded as 75 yards or less. An enforcement officer monitored CB radio and recorded the number of times drivers mentioned the test vehicle's presence. A van (unrecognizable as an enforcement vehicle) containing a video film recorder was parked on a bridge, one-quarter mile from the intersection, and recorded moving violations.

Brackett, R.Q., and Edwards, M.L. 1977. Comparative evaluation of speed control strategies. Volume 2. Detailed description. Final report.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar (K55 model moving radar set).

MEASUREMENT METHOD: Radar was mounted, relatively inconspicuously, in an unmarked research vehicle (an old model station wagon). Only the speeds of oncoming traffic were monitored. The radar unit's useful range was 1/4 mile. One researcher drove the research vehicle; the other recorded the speed of approaching traffic and also noted whether vehicles were equipped with CB radio.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar.

MEASUREMENT METHOD: Standard fixed-radar operating procedures were followed. A visible patrol car was parked on the shoulder of a two-lane highway, parallel to the primary lane of traffic (having the largest volume). Data collection took place only during commuter traffic hours.

Byrne, B.F. et al. 1976. Testing of the tapeswitch system for determining vehicle speed and lateral placement.

A. **MEASUREMENTS:** Speed; lateral lane placement.

MEASUREMENT INSTRUMENT: Tapeswitch system (Tapeswitch is the trade name).

MEASUREMENT METHOD: Pressure sensitive electrical strip switch, which could be cut to any length, was placed on the roadway as a vehicle detector. The switches led to equipment that recorded vehicle speed and lateral lane placement. These data were recorded on a digital recorder that was operated by a researcher.

B. **MEASUREMENT:** Speed and lateral lane placement.

MEASUREMENT INSTRUMENTS: Time-lapse photography; radar

MEASUREMENT METHOD: A radar speedmeter and motion picture camera were placed at the roadside; the camera was focused upon a series of tape strips placed at three-inch intervals on the road, perpendicular to the edge of the highway section. Researchers operated the camera and speedmeter.

California Highway Patrol. 1968. Roadway characteristics and manpower deployment study. Phase II. Moving violation study.

A. **MEASUREMENT:** Speeding.

MEASUREMENT INSTRUMENT: Radar.

MEASUREMENT METHOD: Data were gathered by specially trained CHP traffic officers on two-, four-, and six-lane highways. Radar check operations were maintained on only one side of the road at a time, except when speeds were measured for both directions of traffic.

B. **MEASUREMENT:** Traffic counts.

MEASUREMENT INSTRUMENTS: Automatic mechanical counters; traffic volume estimates.

MEASUREMENT METHOD: (The mechanics of the automatic counters were not described.)

C. **MEASUREMENT:** Traffic violations other than speed, such as following too closely, changing lanes unsafely, and slow driver in the left lane.

MEASUREMENT INSTRUMENT: Observers.

MEASUREMENT METHOD: Inconspicuous trained patrol officers, attired in civilian clothes and travelling in unmarked automobiles, tallied nonspeeding hazardous violations by traffic traveling in both directions. Observers generally agreed beforehand on the violation criteria. However, because of the subjective nature of the violations, the same officers were assigned to this project for the duration of the data collection so that violation criteria could be more uniformly applied.

California Highway Patrol. 1966. Operation 101. Final report. Phase I: Background and accident analysis.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar.

MEASUREMENT METHOD: The document did not describe any specific measurement method. Apparently, the police took measurements both while moving and while stationary, and from both concealed and visible units, as they determined appropriate for each situation.

B. **MEASUREMENT:** Hazardous violations.

MEASUREMENT INSTRUMENT: Trained observers.

MEASUREMENT METHOD: Trained observers viewed drivers from elevated locations near roadway.

Coon, T. 1969. Law enforcement technology welcomes the chopper "copper."

Craig, G. 1975. Eye in the sky.

Darwick, N. 1977. National maximum speed limit (NMSL) enforcement practices and procedures. Final report.

Rasmussen, K. 1977. "Bear in the air": Enforcement in Oklahoma.

York, R. 1975. CHP ascends to higher levels of patrol capabilities with the STOL airplane program.

A. **MEASUREMENTS:** Speed; other traffic violations, such as improper turns and driving left-of-center.

MEASUREMENT INSTRUMENTS: Short take-off and landing (STOL) aircraft; fixed-wing aircraft.

MEASUREMENT METHODS: (a) Aircraft equipped with such equipment as radios, cameras, floodlights, closed-circuit TV cameras, or a public address system were dispatched. These aircraft paced vehicles at speeds ranging from 30-130 mph; when a violation was detected an officer either radioed information to a ground unit or used a siren or public address system to warn the driver. (b) A ground unit was assigned to work with aircraft; the air unit cruised at 1000 feet, clocking the speed of a vehicle over a measured mile-long course, using section lines or prepainted markings as checkpoints. When a violation was detected, the pilot radioed the ground unit with a description of the offending vehicle, its location relative to the ground unit, the speed measured from the aircraft, and the time of day. (c) Patrol officers marked off a half-mile course (consisting of two quarter-mile sections) with portable markers, made from thick, heavy rubberized conveyer belting cut in four foot sections and painted white. The markers were placed on the road shoulder (to lessen wear from traffic), perpendicular to the highway. Pilots flew over the course and timed vehicles travelling through the test area.

Cooper, D.F., and McDowell, M.R.C. 1977. Police effects on accident risk at T-junctions.

A. **MEASUREMENT:** Merging gap acceptance.

MEASUREMENT INSTRUMENT: Portable TV camera.

MEASUREMENT METHOD: A portable camera was used to record the gap acceptance of drivers turning left from a minor road onto a major road.

Cooper, P.J. 1974. Effectiveness of traffic law enforcement: A study to assess the effectiveness of different levels of police enforcement on driver behavior and safety at urban intersections.

A. **MEASUREMENT:** Hazardous violations at intersections.

MEASUREMENT INSTRUMENT: Trained observers.

MEASUREMENT METHOD: Observers made traffic counts, pedestrian counts, and violation counts at intersections with and without police motorcycle patrolmen present. Daily traffic volumes were obtained using detectors.

Council, F.M. 1970. A study of the immediate effects of enforcement on vehicular speeds.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: VASCAR (moving runs)

MEASUREMENT METHOD: An unmarked vehicle, equipped with VASCAR, travelled 1 1/4 miles ahead of a marked enforcement vehicle; another such vehicle travelled 1 1/4 miles downstream. Each unmarked vehicle was occupied by a driver who operated the VASCAR unit, and an observer who counted the vehicles he encountered in the oncoming stream of traffic. Information about each vehicle was dictated onto a tape for later transcription and matching. Observers in unmarked vehicles also operated a radio to ensure that proper distances from the marked vehicle were kept.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: VASCAR (fixed runs).

MEASUREMENT METHOD: Unmarked vehicles were stationed 1 1/4 miles ahead of and behind the marked, visible enforcement vehicle respectively. The unmarked vehicles were either concealed or disguised as vehicles in distress. In each unmarked vehicle, one observer monitored the VASCAR unit, while the other operated the tape recorder and radio (as was done in moving runs).

Dart, O.K., Jr., and Hunter, W.W. 1976. An evaluation of the "halo" effect in speed detection and enforcement.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Static radar.

MEASUREMENT METHOD: Speed measurements, downstream of an enforcement symbol, were taken by a radar unit with its antenna concealed. Another unit was placed in a different downstream location, but with its antenna only partially concealed. Measurements were taken on one side of the highway only.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Visual Speed Indicator (VSI).

MEASUREMENT METHOD: Induction loops placed in the pavement transmitted information to the VSI computer, which computed the speed of vehicles passing over the loops and flashed a visual display informing the driver of his vehicle's speed.

Darwick, N. 1977. National maximum speed limit (NMSL) enforcement practices and procedures. Final report.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Stopwatch.

MEASUREMENT METHODS: (1) A police officer marked off a measured course in the roadway and timed, with a stopwatch, the target vehicle as it passed through the course. (2) An officer, observing the target vehicle from a helicopter, checked its speed by using stopwatches.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar.

MEASUREMENT METHODS: (1) Stationary radar: a stationary patrol vehicle was equipped with radar and parked in the median of a limited-access highway; whenever possible, the vehicle was hidden by overpass supports or other available obstructions. (2) Fixed radar: the radar unit was mounted on a tripod, bridge railing or some stationary base (other than a vehicle). (3) Hand-held radar: the antenna, electrical components and speed readout section were contained within one unit having a pistol grip. That unit could be pointed at the target vehicle the speed of which was visually displayed. (4) Moving radar: a portable radar unit was attached to a patrol vehicle in several ways (usually it was slipped over the top edge of the glass on one of the rear doors, or held to the dashboard by a base with suction cups, springs, or hooks). The radar was aimed in the same direction as the patrol vehicle and was travelling; from the patrol vehicle's speed and the closing speed of the approaching target vehicle, the unit read out the target vehicle's speed.

C. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Visual average speed computer and recorder (VASCAR).

MEASUREMENT METHOD: VASCAR is a computer that measures a vehicle's speed by dividing a measured distance by the elapsed time taken by a vehicle to travel over it. Distance data can either be entered directly (such as by using a course with a known distance) or measured by driving over it. Time data are entered by activating VASCAR when a vehicle enters a selected length of roadway, and deactivating it when the vehicle leaves. Once distance and time are both entered, VASCAR computes the vehicle's speed.

D. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: Speedometer; odometer.

MEASUREMENT METHODS: (1) The patrol vehicle travelled behind or abreast of a suspect vehicle; the officer adjusted his speed to that of the suspect and checked his speedometer to obtain the suspect's speed. (2) The officer travelled at a fixed speed and judged the change in distance between his vehicle and that of the suspect. (3) The officer travelled at or in excess of the speed limit and estimated by the rate of closure, the speed of vehicles attempting to pass him. (4) (Using speedometer and odometer) The officer used his speedometer to ensure he maintained a steady speed. When the suspect vehicle in front of him passed a landmark he noted the odometer reading; when the officer passed the same landmark, he again noted the odometer reading, and computed the difference. The officer repeated this procedure at another landmark; if the second difference in readings was larger than the first, the target vehicle had travelled faster than the police officer's.

Freeborn, K.L.C., and Whiting, P.D. 1949. An instrument for measuring the speeds of vehicles.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: Pneumatic tubes; speedmeter.

MEASUREMENT METHOD: Tubes were placed a known distance apart on a road; when a vehicle crossed a tube, a puff of air activited a clock. Speed was calculated bv dividing the travel time between tubes into the distance between them. After the calculation of travel time was recorded, the clock returned to starting point.

Goetzke, R. E. 1974. Reduction of accident severity through maximum enforcement effort.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: "Speedgun" (radar).

MEASUREMENT METHOD: A speedgun is a lightweight instrument containing all three radar components (antenna, amplifier, and meter) within one compact case. This handheld radar could be aimed in any direction so that targets' speeds could be detected regardless of their direction of travel. The speedgun could be operated either from a marked patrol car or from an independent foot patrol.

Hair, T.; Baxter, I.R.; and Cross, M.G. 1973. Speed measurement by optical speed registering equipment type S375.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: Optical speed measuring system (OSCAR); operator/recorder.

MEASUREMENT METHOD: The system, contained within a single unit, was placed along the side of the road. When a vehicle came within the sensitivity field of the unit, reflected light from the vehicle was received by a photo detector. Eight successive measurements of the vehicle's speed were made in the period of 60 m.sec. The fluctuating frequency was measured by a signal processor and converted to a speed reading. The reading was displayed for one second, and could be noted by the operator/recorder. OSCAR is completely passive in operation, that is, it does not transmit any form of light or radio energy.

Hunter, W.W.; Bundy, H.L.; and Daniel, R.B. 1976. An evaluation of the visual speed indicator.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Visual Speed Indicator (VSI).

MEASUREMENT METHOD: The VSI was placed twenty feet from the edge of the pavement, facing northbound traffic. The basic unit contained: a digital processor; a readout display unit; a digital magnetic tape (cassette) recorder; and standard vehicle loop detectors. As vehicles passed over induction loop detectors buried in pavement, their speed, and the date and time of day were recorded by the VSI. The number of vehicles travelling above and below the speed limit, and the total number of vehicles were counted. Measurements were collected while the sign was activated and not activated. In addition, when the VSI detected a vehicle travelling faster than the speed limit, it flashed the vehicle's measured speed and a warning message.

Hunter, W.W., and Bundy, H.L. 1975. A study of the effect of the speed check zone concept.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: VASCAR; stationary radar.

MEASUREMENT METHOD: Vehicle speeds were measured over a twenty-mile section of one road, and over a twelve-mile section of another. Five speed-monitoring stations were placed on those roads approximately equidistant from each other (five miles apart on one road, three miles apart on another). Researchers, riding either in unmarked staff cars or in private vehicles, monitored traffic speed using stationary radar concealed within their vehicles. Speed data were collected for both directions of traffic under these conditions; only one police configuration-patrol unit was conspicuously displayed with radar attached outside it, on the roadway shoulder. After data were collected from one direction, the patrol officer moved his vehicle to the opposite shoulder and collected data for the opposite direction. Patrol vehicles always were oriented in the same direction as the traffic flow.

Jones, R.K., and Joscelyn, K.B. 1972. Computerized allocation of police traffic services; a demonstration study. Final report.

Joscelyn, K.B.; Bryan, T.H.; and Goldenbaum, D.M. 1971. A study of the effects of law enforcement on traffic flow behavior. Final report.

Joscelyn, K.B.; Jones, R.K.; and Elston, P.A. 1970. Maximum speed limits. Volume I: A study for the selection of maximum speed limits. Final report.

A. **MEASUREMENTS:** Traffic flow information: speed, headway, vehicle length, location direction, and lane of travel.

MEASUREMENT INSTRUMENT: Computer-sensor system "CHTIS" (Computerized Highway Traffic Information System).

MEASUREMENT METHOD: Magnetic loop detectors were embedded in the pavement; vehicles passing over the sensor locations produced electrical signals that were sent via telephone lines to a data collection system, where they were stored and processed. Traffic flow information was gathered for vehicles travelling in both directions on the monitored road.

Munden, J.M. 1967. The relation between a driver's speed and his accident rate.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar.

MEASUREMENT METHOD: Camouflaged (concealed) radar meter.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: Synchronization of stopwatch and portable tape perforating unit; observers.

MEASUREMENT METHOD: Only traffic traveling in one direction was monitored. Speed was measured in journey time: two unmarked vehicles were parked on the verge of the road, about two miles apart. Each vehicle was occupied by a team of two observers, and was equipped with a portable tape perforating unit (reperforator) that emitted tape at the rate of two holes per second. Each pair of observers also had synchronized stopwatches. A hole was punched each time a vehicle passed the unit. One of the punching observers called out the vehicle's registration numbers, which were recorded by the second observer. Each pair of observers compiled a list of registration numbers and arrival times (recorded as holes on tape). Lines were drawn across the tape to mark gaps in the stream of traffic (the end of a "batch" of vehicles.) Later, vehicles' journey times were converted to speeds and entered on computers.

Myers, R.H., and Ottman, M.F. undated. A description of the ORBIS III system and its legal aspects.
Vought Missiles and Space Company. undated. ORBIS III: A new concept in traffic safety and surveillance.

A. **MEASUREMENT:** Speed

MEASUREMENT INSTRUMENT: ORBIS III (a speed-clocking and photographic device).

MEASUREMENT METHOD: Two sensors were placed a fixed distance apart on the roadway. When a vehicle passed over the first sensor it activated the computer; when it crossed the second set of sensors; the computer determined the vehicle speed. When a speeding violation occurred, the camera was activated and recorded on film: the actual vehicle speed; the posted speed; the vehicle's license plate number; and the location, date, and time of the violation. ORBIS III also could photograph the faces of the vehicle's front seat occupants.

New York State Police. 1977. Strike force speed enforcement: Final evaluation.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: Radar; "other speed detection methods."

MEASUREMENT METHOD: Three teams of four troopers and one sergeant, and one team of six troopers and one sergeant, patrolled interstate highways having the highest incidence of NMSL violations. Teams periodically moved to different locations; they operated from 7:00 a.m. to 11:00 p.m., seven days per week. This document did not describe how radar was used.

<u>O'Neal, R.A. 1967. Here's VASCAR!</u>

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: (VASCAR).

MEASUREMENT METHOD: VASCAR is a computer that measures a vehicle's speed by dividing a measured distance by the elapsed time taken by a vehicle to travel over it. Distance data can either be entered directly (such as by using a course with a known distance) or measured by driving over it. Time data are entered by activating VASCAR when a vehicle enters a selected length of roadway, and deactivating it when the vehicle leaves. Once distance and time are both entered, VASCAR computes the vehicle's speed.

<u>Pilot, J. 1969. Instant re-play for the traffic violator.</u>

A. **MEASUREMENT:** Traffic violations other than speeding, such as following too closely.

MEASUREMENT INSTRUMENT: Portable videotape unit.

MEASUREMENT METHOD: The videotape unit contained a television camera, which was 2 3/4" x 8 1/4", had an attached microphone, and zoom lens. It could be panned left and right or up and down; it also had a pistol grip allowing manual operation. The unit was mounted on a trooper's vehicle, and an inverter in the trunk enabled the unit to operate from the patrol vehicle's own power. Before cruising on patrol, the officer activated the camera and set the camera lens; the camera then recorded what the officer observed. An attached unit allowed an officer instantly to show the offending driver the infraction he committed.

Reinfurt, D.W.; Levine, D.N.; and Johnson, W.D. 1973. Radar as a speed deterrent: An evaluation.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar (Decatur Model 99).

MEASUREMENT METHOD: Speed measurements, using the radar unit, were taken during different stages of the experiment. Sometimes the radar and clocking vehicle were concealed; other times they were visible. Other variables controlled for were included: city size; publicity; and ticketing practices.

Rowan, N.J., and Keese, C.J. 1962. A study of factors influencing traffic speeds.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: "Event recorder;" observers.

MEASUREMENT METHOD: An event recorder is a 20-pen ink type recorder. It was used with a series of road tubes, and air switches connected to the pens by field telephone cables. When a vehicle passed through the control section and crossed a road tube, a mark was made by the pen on the chart. Because the chart in the recorder moved at a constant, predetermined speed, the distance between successive marks was proportional to the time required for the vehicle to travel between the road tubes. The direction of vehicle travel could be identified by special tube arrangements. At one station in the study section an observer, using a portable voice recorder, noted the license number and direction of travel of each vehicle. Other observers also recorded turning, crossing, exiting and passing maneuvers to aid later interpretation of the recorder charts.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Radar speed meter with graphic recorder.

MEASUREMENT METHOD: For rural speed observations, a radar speed meter was camouflaged within a mailbox, and the graphic recorder was placed in an inconspicuous position. (It was not stated, but it is assumed that an observer recorded the license number, direction of travel, and description of the passing vehicle.)

C. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Concealed and visible radar.

MEASUREMENT METHOD: A radar speedmeter was mounted on a tripod on the shoulder of the road; patrolmen observed speeds from a marked vehicle parked 150-200 feet beyond the radar unit. The procedure for measurement by concealed radar was not explained.

Sanders, J.H.; Berger, W.G.; and Itanscom, F.R. 1977. The traffic evaluator system. An innovative data collection tool.

A. **MEASUREMENT:** Traffic flow characteristics.

MEASUREMENT INSTRUMENT: Traffic Evaluator System (TES).

MEASUREMENT METHOD: Tire sensors (tapeswitches) were taped to the road surface. Computer programs tracked vehicles passing through the instrumented section of road; these data were collected on magnetic tape.

Shumate, R.P. undated. The long range effect of enforcement on driving speeds.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Electromatic-radar speed measuring device.

MEASUREMENT METHOD: The radar device consisted of a sensing unit, a speedmeter and a power source. The sensing unit was placed in a specially prepared set of mailboxes located adjacent to the highway; the power source was concealed in the base. Observers (off-duty state patrol officers) who were housed in a station wagon and concealed from traffic, recorded speeds of passing vehicles. The speed of each vehicle was recorded on a special form. Speeds were grouped into 5 mph intervals.

Singleton, M., and Ward, J.E. 1977. A comparative study of various types of vehicle detectors. Final report.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Speed Measuring Systems (SMS II).

MEASUREMENT METHOD: The SMS consisted of two loops placed across the road and two detecting devices. It measured the speed of each vehicle crossing the loops by processing the time delay between the activation of the two detectors. A camera, which could photograph every vehicle that exceeded a preset speed also was attached.

B. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Speed Analysis System (SAS).

MEASUREMENT METHOD: The SAS consisted of speed discrimination units (maximum speed detectors) that were linked to counters. the threshold speed of each unit could be adjusted; and switches could be set to different values on each unit. Using the SAS the number of vehicles passing in various speed bands also could be recorded.

C. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENT: Speed-responsive radar detectors.

MEASUREMENT METHOD: Speed-responsive radar detectors (radar sensor antennae) received impulses indicating the presence of passing vehicles and their speeds (computed from the time taken for the vehicles to travel a known distance). Radar detectors were mounted either alongside or over the roadway, were able to cover from one to three lanes.

Smith, R.D. 1962. The effect of enforcement on driving behavior.

A. **MEASUREMENTS:** Spot speed, as measured in mph; time, in seconds, required for the vehicle to travel from one observation point to another.

MEASUREMENT INSTRUMENT: Radar and camera device.

MEASUREMENT METHOD: Vehicles passing over small pneumatic tubes activated measurement instruments concealed in "dummy" rural mailboxes. These instruments measured the vehicle's speed and recorded, on film, the exact time of the observation and the location of the observation point.

Solomon, D. 1964. Accidents on main rural highways related to speed, driver, and vehicle.

A. **MEASUREMENT:** Speed.

MEASUREMENT INSTRUMENTS: Driver-observer recorder teams; concealed speed measuring devices.

MEASUREMENT METHOD: A test car was driven over the highway, moving with the normal flow of traffic and recording its speed at periodic intervals; the speed was averaged for intervals along the highway. Spot speeds were measured by concealed devices (no further explanation was given).

Sumner, R., and Baguley, C. 1978. Close following behaviour at two sites on rural two lane motorways.

A. **MEASUREMENTS:** Following too closely; speed; other traffic flow characteristics.

MEASUREMENT INSTRUMENTS: Video camera and recorder; electronic clock.

MEASUREMENT METHOD: The sites chosen for observation were two-lane rural roads where the horizontal alignment was as straight as possible and where the intersections were more widely spaced. Two video cameras were placed on an embankment and focused upon two small markers twenty meters apart. The video images were fed simultaneously to a video recorder together with a time signal from an electronic clock.

The times at which each vehicle arrived at both markers were noted; speed (converted from travel time between markers) and headway were recorded. A grid was electronically superimposed on the video display to determine vehicle length. From the vehicle length, speeds, and headways, the gap ahead of each vehicle was calculated by a computer.

Traffic Safety Systems, Inc. 1971. FTC monitor system: A new traffic safety device.

A. **MEASUREMENT:** Vehicle following distance.

MEASUREMENT INSTRUMENT: Following Too Closely (FTC) Monitor.

MEASUREMENT METHOD: The FTC monitor measured gap time between following vehicles, and displayed a "danger" or "violation" message to the driver of a vehicle that followed another at less than a predetermined distance, as measured by the gap time between them. The FTC Monitor was installed along the roadway; detectors were embedded in the pavement and activated by the front and rear tires of every automobile passing over them in the lane of travel. The FTC Monitor's logic system signalled the display unit if a vehicle was detected as following too closely. A camera also could be connected to the unit to photograph violators.

Transportation Data Corporation. undated. Traffic analyzer system.

A. **MEASUREMENT:** Traffic flow characteristics.

MEASUREMENT INSTRUMENT: Traffic Analyzer System/Traffic Data Recorder.

MEASUREMENT METHOD: Cable sensors embedded in the roadway were activated by pressure from tires. These sensors were connected to the Traffic Data Recorder and programmer, which could monitor four lanes independently and simultaneously. All data were recorded on digital tape cassettes.

APPENDIX E

SUMMARY OF REPRESENTATIVE COURT DECISIONS AND LEGISLATION GOVERNING SPEED ENFORCEMENT TACTICS AND EQUIPMENT

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SUMMARY OF REPRESENTATIVE COURT DECISIONS AND LEGISLATION GOVERNING SPEED ENFORCEMENT TACTICS AND EQUIPMENT

This appendix presents, in the form of a bibliographic essay, representative court decisions and legislation that could impose legal constraints on the use of certain enforcement tactics and certain speed detection and measurement devices. The materials cited here are intended as an example only, not a comprehensive, state-by-state review of applicable law.

Restrictions on the Use of Certain Enforcement Procedures

"Speed Traps"

Time-distance measurements are classified in a small number of states as "speed traps," which are prohibited by law. Representative provisions include CAL. VEH. CODE §§ 40801l-40805 (West 1971 and West Supp. 1979) and WASH. REV. CODE ANN. § 46.61.470 (1970).

These statutes prohibit the use of stopwatches as well as VASCAR, which operates on the time-distance principle. However, speed-trap prohibitions do not forbid the use of radar speedmeters; in this regard see, People v. Beamer, 130 Cal. App. 2d 874, 279 P.2d 205 (1955) and State v. Ryan, 48 Wash. 2d 304, 293 P.2d 399 (1956).

Radar

A variety of statutes, which vary from state to state, either specify who may use radar to enforce speed laws, or set out the places or conditions under which radar may be used. The following provisions are representative: GA. CODE ANN. §§ 68-2101--68-2111 (1975 and Supp. 1978) [prohibiting the use of radar, for example: within 500 feet of a sign warning that radar is being used, within 300 or 600 feet (depending on its location) of a signed reduction in the speed limit, anywhere the posted speed limit had been reduced within the preceding 30 days, on any grade in excess of seven percent, or where police or court revenues are subsidized by traffic fines; requiring that radar units be visible to traffic from a distance of at least 500 feet; and making the use of radar by local authorities subject to other restrictions not applicable to the state highway patrol]; ILL. ANN. STAT ch. 95 1/2, § 11-602 (Smith-Hurd Supp. 1978) [prohibiting the use of devices within 500 feet of a change in the posted speed limit]; and MISS. CODE ANN. § 63-3-519 (1973) [prohibiting local police agencies in municipalities having less than a given population from using radar on federal or state highways].

In addition, a number of states require the placement of warning signs in areas where radar is being used; typical provisions include: GA. CODE ANN. § 68-2105 (1975) [applies only to radar used by local authorities]; and VA. CODE § 46.1-198.2 (1974).

Evidential Restrictions in Speed Prosecutions

In most states, speeding is still considered a criminal offense; thus, under the U.S. Constitution a suspected speed violator's guilt must be proved beyond a reasonable doubt (see, In re Winship, 397 U.S. 358, 361-62 [1970]). A number of states have taken various steps to "decriminalize" speeding and other moving traffic violations (U.S. Department of Transportation 1977b). Most of these "decriminalized" states continue to require proof of guilt beyond a reasonable doubt; however, several of these states—including New York, North Dakota, Oregon, Rhode Island, and Wisconsin—now require a lesser degree of proof.

Restrictions on the Use of Devices in Connection with Traffic Prosecutions

Reliability of Evidence Obtained from Electronic Devices

The leading case that accorded judicial notice to the radar speedmeter is State v. Dantonio, 18 N.J. 570, 115 A.2d 35 (1955). In nearly every state, either the courts have followed Dantonio or the legislature has passed a statute having the same effect. Examples of these statutes include: ME. REV. STAT. ANN. tit. 29, § 1254 (Supp. 1978-79); N.D. CENT. CODE § 39-03-15 (1972); and W. VA. CODE §§ 17C-6-7 (1974). A number of states have passed statutes governing the use of radar, and all of these states have at least implicitly acknowledged the general reliability of radar. Most states, moreover, have enacted specific legislation specifically approving the use of radar to identify speeders (Note 1974, pp. 449-59).

Although police radar has gained judicial notice, this has not been the case with respect to other speed detection and measuring devices. For example, in People v. Leatherbarrow, 69 Misc. 2d 563, 330 N.Y.S. 2d 676, 679 (Erie County Court 1972), and People v. Persons, 60 Misc. 2d 803, 303 N.Y.S. 2d 728, 730 (Pittsford Ct. of Special Sessions 1969), the court held that expert testimony would be required to establish the validity of the scientific principles of VASCAR. However, the New Jersey courts have accorded this device judicial notice; see, State v. Finkle, 128 N.J. Super. 199, 319 A.2d 733, 734-38 (App. Div. 1974), cert. denied, 423 U.S. 836 (1975). Similarly, judicial notice has not been accorded ORBIS III. Even though evidence gathered by a device similar to ORBIS was admitted in People v. Pett, 13 Misc. 2d 975, 178 N.Y.S. 2d 550, 553-54 (Garden City Police Justice's Ct. 1958), expert testimony relating to the operation of that device was required to be introduced at the trial.

The Impact of Sanctioning in Enforcement Procedures

Penalties for NMSL Violations

Some states have passed legislation forbidding driver-licensing authorities to assess violation points against drivers who exceed the NMSL at speeds below previously posted maximum limits. Typical statutes in point-system states include: MICH. COMP. LAWS ANN. § 257.320a (6)(a) (1977); and OHIO REV. CODE ANN. § 4511.21(N) (Page Supp. 1978). In addition, a number of states have passed statutes providing that convictions based on speeds above the NMSL but below previous limits cannot be considered for the purpose of license suspension; these statutes include: MONT. REV. CODES ANN. § 32.2144.6(2) (Supp. 1977); OKLA. STAT. ANN. tit. 47, § 11-801c (West Supp. 1978-79); and TENN. CODE

ANN. § 59-852(g) (Supp. 1978).

Some states use a variation of this approach, and in effect create a legislative speed "tolerance." Typical provisions include the following: GA. CODE ANN. § 68B-307(c) (Supp. 1978) [no points assessed for speeding ten or fewer miles above posted limit]; IDAHO CODE § 48-681(3) (Supp. 1978); [NMSL violations at speeds not over 70 mph not considered "moving violations" for purposes of license suspension]; KAN. STAT. ANN. § 8-1341 (1975) [same; speeds not over 65 mph]; and NEB. REV. STAT. § 39-669.26(10)(c) (Cum. Supp. 1978) [no points assessed for speeding ten or fewer mph above posted limit on interstate highways]. In addition, OKLA. STAT. ANN. tit. 47, § 11-801b (West Supp. 1978-79) specifically prohibits insurers from basing rate increases on the presence of NMSL convictions for speeds not in excess of previous limits.

Finally, some states have passed statutes fixing small maximum fines for NMSL violators who are not guilty of excessive speeding. Examples include: IDAHO CODE § 49-681(3) (Supp. 1978) [$5 maximum fine, provided speed is not greater than 70 mph]; MONT. REV. CODES ANN. § 32.2144.6(1) (Supp. 1977) [$5]; NEB. REV. STAT. § 39-662.02 (Cum. Supp. 1978) [$10 maximum, provided speed is not greater than 10 mph above posted limit]; and N.M. STAT. ANN. § 66-8-116 (1978) [$15 maximum, provided speed is not greater than 15 mph above posted limit].

"Prima Facie" Speed Limits

The Uniform Vehicle Code has, since 1956, contained absolute rather than prima facie speed limits; see, UNIFORM VEHICLE CODE § 11-801.1 (Supp. II 1976). Nevertheless, a small number of states continue to use prima facie limits. These limits require proof of two facts to establish a driver's guilt of speeding: speed in excess of the posted limit; and speed that is unreasonable under the conditions (such as daylight, weather, traffic, and road conditions). Statutes establishing prima facie speed limits include the following: MASS. ANN. LAWS ch. 90, § 17 (Michie/Law. Co-Op Supp. 1978); N.H. REV. STAT. ANN. 262-A:54 (Supp. 1978) [NMSL only]; TEX. REV. CIV. STAT. ANN. art. 6701d, § 169B(j) (Vernon 1977); and UTAH CODE ANN. § 41-6-46 (1970).

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