IDENTIFICATION OF GENERAL RISK-MANAGEMENT COUNTERMEASURES FOR UNSAFE DRIVING ACTIONS. VOLUME I: DESCRIPTION AND ANALYSIS OF PROMISING COUNTERMEASURES

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

A series of general risk-management countermeasures for speed UDAs are described in this report. First, countermeasure elements in three functional areas, detection, information, and action, are identified. Three comprehensive countermeasure programs incorporating these elements are then outlined and discussed with respect to their feasibility and effectiveness. General requirements for testing and evaluating this type of countermeasure are presented. Other results of the study are reported in Volume II: A Review of Selected Literature, and Volume III: A Definitional Study of Speeding, Following Too Closely, and Driving Left of Center.

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CONTENTS

CHAPTER ONE
INTRODUCTION

This report presents a set of general risk-management countermeasures for reducing the incidence of speed-related unsafe driving actions (UDAs). The countermeasures were developed by the staff of the Policy Analysis Division of The University of Michigan Highway Safety Research Institute (HSRI) under National Highway Traffic Safety Administration (NHTSA) contract No. DOT-HS-7-01797. Two other reports present the results of supporting substudies. These reports are:

Volume II:
A Review of Selected Literature, and

Volume III:
A Definitional Study of Three Unsafe Driving Actions.

Initially, three UDAs were considered as possible targets for countermeasures to be developed under this contract. These UDAs were: speeding, following too closely, and driving left of center. Later, as a result of the substudy reported in Volume III, it was decided that the countermeasure targets be limited to speed-related UDAs because of the relatively low level of risk created by following too closely and driving left of center.

OBJECTIVES

The general objective of this project was to identify general risk management countermeasures that will reduce the incidence of unsafe driving actions. The focus of the countermeasure development effort was on speed-related UDAs. Specific objectives were to:

- select promising countermeasuress;
- assess the potential utility and the feasibility of the

countermeasures;

- refine the promising countermeasures and specify a set of recommended countermeasures; and
- specify test requirements for determining the highway safety impact of the countermeasures on the incidence of speed-related UDAs.

BACKGROUND

Studies that have examined traffic crash causation have consistently shown that unsafe driving actions are a major cause of traffic crashes. NHTSA, as part of a broad research and action program to reduce the traffic crash risk, has sponsored a series of studies to identify the risk associated with unsafe driving actions and to develop methods to reduce their occurrence. Unsafe driving actions that occur frequently, are involved in serious crashes, and appear to result from driver decision-making, were established as a priority for early study. The premise was that reduction of the incidence of such actions should reduce the overall crash risk. Further, acts resulting from deliberate driver decisions should be more susceptible to intervention through safe driving conformance strategies than nondeliberate acts committed by a driver.

Earlier studies (Hiett et al. 1975) developed initial definitions of unsafe driving actions. Other studies (Lohman et al. 1976) attempted to assess relative priority among the various unsafe driving acts in the context of the rate of involvement in crashes. These studies led NHTSA to identify three types of unsafe driving actions for more detailed examination. These three UDAs were speeding, following too closely, and driving left of center.

Two studies were then planned to be conducted in parallel. One study, "Police Enforcement Procedures for Unsafe Driving Actions," (contract number DOT-HS-8-01827) was designed to review and assess police enforcement strategies and tactics for the three UDAs. The second (this study) was entitled "Identification of General Deterrence Countermeasures for Unsafe Driving Actions" and was designed to develop a broad range of countermeasures not limited to those operated primarily by police enforcement or other legal-system agencies. To underline this distinction, we have substituted the term "general risk management" for the term "general deterrence," which is a term of art applied to specific strategy employed by legal system agencies. The nature of the general deterrence strategy and its relationship to other possible strategies against UDAs are described in Chapter Two.

Our two UDA studies started in 1977. As they began, it became apparent that the existing definitions for the three UDAs lacked operational specificity. In order to develop adequate estimates of the risk posed by the particular acts and to determine the nature and extent of current responses, adequate operational definitions were necessary. Thus, an initial task of both the Police Enforcement project and the so-called General Deterrence project was to develop operational definitions and preliminarily assess the risk associated with each to the three UDAs. This effort was primarily conducted under the General Deterrence project. The initial results are reported in Volume III of this report. NHTSA had recognized the need for better definitions and better data on the unsafe driving actions prior to the start of the two projects discussed above. A third project was developed by NHTSA to develop such information for a broad range of unsafe driving actions. This study, entitled "National Analysis of Unsafe Driving Actions and Behavioral Errors in Accidents" (Contract number DOT-HS-8-02023), was started in the fall of 1978 and involved the study team members of the present project.

The management and technical direction of the three projects was coordinated at NHTSA and HSRI. The results of the definitional studies established in earlier findings that the following-too-closely UDA was a priority UDA were not supported, particularly when the UDA is defined in legal terms, as is relevant for police enforcement action. Also, the driving-left-of-center UDA did not appear to result from the type of driver decision-making process that was reasonably susceptible to new-driver-oriented interventions. For example, many crashes that involve driving left of center occur through loss of control by the driver. The driver did not deliberately plan to drive left of center. (Chapter Three of this report discusses these points in greater detail.) The definitional studies also showed that the speeding UDA in all its forms was a significant factor in traffic crashes. These findings led NHTSA and HSRI study team members to focus the first two studies primarily on the speeding UDA. The third study continues to examine a broader range of unsafe driving actions and will lay the foundation for future studies that will address strategies and tactics to reduce the occurrence of high-priority UDAs.

SCOPE AND APPROACH

After completion of the definitional study, the project focused on driver-oriented countermeasures against the speeding unsafe driving action. Emphasis was placed on conscious and intentional commissions of the UDA rather than on nondeliberate occurrences due to driver inattention, distraction, impairment, and other factors.

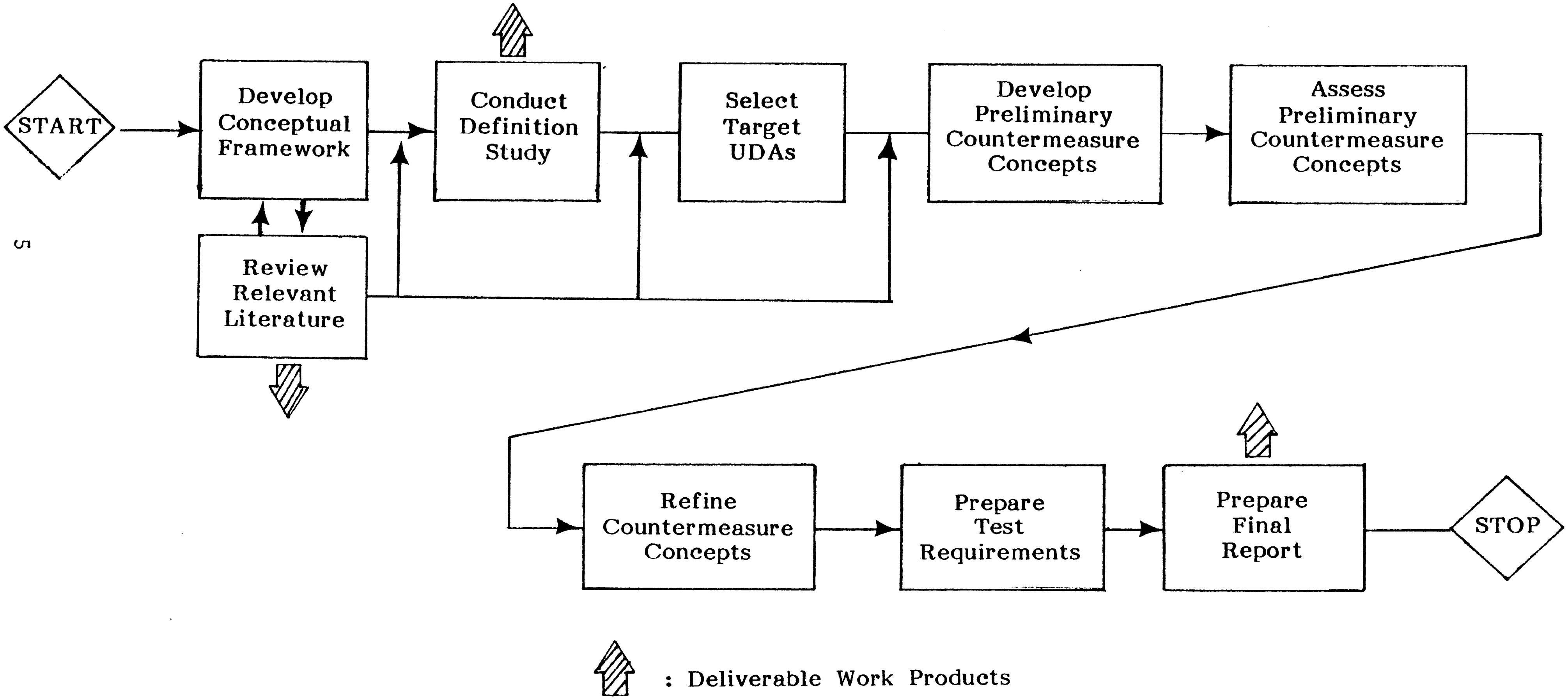
As noted earlier, our countermeasure development effort concentrated on what we have termed **general risk-management countermeasures.** Such countermeasures are aimed at managing traffic crash risk caused by the speeding UDA by influencing the behavior of drivers who have not necessarily been detected committing the UDA. General deterrence is only one approach to achieving such influence. It attempts to influence behavior by creating a perception among drivers that they will be caught and punished by the legal system if they engage in the UDA. It is, in essence, a negative strategy. It tries to make the perceived negative consequences of a UDA (for example, a fine imposed by a traffic court) outweigh the perceived positive consequences of the act (for example, decreased travel time).

Our study includes general deterrence countermeasures, but is not limited to them. Other negative approaches not requiring legal system action are considered along with positive approaches that provide rewards or incentives for **not** committing the UDA. Chapter Two describes the various strategies we used in generating countermeasures.

Our study approach involved the task areas depicted in Figure 1-1. First, a conceptual framework was developed for placing the UDA-

FIGURE 1-1

STUDY APPROACH



countermeasure problem within the context of the highway-safety process that deals with the traffic crash risk. The risk-management construct developed by the coprincipal investigators (see, for example, Joscelyn and Jones 1978) was the basis for this framework. It was expanded to include explicit driver-decision components and led to the identification of four basic strategies for countermeasures for the speeding UDA.

A literature survey was conducted concurrently with the conceptual framework development. The survey sought information for use in developing the framework and was in turn guided by the framework itself, which identified key areas where substantive information was needed. Two of these areas, decision-making and social-control processes, were explored in depth to identify major theories, concepts, and principles that would help in creating countermeasures based on a firm scientific foundation. This review is presented in Volume II of this final report. Abstracts of articles and reports on specific countermeasure concepts were also prepared for use by the project staff.

The definitional study of speeding, following too closely, and driving left of center followed. It drew upon information provided by the literature survey and also used data taken from HSRI's accident files. The study developed rigorous definitions of the terms used to describe traffic crash risk, provided a narrative description of the three UDAs, and developed quantitative data describing the crash risk and associated characteristics of the UDAs. It recommended that countermeasure development efforts under the contract focus on speed-related UDAs because of their higher risk. The definitional study is presented as the third volume of this final report.

The next major task area was the development of a series of preliminary countermeasure concepts against the speeding UDA. The concepts were based on ideas from a wide variety of sources, including technical reports, journal articles, scientific literature from the behavioral sciences, newspaper stories, discussions with colleagues and practitioners, and suggestions that NHTSA had received from its staff and from others. The concepts were presented in a working paper that described each concept and its method of application, indicated its primary target and user groups, and discussed key operational factors and their possible effects on feasibility, effectiveness, and efficiency of the concept.

The countermeasure concepts report was sent to a panel of researchers and practitioners in related fields for review and comment. The report was also circulated within NHTSA to obtain comment. Reviewers were asked to assess each concept with respect to (1) its effects on the incidence of speeding if it functioned as intended, (2) the likelihood that it could be designed and implemented to function as intended, (3) problems that might occur in developing and operating the countermeasure, (4) cost and other resource requirements, (5) development time, and (6) data needed to make more accurate estimates of effectiveness, feasibility, and cost.

The comments of the reviewers proved extremely useful in refining both the substance and the presentation of the countermeasures. The reviews indicated a need to present not only countermeasure **elements** that could be incorporated into ongoing countermeasure efforts in a jurisdiction, but to select several countermeasure **programs** combining the elements in a way that would enhance their total effect on the speeding UDA. The refined countermeasures are presented in this dual format in this report.

The final substantive task area in the project was to develop a set of requirements for testing and evaluating the countermeasure programs. The requirements were stated in terms of measures of effectiveness, evaluation, design, and efficiency considerations.

ORGANIZATION OF THIS REPORT

This volume is presented in seven chapters. Following this introduction, Chapter Two describes the conceptual framework for the study and states the four risk-management strategies that were used in generating the countermeasures. Chapter Three summarizes the major findings of the definitional study. Chapter Four describes seven countermeasure elements, and Chapter Five identifies and assesses three countermeasure programs that combine these elements. Test and evaluation requirements for the countermeasure programs are presented in Chapter Six. Chapter Seven sets forth the major conclusions and recommendations of the study.

CHAPTER TWO
CONCEPTUAL FRAMEWORK

The development of optimal strategies to reduce traffic crash risk requires a framework for examining the many interacting factors that influence the generation and control of that risk. This chapter describes such a framework that has been used by the authors in past highway safety research. The implications of the framework are stated, and basic strategies for reducing the incidence of speed-too-fast UDAs are defined.

THE CONCEPT OF RISK MANAGEMENT

The Highway Transportation System and its Output

The first element of our conceptual framework is the nation's Highway Transportation System (HTS), consisting of highways, vehicles, and users, plus their supporting elements. The primary objective of the HTS is to provide fast, convenient road transportation, but it also has many secondary objectives such as providing recreation and pleasure for drivers, providing a market for the automobile transportation industry, and supporting the national economy.

The HTS produces both positive and negative output in the course of its operations. Its positive output (called **utilities**) include individual mobility, rapid transportation of goods, and social and economic well-being. Foremost among its negative output (called **disutilities**) are deaths, injuries, and damage to property due to highway crashes. Other disutilities of the HTS include environmental pollution, depletion of natural resources, and disruption of social patterns.

In this project, disutilities generated by the **driver** component of the HTS are of concern. The target disutilities are crash losses brought about by UDAs, but the specific target of the UDA **countermeasures** is the driver. Countermeasures may also be directed against intermediate targets (e.g., passengers, employers) who may influence driver actions.

Utilities associated with the UDAs must also be considered. For speed-too-fast UDAs these may range from a perceived reduction in travel time to peer group approval for "cheating death" by driving at high speed.

Risk and Exposure

The concept of **risk** is useful in dealing with the uncertainties surrounding the occurrences and consequences of highway crashes. In our conceptual framework, risk is defined as the probability of the occurrence of an event that will produce disutility. The event can be the crash itself or the consequences of the crash, e.g., loss of life or property, injury, etc. The event can also be defined in terms of the individual who causes it to occur and in terms of the conditions under which it occurs. In short, risk can be defined at any level of detail that suits a particular analysis.

Clearly, the longer the time period during which an event **can** occur, the greater the probability that it **will** occur. Time, in this case, is a measure of **exposure.** Traffic crash risk is thus a function of driving time or of the time period during which a person **might** drive or be exposed to crashes caused by other drivers. Traffic crash risk can also be expressed as a function of the time period during which some specific driving activity is occurring, e.g., the time spent driving in excess of 70 mph. Since distance is a function of time for any given speed history, miles traveled can also be used to measure exposure except for the trivial case where a vehicle is not moving (e.g., stopped at a stop light).

Thus, risk cannot be completely defined until the risk event and exposure are defined. The definition of exposure must specify both the nature and amount of the exposure. The definition of the risk event must specify the type of crash loss and conditions under which the loss can occur. A complete statement of risk might read, then, as follows:

> The probability that any licensed driver will cause a fatal accident during a one-year period is .0004.

Here, the undesirable event is "a fatal accident caused by any licensed driver" and the exposure is one year. The statement implies that the risk is that of "any licensed driver," all of whom comprise the "population at risk." The population at risk could also be defined as the individuals who might be killed, injured, or suffer property damage in a fatal accident.

A more specific statement of risk must be made when defining the risk created by a given driving action. For example, such a statement might read:

> The probability of a fatal accident caused by a given driving action committed by any driver who commits that action continually for a period of one year is 0.10.

In this report we call this a statement of **conditional risk** because it specifies the risk of a fatal crash, given the **condition** that the driving action is being performed. The population at risk is composed of drivers who commit the driving action. If the population at risk were redefined to consist of all licensed drivers, then the risk statement should read:

> The probability of any licensed driver being involved in a fatal crash caused by a given driving action in a one-year period is .004.

We call this type of risk **unconditional risk** because it is not known beforehand whether a member of the population at risk is performing the specified driving act or even driving at all during the one-year period.

In many fields a term called a **hazard rate** is used as a key parameter of risk when risk is a continuous function of time. Hazard rate is measured in terms of number of risk events (termed "hazards" in this case) per unit time per member of the population at risk. Volume III explains the relationships between hazard rate and risk. The term is widely used in such diverse fields as reliability engineering, systems safety analysis, epidemiology, demography, and the actuarial sciences. It has not been widely used in highway safety, although it is ideally suited to describing many types of traffic crash risk, including that created by the so-called nondiscrete unsafe driving actions that are the subject of this study.

Risk Management

Society, as individuals and through its institutions, attempts to manage risk-producing factors so as to reduce the frequency of occurrence of events that produce disutility **and** to minimize loss if the events do occur. Through this process of **risk management,** society seeks to reduce risk to a **tolerable** level rather than to eliminate risk entirely. What is "tolerable" is a complex balance between what society **perceives** to be the utility and the disutility of various elements or practices of the Highway Transportation System (HTS).

Our conceptual framework identifies a set of public and private institutions that practice risk management on a more deliberate basis than private citizens or society as a whole. Some of these institutions are linked together by formal and informal working arrangements to form discrete, identifiable risk-management systems. An example of a formal risk management system is the nation's traffic law system consisting of the state and local agencies that generate and enforce traffic laws; that determine the guilt or innocence of individuals accused of violating the laws; and that impose sanctions on those found guilty of violations.

Risk management systems also include parts of formal systems that have their primary focus on broader aspects of society (e.g., health care delivery systems) and less formalized systems (e.g., the media used for public education and information). Many societal influences (e.g., customs, ethics, mores, folkways, family structures, and peer pressures) are based on the principle of risk management.

Formal risk management systems attempt to reduce the disutility of the HTS by exerting **control forces** on the HTS. Such forces include legal sanctions against drivers found guilty of proscribed high-risk behavior (e.g., speeding), mass-media messages about the nature of HTS risk (e.g., how many people are killed each year in crashes involving speeders), and new methods of reducing the consequences of crashes after they have occurred (e.g., faster delivery of injured persons to medical facilities). The control forces result from pressures exerted by society as a whole in response to its perception of highway crash risk and to its weighing of disutility against utility. Such pressures may call for new laws, institutions, or methods; for the more effective and efficient application of existing tools; or for the expenditure of additional resources.

Risk management systems operate under a fundamental constraint in their application of control forces. The constraint limits control forces to those which themselves generate no more disutility than will be tolerable to society. For example, lowering the national maximum speed limit to 30 mph would reduce fatal crashes greatly, but would not be accepted because of the high disutility associated with the action itself. In this example, the perceived disutility generated by the control force would be greater than the perceived disutility of speed-related crashes and the control force would be rejected by society.

A rational process for risk management includes the following six steps (Joscelyn and Jones 1978):

1. Identification of risk,
2. Establishment of priorities among risk,
3. Selection of risk-management strategies and tactics,
4. Determination of allocation of resources,
5. Implementation of risk-management actions, and
6. Evaluation of outcomes in terms of risk reduction.

The development of countermeasures for the speeding UDA involves all of these steps, but our study is most concerned with the first four. Considerations about implementation and evaluation are limited to key issues governing feasibility and to the requirements for designing future test and evaluation programs.

DRIVER DECISION BASIS

From the preceding discussion it is clear that the development of risk-management strategies to reduce the incidence of UDAs should start with an understanding of the factors that create the risk. Since we have defined a UDA as an act that flows from conscious decision-making by a driver, we can describe the decision process to encompass a balancing of equities.

It may be useful to think of the creation of the risk of a UDA as emerging from two steps:

1. A human decision yields the unsafe driving act.

2. The human decision results from a balancing of the utilities and disutilities associated with the UDA. If the perceived utilities outweigh the perceived disutilities, the UDA is committed. Note, that such a balancing process is not necessarily deliberate or even "rational" in the usual sense of the word. Also, the utilities and disutilities associated with a given act are not necessarily the same for all individuals. See Volume II of this report for further discussion of decision-making models.

In equation form, the balancing step may be represented as:

$$UDA_{decision} = (u_1, u_2, u_3, \ldots, u_m; d_1, d_2, d_3, \ldots, d_n)$$

where u_1 to u_m represent the range of positive expected values associated with the UDA and d_1 to d_n represent the range of negative expected values flowing from the UDA.

One may influence the decision either by reducing the total utility (a positive strategy in our terms) or by increasing the disutility (a negative strategy). Past approaches to highway safety have focused almost entirely on increasing the disutility. The primary emphasis has been on the use of the traffic law system to sanction offenders to create the general deterrent threat of law action if a UDA is undertaken. The threat of traffic law system action is only one of the disutilities considered by a driver in making a decision. There are many more that are not usually considered in developing highway safety countermeasures. Examples of these disutilities are given in the next subsection.

BASIC STRATEGIES

This section identifies and describes four basic risk-management strategies for speed-too-fast UDAs. The strategies are based on the considerations discussed in the two preceding sections.

The emphasis is on general strategies that follow the process illustrated in Figure 2-1. As the figure indicates, a driver's decision about whether to engage in a UDA is influenced by **information** on the outcomes of his past UDAs, the outcomes of UDAs by other drivers, and risk-management actions taken prior to his UDA. Special risk management is seen to be only one part of the general strategy, generating information about UDAs after a UDA has been committed and discovered. General risk management makes use of additional information provided to the decision-maker (i.e., the driver) prior to the "interception" of a UDA.

Strategy I - Decrease the Utility of Committing the UDA

In this strategy a favorable balance between utility and disutility is obtained by decreasing the utility the driver receives from committing the UDA. As a result, the driver associates a net disutility with the UDA and decides not to commit it. For example, if the motivation behind the UDA is to reduce travel time and thereby be rewarded with money or peer approval, then this strategy calls for the reward to be reduced or eliminated.

The reduction in utility must be perceived by the driver as being of sufficient magnitude to swing the balance of his utility-disutility equation to a "no-go" condition. Education and information countermeasures could be used to create such a perception even if the **actual** decrease in the reward were too small to create the desired effect. On the other hand, countermeasures to reduce the actual reward from the UDA would require an education and information component to make the undesirable outcome of the UDA known to the driver prior to his committing the UDA.

Strategy II - Increase the Utility of Not Committing the UDA

This strategy focuses directly on safe driving as a desirable behavior. In effect, it offers a **reward** for such behavior with the reward being of sufficient magnitude to offer more utility for not committing the UDA than for committing the UDA.

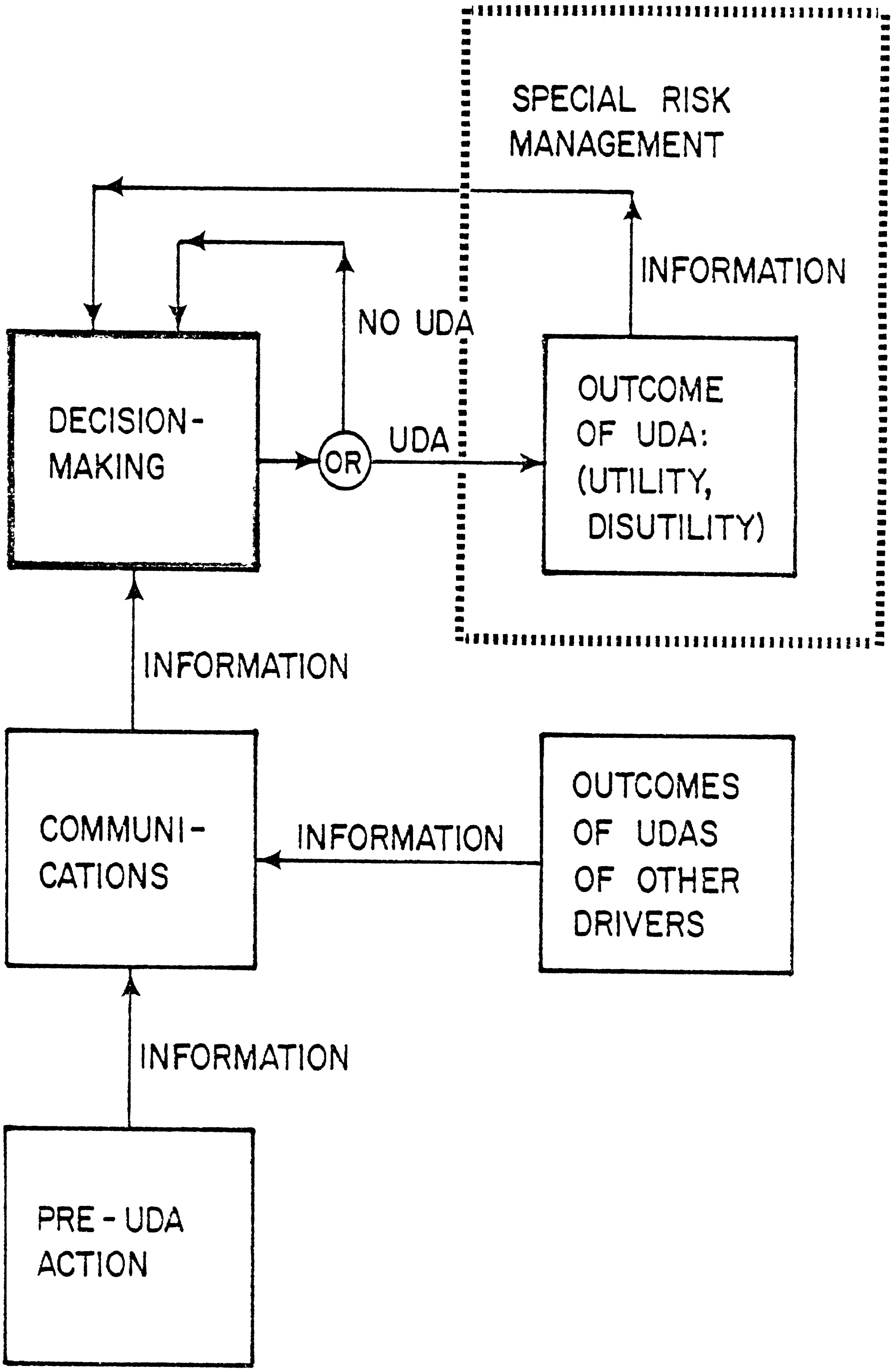


Figure 2-1. General Risk Management of Individual UDAs.

Again, both the perceived and actual rewards of driving safely can be increased through this strategy. Education and information components are required in either approach, but are more important if perceived rewards are the target.

Strategy III - Increase the Disutility of Committing the UDA

This is the classical negative approach to behavior modification. It operates on the principle that a driver contemplating a UDA will be deterred if the driver believes the negative results of the action will be greater than the positive results. It then concentrates on increasing the former so as to tip the utility-disutility balance to favor a no-go decision by the driver.

In the past, the Traffic Law System (TLS) has been the risk-management system that society has relied on most in applying this strategy to unsafe driving. When applied by the TLS, general risk management is called "general deterrence."

However, negative approaches do not have to rely on the TLS. Other risk-management systems have appeal because they are not bound by the constraints of the TLS which require the fundamental protection of the Constitution. For example, insurance "systems" can impose punishments (in the form of rate increases) without following the strict procedural formalities required of the TLS.

Analogous to Strategies I and II, both the perceived and actual punishments may be increased through this strategy. Deterrence theory (and common sense) dictates that the approach will be most effective when both occur.

Strategy IV - Decrease the Disutility of Not Committing the UDA

In this strategy the disutility the driver associates with not committing the UDA is decreased sufficiently to create a favorable balance in the utility-disutility equation.

For example, a driver might believe he would lose his job if he were late to work and thus might attach a high disutility to observing the speed limit. For this example, a possible countermeasure might be to persuade the employer not to fire the tardy driver but to seek other ways to encourage punctuality. Countermeasures to decrease the **perceived** punishment for safe driving would also be possible under this strategy.

We note that Wilde and his associates in Canada also have developed independently a similar set of strategies (called tactics) of human-oriented highway-safety countermeasures (Murdoch and Wilde 1980). These investigators have pursued a line of research similar to ours over the past several years and use many of the elements that we have incorporated into our risk-management paradigm.

SUMMARY AND CONCLUSIONS

The concept of risk management provides a useful framework for generating and assessing countermeasure concepts for reducing the incidence of speed-too-fast UDAs. The framework indicates that risk-management strategies aimed at the human component of the Highway Transportation System should seek to achieve a favorable balance between the utilities and the disutilities that a driver associates with such UDAs. Four possible strategies are suggested for striking such a balance.

1. Decrease the utility of committing the UDA.
2. Increase the utility of not committing the UDA.
3. Increase the disutility of committing the UDA.
4. Decrease the disutility of not committing the UDA.

CHAPTER THREE
OPERATIONAL DEFINITIONS OF SPEEDING, FOLLOWING TOO CLOSELY, AND DRIVING LEFT OF CENTER

The first step in applying the risk-management concept to this study is to define the risk to be managed. The results of our effort to develop operational definitions of the three subject unsafe driving actions (UDAs) are summarized in this chapter. The detailed results of the definitional study are presented in Volume III of this final report.

This chapter also presents the results of a preliminary risk analysis of these three UDAs. Risk figures are presented in terms of percentage of all crashes in which the UDA is a cause. The figures are taken from the definitional study reported in Volume III and are based on data presented in the literature and on special analyses of existing accident files at HSRI. Finally, this chapter briefly summarizes the characteristics of crashes involving these UDAs and indicates the degree to which the UDA-caused crashes were conscious and intentional.

SPEEDING

Two types of speeding UDAs were identified: the absolute-speed UDA and the relative-speed UDA. The **absolute-speed UDA** is defined as follows:

> The absolute-speed UDA is the act of driving a vehicle at a speed in excess of a maximum legal limit, or, in a normal driving environment, at a speed below a minimum limit.

Speed in this case is measured relative to the roadway. The limit may be set by any legally recognized authority. A "normal" driving environment is that associated with roadway usage under baseline or design conditions, for example, dry pavement, no construction, "average" traffic density, etc. Examples of the absolute-speed UDA include:

- driving any vehicle above the 55 mph national maximum speed limit;

- driving any vehicle above the posted maximum speed limit in a school zone during specified hours; or

- driving a special vehicle (e.g., a tandem-trailer gasoline transport) above the legal limit for that class of vehicle.

The **relative-speed UDA** was defined as:

> The relative-speed UDA is the act of driving a vehicle at a speed that is so different from the speeds of vehicles around it that the risk of a traffic crash exceeds that which is societally tolerable.

Here, speed is measured in one of the following ways:

1. As a difference in absolute speeds between two vehicles.

2. As a difference between the absolute speed of a subject vehicle and the mean speed of a sample of vehicles that contains the subject vehicle. This difference may be expressed either in units of speed (e.g., miles per hour) or in units of standard deviation from the mean of the sample of vehicles.

Subject to other conditions defined below, we assume that the relative-speed UDA occurs when the speed of the subject vehicle is greater than a speed not being exceeded by ninety-five percent of vehicles in the traffic stream. A relative-speed UDA also occurs where the speed of the subject vehicle is less than a speed being exceeded by ninety-five percent of vehicles in the traffic stream. Examples of the relative-speed UDA are:

- A vehicle traveling 35 mph when ninety-five percent of the vehicles in the same traffic stream are traveling 50 mph or more.

- A vehicle traveling 50 mph on an expressway when ninety-five percent of the vehicles in the same traffic stream have slowed to 35 mph because of snow.

The absolute-speed UDA is reflected in speed limit laws, whereas the relative-speed UDA is dealt with by such laws as those prohibiting driving too fast for conditions and reckless or careless driving. Relative-speed UDAs are also reflected in speed limit laws in most jurisdictions because of the methods that are used to set and enforce the limits. Such methods result in the establishment of speed limits at the eighty-fifth percentile level (Joscelyn, Jones, and Elston 1970).

Three classification rules were defined to make the definitions mutually exclusive. They are:

> **Rule 1:** The absolute-speed condition dominates the relative-speed condition for maximum speed limits.
>
> **Rule 2:** The relative-speed condition dominates the absolute-speed condition for minimum speed limits.
>
> **Rule 3:** Poor driving conditions (e.g., icy roads) remove minimum speed limits.

The results of applying these rules to various combinations of conditions are summarized in Table 3-1.

The "too fast" and "too slow" dimensions of speed-related UDAs require that we explicitly define another top-level variable for classifying UDAs. This variable classifies all speed UDAs as either speed-too-fast or speed-too-slow and leads to the following four types of speed UDAs:

Type 1 - too fast, absolute
Type 2 - too fast, relative
Type 3 - too slow, absolute
Type 4 - too slow, relative

Table 3-2 shows the estimated involvement percentages of these four types of speed UDAs in the general population of nonpedestrian crashes nationwide. All types combined appear in about 28% of such crashes. Speed-too-slow UDAs occur in 10% of these; speed-too-fast UDAs occur nearly twice as often (18%) as speed-too-slow UDAs. Some 10% of the speed-too-fast UDAs are classified as absolute (Type 1), and 8% are relative (Type 2). The data did not permit the speed-too-slow UDAs to be broken down further into absolute or relative categories.

Characteristics most common among all types of crashes caused by

TABLE 3-1

CLASSIFICATIONS OF POSSIBLE UDAs

Absolute Speed of Subject Vehicle	Mean Speed of Traffic Flow		
	Higher Than Maximum Limit	Lower Than Minimum Limit	Within Both Limits
Higher Than Maximum Limit	Absolute (too fast)	Absolute (too fast)	Absolute (too fast)
Lower Than Minimum Limit	Absolute (too slow) Under Good Conditions; Relative (too slow) Under Poor Conditions	Relative (too fast or too slow)	Absolute (too slow) Under Good Conditions; Relative (too slow) Under Poor Conditions
Within Both Limits	None	Relative (too fast)	Relative (too fast or too slow)

TABLE 3-2

ESTIMATES OF CRASH INVOLVEMENT FOR
SPEED-RELATED UDAs

Type of Speed UDA	Percent of All Crashes	
	Range	Best Estimate
1-Too fast, absolute	4-16	10
2-Too fast, relative	5-12	8
3-Too slow, absolute	Not known	--
4-Too slow, relative	Not known	--
All too fast (Types 1 & 2)	9-28	18
All too slow (Types 3 & 4)	5-20	10
All absolute (Types 1 & 3)	Not known	--
All relative (Types 2 & 4)	Not known	--
All types	14-48	28

Source: Treat et al. 1980

speed-too-fast UDAs (i.e., Types 1 and 2) are listed in Table 3-3. The table also lists characteristics that tend to distinguish crashes caused by speed-too-fast UDAs from other crashes. Detailed breakdowns of crash characteristics by type of speed-related UDA are not available.

Our analyses indicate that speed-too-fast UDAs and each of their component types are overwhelmingly conscious and intentional. Our clinical assessments suggest that impairment (e.g., by alcohol) is a major factor in the relatively small percentage of unconscious and unintentional speed-too-fast UDAs that cause crashes.

FOLLOWING TOO CLOSELY

Our definition of following too closely (FTC) is as follows:

> The FTC UDA is the act of driving a vehicle following another vehicle such that the time separation between the two vehicles is so short as to create a societally unacceptable level of crash risk.

"Following" is defined as driving at about the same speed as a lead vehicle when both vehicles are in the same lane of traffic. "Time separation" is defined as the distance between the two vehicles divided by their speed. The time separation consists of two major components, a component due to the reaction time of the following driver and a component due to the difference in braking capacity of the two vehicles. Generally speaking, time separations should be greater than one to two seconds to avoid an unacceptably high risk of an FTC-caused crash.

Note that this definition explicitly excludes instances of "gross inattention" and that the term "reaction time" includes a component for allowing a driver to **recognize** a stopping maneuver by a lead vehicle. Thus, actions involving a delayed response by a following vehicle to a stopping or stopped vehicle are excluded from this category of UDAs.

About one percent of crashes nationwide involve this UDA as a causal factor. Characteristics associated with FTC crashes are listed in Table 3-4. Such crashes are predominantly of the low-severity, rear-end type involving young males on straight-and-level stretches of four-or-more-lane

TABLE 3-3

CHARACTERISTICS OF CRASHES CAUSED BY SPEED-TOO-FAST UDAs

CRASH VARIABLE	MOST FREQUENT VALUE	MOST FREQUENT VALUE RELATIVE TO VALUE FOR CRASHES IN GENERAL
Crash Severity	Low	Very High
No. of Vehicles in Crash	About the same for one and more than one	One
Impact Configuration	Intersecting	Sideswipe, rearend
Driver Age	Young	Young
Driver Sex	Male	Male
Road Type	City Streets	Secondary and Interstate
Road Lane Configuration	Two-lane	Four-lane divided and Two-lane
Road Alignment	Straight and level	Curves and/or hills
Precipitation	None	Rain & Snow

SOURCE: Jones, Treat, and Joscelyn 1980

TABLE 3-4

CHARACTERISTICS OF CRASHES CAUSED BY FTC UDAs

CRASH VARIABLE	MOST FREQUENT VALUE	MOST FREQUENT VALUE RELATIVE TO VALUE FOR CRASHES IN GENERAL
Crash Severity	Low	Low
No. of Vehicles in Crash	Multiple	Multiple
Impact Configur- ation	Rear end	Rear end
Driver Age	Young	Young
Driver Sex	Male	No difference with respect to sex
Road Class	City streets; U.S. & state turnpike	Interstate & turnpike
Road Lane Configuration	Four or more lanes, divided and nondivided	Four or more lanes, divided and nondivided
Road Alignment	Straight and level	Straight and level
Precipitation	None	Rain

SOURCE: Jones, Treat, and Joscelyn 1980

city streets and turnpikes. Data suggest but do not show conclusively that FTC UDAs are most often the result of conscious and intentional driver actions.

DRIVING LEFT OF CENTER

The definition used for this UDA is as follows:

> The DLOC UDA is the act of driving a vehicle over or on the center line of a two-way, two-lane road when not passing or turning.

We estimate that about ten percent of all crashes nationwide involve this UDA as a cause. Crashes that were caused by a noncontact, "phantom" vehicle are included in this figure.

DLOC crashes tend to be much more severe than other types of crashes (see Table 3-5). Most often, DLOC-caused crashes involved more than one vehicle on two-lane, straight-and-level city streets in any weather. However, DLOC-caused crashes occurred more frequently on curved or hilly country roads and state secondary roads than did crashes in general. Snowy weather also was overrepresented in DLOC-caused crashes. There are strong indications that drivers in DLOC-caused crashes are far more likely to be cited for drunk driving than drivers in crashes in general.

Relatively few crashes (about 3%) appear to involve a conscious and intentional commission of DLOC. DLOC-caused crashes that are conscious and intentional, but not due to environmental factors (e.g., poor visiblity, need to avoid a bicyclist) are rarer still.

SUMMARY AND CONCLUSIONS

Operational definitions of three unsafe driving actions (UDAs) were developed using data from the literature and accident files at HSRI. **Speed-related** UDAs were divided into four basic types:

TABLE 3-5

CHARACTERISTICS OF CRASHES CAUSED BY DLOC UDAs

CRASH VARIABLE	MOST FREQUENT VALUE	MOST FREQUENT VALUE RELATIVE TO VALUE FOR CRASHES IN GENERAL
Crash Severity	Low to moderate	Very high
No. of Vehicles in Crash	Multiple	Multiple
Impact Configuration	Head-on	Head-on; Sideswipe
Driver Age	Young	Young
Driver Sex	Male	Male
Road Class	City streets	County roads; state secondary roads
Road Lane Configuration	Two-lane	Two-lane
Road Alignment	Straight and level	Curve, hill, or both
Precipitation	None	Snow

SOURCE: Jones, Treat, and Joscelyn 1980

Type 1 - too fast, absolute
Type 2 - too fast, relative
Type 3 - too slow, absolute
Type 4 - too slow, relative

The absolute-speed UDAs (Types 1 and 3) occur when a vehicle is driven in excess of an appropriately established maximum speed or, in a normal driving environment, at a speed below an appropriately established minimum limit. Relative-speed UDAs (Types 2 and 4) occur when a vehicle's speed is so different from that of vehicles around it to create unacceptably high risk of a crash. Studies indicate that unacceptably high risk occurs at speeds less than the fifth percentile speed of traffic and at speeds greater than the ninety-fifty percentile speed.

The **following-too-closely** (FTC) UDA occurs when a vehicle follows another vehicle at distance such that the time separation between the two vehicles is so short as to create unacceptably high risk. Studies indicate such risk at time separations of less than one to two seconds.

The **driving-left-of-center** UDAs occur when a vehicle crosses the center line of a two-way road when not passing or turning.

Speed-related UDAs are by far the most prevalent of the three. We estimate that some 28% of all crashes nationwide are caused, at least in part, by these UDAs. More than half of these are caused by speed-too-fast types which are predominantly conscious and intentional.

The FTC UDAs are the least prevalent of the three, appearing as a causal factor in only about one percent of crashes. FTC-caused crashes tend to be less severe than crashes as a whole. Most FTC UDAs that cause crashes appear to be deliberate.

DLOC UDAs are moderately prevalent, but usually are not conscious and intentional in the crashes they cause. Environmental factors accompany a large percentage of crashes that involve DLOC. Only a very small percentage of crashes (i.e., less than one percent) would appear to involve DLOC UDAs that would be an appropriate target for enforcement countermeasures. Thus, such countermeasures could have, at best, only a minimal effect on overall crash frequency.

Thus, speed-too-fast and speed-too-slow UDAs should be given high priority by risk management agencies. Violations of statutes relating to FTC and DLOC should be enforced when observed, but large-scale, nationwide programs and large expenditures of funds for personnel and equipment are not indicated.

CHAPTER FOUR
COUNTERMEASURE ELEMENTS

This chapter describes seven countermeasure elements that appear promising for reducing the incidence of the speeding unsafe driving action. We use the term "element" to underscore the fact that these countermeasures would not likely be used alone in any operational program. Instead, they would be used as building blocks to be worked into existing or new programs. Chapter Five presents three such comprehensive programs that incorporate the elements described here.

The countermeasure elements in this chapter fall into three groups:

- Traffic Law System countermeasures,
- informational countermeasures, and
- technological countermeasures.

Each countermeasure element within these groups is described with respect to its overall approach, its primary target and user groups, and support needed from other countermeasures.

TRAFFIC LAW SYSTEM COUNTERMEASURES

This group of countermeasures uses the methods and resources of the Traffic Law System (TLS) to reduce the incidence of speed UDAs. The countermeasures are applications of risk-management Strategy III as described in the preceding section. This strategy attempts to increase the disutility a driver believes will be incurred as a result of committing a speed UDA. The driver is thus deterred from committing a UDA, either as a result of being caught and punished for a prior UDA (called special deterrence) or as a result of the fear of **possibly** being caught and punished for committing the UDA (called general deterrence).

TLS countermeasures may be applied in the course of performing the following four functions of the system:

- Law generation: the generation of laws defining and prohibiting UDA and the specification of possible sanctions for violating these laws.

- Law enforcement: the enforcement of these laws either by manipulating individual behavior or by initiating formal system action (i.e., an arrest or citation).

- Adjudication: the determination of fact and law in a particular event involving an individual charged with committing the UDA.

- Sanctioning: application of the ultimate system response that is intended to prevent future UDAs by the law violator and other potential violators.

The TLS is often supported by a more informal fifth function, public information and education, whose objective is to inform drivers about the deterrent threat of the system. Countermeasures based on this function are described later in this chapter.

Studies suggest that three factors are of primary importance to deterring a specified behavior (See Volume II):

1. the characteristics of the target population (e.g., assessment of risk, willingness to take risks, attitudes about authority, social status, impulsiveness),

2. the target population's knowledge of the presence of the deterrent threat, and

3. the credibility of the deterrent threat to the target population (i.e., sure and universal application of a suitably unpleasant punishment).

The two TLS countermeasure elements we suggest address all of these factors and involve all of the four functional areas of the system. Specifically, the countermeasures seek to:

- increase the severity of sanctions against convicted violators of speed laws, and

- increase the overall enforcement of speed-law violations committed by selected target groups.

Brief descriptions of these two countermeasures are presented below.

Countermeasure Element A-1: Increase the Severity of Sanctions Against Convicted Violators of Speed Laws

This countermeasure element greatly increases the severity of punitive sanctions imposed on speed-law violators by the TLS to enhance special deterrence directly and general deterrence ultimately. The target group is composed primarily of drivers who deliberately and repeatedly engage in the highest-risk, speed-related UDAs. Such UDAs include both absolute-speed and relative-speed UDAs at the upper regions of the speed-risk curves. Drivers who are heavily inclined toward risk-taking for whatever reasons are highly overrepresented in this target group.

Other drivers who tend not to be deterred by existing mild punishments for the less serious speeding law violations comprise a secondary target group for this countermeasure. The general deterrence effect of more severe sanctions is the main force for modifying the driving behavior of this more risk-averse group.

The severity or "strength" of TLS-imposed sanctions is increased in several different ways. First, it increases **punitive** sanctions greatly in an attempt to swing the utility-disutility balance to favor a no-UDA decision by the driver. These sanctions include several-fold increases in the amounts of fines, more frequent and longer periods of driver license suspensions, and in some cases, jail sentences. Some of these punitive sactions also serve an **incapacitative** purpose in that they remove the opportunity for committing the UDA. The interaction of this incapacitative effect with enforcement and purely punitive effects is synergistic in its overall effect on repeat violations. **Rehabilitative** sanctions for treating the underlying psychological and social factors that contribute to some instances of problem driving behavior are also included.

This countermeasure would also make use of other, more informal, sanctioning mechanisms to increase the indirect costs associated with a high-risk speeding UDA. These might involve, for example, rapid notification of the driver's insurer, followed by a sharp rise in insurance premiums.

To function effectively, this countermeasure element would need to be supported by other elements that would help establish the credibility of the increased deterrent threat. First, it would have to be coupled with an effective enforcement component to establish a sufficiently high probability that high-speed drivers will be detected and delivered to adjudication and sanctioning authorities. Second, it will be necessary to include a public information component to ensure that the target group will perceive the deterrent threat to be sufficient to outweigh perceived benefits of the unsafe driving action. Finally, this element must be compatible with all of the functions of the Traffic Law System, including law generation and adjudication as well as enforcement and sanctioning. This means that a viable statutory basis must be established, that the system must be able to absorb the increased caseload of speed-law violators, and that system personnel must be adequately trained and motivated to perform their tasks.

COUNTERMEASURE ELEMENT A-2: INCREASE POLICE ENFORCEMENT OF SPEED-LAW VIOLATIONS BY SELECTED TARGET GROUPS

This countermeasure uses police enforcement resources selectively against drivers of heavy trucks and buses that violate the 55 mph national naximum speed limit (NMSL) on limited access highways. It aims to reduce the mean speed and variance of traffic in general by reducing the speed of heavy trucks and buses that often act as pacesetters on these highways. Other vehicles traveling over 55 mph on these highways are a secondary target group.

Police agencies that enforce speeding laws on limited access highways are the user group of this countermeasure. Such agencies most often will be state-level agencies and will be supported by other TLS components and information and education elements.

Classic selective enforcement techniques are used for identifying target segments of highway. The countermeasure employs enforcement procedures suggested by research to be most effective for controlling speeding violations (see Joscelyn and Jones 1980).

Identification of high-violation locations is made through mobile sensor systems. Visual observations by police-patrol officers, citizens' complaints, and accident reports provide supplementary target-identification data or may be primary data sources where sensor systems are not available. Exact locations of enforcement vehicles are varied periodically to create the impression of a higher intensity of enforcement than actually exists. An optimal ratio of patrol presence to patrol absence at a site is used over the period of selective enforcement activity.

Patrol vehicles assigned to the target area are predominantly marked cars and/or motorcycles and are parked conspicuously along the highway in a high-threat configuration (e.g., flashing light, issuing a citation). Radar is used for detection and speed measurement where statutes permit. Written warnings or citations are given to apprehended violators. Unconventional enforcement vehicles (e.g., large trucks) are used to augment the visible symbols to create an impression that any vehicle could be a police vehicle.

Like Countermeasure Element A-1, this countermeasure must be carefully integrated into existing Traffic Law System operations in a jurisdiction. Support by an effective public information countermeasure is probably even more important than it is for element A-1.

INFORMATIONAL COUNTERMEASURES

This group contains two separate classes of countermeasure elements. The first class, called **direct** information countermeasures, provides information about the possible consequences of a speed-related UDA to drivers to influence them to decide not to commit the UDA. A second class of **indirect** information countermeasures provides information to others for use in influencing driver decisions about UDAs.

The direct countermeasure element described here (Countermeasure element B-1) employs strategy I (decrease the utility of committing the UDA), strategy II (increase the utility of not committing the UDA), and strategy III (increase the disutility of committing the UDA). It will be seen that information countermeasures employing strategy IV are also possible but have less general applicability to a broad range of jurisdictions. Both the direct and the indirect countermeasures in this section are described in general programmatic terms with illustrative examples of specific applications. Educational and training applications are treated within the indirect category (countermeasure element B-2).

Principles stated in Volume II of this report are used in identifying target groups, developing message content, and identifying media and communications channels. These principles suggest that:

- informational countermeasures should be aimed at specific target groups with specific decision problems;
- groups who tend to make decisions to model the behavior of others should be given credible models of behavior to follow;
- groups who tend to weigh the advantages and disadvantages of a behavior should be given information on the outcomes of a UDA decision;
- the uses of the vehicles by a target groups (e.g., transportation vs. recreation) should be considered in designing informational elements;
- information should stress the immediate consequences of a UDA or non-UDA decision rather than long-term consequences or the probability of an outcome;
- informational elements should attempt to utilize the informal influence of groups in addition to the more formal influences of institutions (e.g., the legal system) ; and
- messages used in supporting legal-system strategies should stress the legitimacy of the law as well as the negative effects of legal sanctions.

COUNTERMEASURE ELEMENT B-1: PROVIDE INFORMATION TO DRIVERS ON THE CONSEQUENCES OF SPEED-RELATED UDAs

This countermeasure provides information to show that committing a speed-related UDA does not significantly reduce travel time and has a high potential cost, while complying with speed laws reduces the cost of operating a motor vehicle. Media for these messages include radio, billboards, and other media that reach drivers while they are driving (i.e., provide "immediacy").

The target group for this countermeasure is drivers who exceed posted speed limits on limited access and secondary roads. Possible subgroups of drivers include:

- young drivers,
- old drivers,
- drivers of certain classes of vehicles (e.g., heavy trucks, buses), and
- commuters.

A variety of user groups is possible, depending on the specific informational content and media that are chosen. Likely initiators of the countermeasure are state and local highway safety agencies and groups; state highway departments and local road commissions; and public information and education (PI&E) groups within large police departments. User groups could include some of these same agencies plus private sector organizations, for example, fleet owners, trade associations, unions, etc.

Three major types of appeals are used:

1. noncompliant behavior does not appreciably reduce travel time in many instances (strategy I),
2. compliant behavior reduces the cost of operating a motor vehicle (strategy II), and
3. the potential cost of noncompliant behavior is very high (strategy III).

Appeal 1. This presents information on travel time in various driving situations (e.g., type of highway, traffic volume, weather, trip length). The information shows that the amount of time saved by committing the UDA is small, both in an absolute sense and relative to the time lost due to an enforcement action or a traffic crash.

Appeal 2. This presents vehicle operating cost data as a function of speed and miles driven per year. The information is presented in a form that is relevant to the target group(s) and their driving habits. It shows that substantial reductions in economic costs can be achieved by observing speed limits. A variant of appeal 2 stresses other types of cost savings realized through compliant behavior. These noneconomic costs include loss of energy independence (including national pride) and the effects of energy wasted on high-speed driving on compliant drivers and various aspects of everyday life (e.g., employment, keeping warm, inflation).

Appeal 3 presents information on the potential costs of noncompliant behavior, with emphasis on economic and other costs resulting from enforcement actions or crashes or both. For example, the various components of such costs would be listed and tallied in a presentation, viz.:

• time lost from work:	$xxx
• medical costs not covered by insurance:	$xxx
• nondeductible auto repair costs:	$xxx
• increase in auto insurance premiums:	$xxx
• fine for law violation:	$xxx
Total:	$xxx

The three types of appeals could be used separately or in combination. Models of appropriate behavior as well as more "rational" justifications are provided.

The most appropriate media for this countermeasure element would be those that are accessible to the driver while driving. These would include:

- radio (AM, FM, CB),
- billboards,
- roadside signs,
- dashboard stickers and bumper stickers (for simple messages), and
- on-board microcomputers with displays.

Research indicates that changes in driver behavior are not likely to result from PI&E campaigns unless they are combined with other countermeasure elements. Apparently, some kind of action component is needed to back up the threats and rewards that are proclaimed in the informational programs. Thus, to make appeal 3 more effective, elements that would make the cost components credible to a driver would have to be added. For example, one could increase the probability of detection of the UDA by increasing enforcement (element A-2). This would provide backup for the advertised cost of driving too fast. Other countermeasure elements could be incorporated to back up other appeals.

COUNTERMEASURE B-2: PROVIDE INFORMATION TO OTHERS TO INFLUENCE DRIVER DECISIONS ABOUT COMMITTING SPEED-RELATED UDAs

This countermeasure uses messages on car bumpers, billboards, radio, etc., to inform drivers where and how to report speed-law violations. The reports are then used by private groups and organizations as a basis for punishments for noncompliances with the laws or for rewards for compliance. Also, information on the risk of speed UDAs and information on how best to manage that risk may be provided to TLS staff. The countermeasure augments limited police resources in detecting speed-law violators and provides information for improving the operation of the TLS in dealing with such violators.

This countermeasure element addresses two distinct target groups:

- Group 1: other drivers in the traffic stream who observe speed-law violations, and
- Group 2: Traffic Law System personnel who operate deterrence countermeasures.

Drivers in group 1 are conforming to the speed laws when they observe the violations of other drivers. Group 1 drivers may be driving any type of vehicle under any type of traffic condition. Group 2 includes police officers, prosecutors, traffic court judges, and driver licensing personnel.

Both of these groups are intermediate target groups. The ultimate target group is drivers who exceed maximum speed limits, especially those who exceed speed limits by a large amount.

Initiators and operators of the countermeasure element directed at target group 1 include citizen groups, automobile associations (e.g., AAA), highway safety agencies (e.g., agencies that administer a state's 402 program), employers, schools/colleges, unions, and Traffic Law Systems agencies (e.g., a police department). Initiators and operators of the element directed at target group 2 are primarily highway safety agencies and TLS agencies.

Two modes of operation are envisaged. In mode 1, information is provided to drivers to enable them to report speeding law violations to a central location. The information appears in different forms depending on the media used for the messages, for example:

- bumper stickers and dashboard stickers: a terse statement informing drivers of the phone numbers and/or CB channels that should be contacted to report violations,

- billboards: longer messages giving information to motivate contacts, and

- radio: a talk show explaining the driver reporting program and its rationale.

Various alternatives are available for using the motorists' reports of speeding violations. For example, violations could be reported to the state driver licensing authority, which could require the driver or vehicle owner to appear for an interview or hearing. Violations could also be reported to private groups and organizations (e.g., parent's organizations, automobile clubs, and fraternal groups). Reporting of violations to TLS agencies for subsequent prosecution is not recommended because of other requirements that must be met to use the reports in obtaining convictions (e.g., necessity to obtain an arrest warrant, the possibility that the reporting driver might have to testify in court, etc.).

Mode 2 of this countermeasure provides information to TLS agencies to support their law generation, enforcement, adjudication, and sanctioning activities relative to speed-too-fast UDAs. Such information would define the risk associated with these UDAs and would describe the programs (planned or currently operating) to deal with that risk. The information would be provided through training and educational programs for interfunctional groups of TLS personnel (e.g., for police officers, legislators, or judges) or for intrafunctional groups. The small group seminars for police, legislators, prosecutors, judges, etc., given to support the Alcohol Safety Action Projects (ASAPs) are an example of interfunctional programs, and the NHTSA-sponsored seminars in Traffic Case Adjudication Systems are an example of interfunctional programs.

Again, this countermeasure element will require the support of other countermeasure elements to achieve its intended effects. In the case of citizen reporting of violations (mode 1), it will be necessary to establish that the reports are actually used so that the reporting motorist will not regard the effort taken to make the report as wasted. Mode 2, which calls for disseminating information to TLS personnel, obviously requires that a user jurisdiction have an integrated TLS program against the speed-too-fast UDA, which in turn implies a need for TLS countermeasure elements, that is, more severe sanctions (A-1), and increased enforcement activity (A-2).

TECHNOLOGICAL COUNTERMEASURES

Countermeasure elements based on the use of modern technology are in this group. In general, such countermeasures grow out of a need to improve existing approaches (for example, Traffic Law System countermeasures) or are completely new approaches suggested by the new technology itself.

Both of these two types of countermeasures are represented in the concepts described in this section. The countermeasure elements are:

- an automatic detection device for detecting speed-law violators,
- an operating speed recorder, and
- a device for warning drivers and passengers when the drivers are committing speed-law violations

COUNTERMEASURE ELEMENT C-1: AUTOMATED DETECTION DEVICE

In this countermeasure, automated detection devices are used to identify and detect violators of the 55 mph NMSL and other speed laws. Information on a violation is provided to TLS and non-TLS organizations for use in sanctioning violators. The countermeasure increases both the perceived and actual probability of detection without increasing police patrol activity.

The primary target group is drivers who violate the 55 mph national maximum speed limit (NMSL) on limited access highways. Secondary target groups include violators of maximum speed limits on other types of roads, drivers who exceed maximum safe speeds under certain environmental conditions, and individuals who drive less than the minimum posted speed limit on selected segments of highways.

Law enforcement agencies are the primary user group of this countermeasure element. Such agencies include police departments and highway patrols at the municipal, county, and state levels, depending on the location of the target segment of highway. Secondary user groups are driver licensing agencies and other TLS and non-TLS agencies.

Automated devices are used to detect violators of speeding laws. The hardware for detecting and identifying violators is of the type developed by the Boeing Corporation for the ORBIS III tested in the United States and the Multanova system being used in Germany (Glauz and Blackburn 1980).

The detection device consists of a speed sensor and a camera. Vehicle speeds are measured by the speed sensor. Vehicles traveling at preset speed ranges (e.g., greater than 60 mph) are automatically photographed by the camera. The photographs show the vehicle registration number, vehicle speed, and the time, date, and location of the violations. Some versions of this device also photograph the driver to aid in identification.

The photographs are collected periodically from the cameras and the data used for a series of possible subsequent actions, depending on the particular operational mode chosen. Such actions could include:

- warning letters to the vehicle owners;
- citation and subsequent prosecution of violators;
- advisory letters to employers of the drivers when the vehicles were provided by the employer;
- advisory letters to others as appropriate (e.g., parents, car rental agencies, insurance companies); and
- lists of the owners of speeding vehicles presented in the news media (e.g., newspapers, radio, television).

Dissemination and use of the data would, in general, involve other TLS agencies (e.g., driver license administrators) and could involve agencies and organizations outside of the TLS.

Clearly, this countermeasure element must function as a part of a total program that would not only detect speed-law violators, but would take also action to deal with those violators. Smooth integration into existing Traffic Law System operations would be essential. The effect of this countermeasure on the incidence of speeed-too-fast UDAs would be expected to be enhanced by combining it with informational countermeasure elements, for example, B-1.

COUNTERMEASURE ELEMENT C-2: OPERATING SPEED RECORDER

The operating speed recorder (OSR) provides speed-time or speed-distance histories of a trip to owners of vehicles that are used by employees or dependent children. The information is used for negative measures to discourage speed-law violations (e.g., reprimands, reduction of bonuses) or for positive measures to encourage compliance (e.g., awards, increased vacation). The OSR helps reduce the number of police officers required to detect and report a given number of violations and also eliminates the need for subsequent action by other TLS elements.

This countermeasure element is directed primarily at two types of target groups:

- Target Group 1: individuals who violate speed laws while driving certain types of commercially-owned and government-owned vehicles, including autos, trucks, and buses.

- Target Group 2: dependent children who violate speed laws while driving their parent's vehicles.

The user group for countermeasures in target group 1 are the companies and agencies that own the vehicles that are being driven in violation of speed laws. The companies include owners of fleets of vehicles used by company personnel and owners of fleets of vehicles that may be rented or leased to private citizens or to other companies. Governmental agencies include those at the federal, state, and local levels.

The user group for target group 2 countermeasures are the parents who own the vehicles that their children drive at illegally high speeds.

In this countermeasure, speed-time information is fed to a computer-recorder unit, that is, the operating speed recorder, (OSR), which provides speed-time and/or speed-distance histories of a given trip or series of trips. More advanced versions could use the speed-time data to calculate and record acceleration histories as well. The OSR device is a modern electronic version of earlier, mechanical devices (e.g., the Tachograph) that provided similar information.

The speed records are provided to the OSR user as a basis for either positive measures to encourage speed-law compliance or negative measures to discourage noncompliance. Negative measures for target group 1 drivers could include verbal and written reprimands, fines, reduction of bonuses, reduction in share of profits (in companies with profit sharing plans), and even dismissal for chronic speed-law violators. Vehicle leasing and rental agencies could charge higher rates based on some function of speed in excess of the speed limit and amount of time spent driving over the speed limit. Tax disincentives might be applied to companies with histories of excessive violations of speed laws. Insurance rates might also be increased for such companies. Positive measures for target group 1 could mirror the negative measures, for example, praise, awards, financial rewards, increased vacation time, and lower vehicle rental rates for compliant drivers; and tax incentives for exemplary companies. Companies and governmental agencies could use the data from the OSR to establish more realistic schedules so that drivers would not be forced to violate speed laws to meet the schedules.

For target group 2, parents could allocate their children's use of their vehicle on the basis of speed-law compliance. Other rewards and punishments also could be tied to compliance.

The data from the OSR might be displayed to the driver to show when negative or positive "points" were being tallied. The current net value of rewards or punishments might be presented in such a display.

As with other countermeasure elements that detect speed-law violations (and as suggested above), the OSR should be complemented with elements that take action against the detected violators. This strengthens the special risk-management dimension of the detection mechanism which in turn strengthens general risk-management. The actions may be taken by formal, governmental risk-management systems such as the Traffic Law Systems (implying additional countermeasure elements from group A) or by systems outside of government (e.g., insurance companies, private employers). Applications of the OSR would be further enhanced by providing information to drivers on the consequences of speeding and the role of the device in lessening the utility of speeding to the driver.

COUNTERMEASURE ELEMENT C-3: ON-BOARD SPEED WARNING SYSTEM (OSWS)

This device provides a visual and/or an audible warning signal to drivers and passengers when a vehicle's speed exceeds a preset value. Drivers of commercial vehicles or rental vehicles are the primary target group. The OSWS could be placed on all vehicles (most probably at time of manufacture) or on special groups of vehicles (e.g., buses, taxis, privately-owned automobiles, rental automobiles) by the owners.

The OSWS is a device that provides an audible warnings, a visual warning, or both to a driver when his speed exceeds a preset value. Many different versions of the device may be conceived. For example, the warning threshold could be set at 55 mph, and the warning signal could increase (or decrease) in intensity or frequency as the amount of the speed violation increased. One very simple configuration (described by Richard Olson of Pennsylvania State University in a letter to Terry Jackson of NHTSA) would emit a clicking sound when a car exceeded 55 mph, with the clicks becoming more frequent but less loud as the speed increased above 55 mph.

More sophisticated versions tied into the operating speed recorder and displays of the type described earlier in this chapter are also possible. Further, the device could be a part of an integrated warning system that would provide warning signals to other drivers when a vehicle's speed reached a very high level (e.g., 20 mph over the speed limit). Informational countermeasure elements would also enhance the effects of this device.

SUMMARY

Three broad classes of countermeasure elements offer promise for reducing the incidence of speed-too-fast unsafe driving actions. They are:

- Traffic Law System Countermeasures,
- Information Countermeasures, and
- Technological Countermeasures.

Traffic Law System countermeasures attempt to reduce the incidence of speed-too-fast UDAs by generating and enforcing laws prohibiting such behavior, by adjudicating cases against accused violators, and by imposing sanctions against drivers found guilty of a violation. Theory holds that successful accomplishment of all these functions will deter many drivers from committing the UDA.

The two TLS countermeasure elements described in this chapter are aimed at increasing the magnitude of the TLS deterrent threat by increasing the severity of TLS sanctions against speed-law violators (element A-1) and by increasing the overall enforcement of speed-law violations by heavy trucks and buses (element A-2). The first countermeasure is responsive to the need to back up police enforcement activity to create a credible ultimate threat that will achieve a favorable balance in a driver's utility-disutility equation. The second countermeasure addresses the need to achieve leverage in TLS activity. It does so by aiming at a small target group that influences the driving behavior of a much larger group.

Driver decisions about UDAs are influenced by information on the possible outcomes of speed UDAs, and risk-management system response to the speed-UDA problem requires information about the problem and how to deal with it. The two informational countermeasure elements described in this section address both of these fundamental needs. Countermeasure element B-1 informs individual drivers about specific losses that stem from UDAs and specific gains attainable by not committing UDAs. Countermeasure element B-2 advises other drivers in the traffic stream about what actions to take against an observed UDA and provides information about UDA risk and risk responses to TLS agencies.

Modern technology provides another means of gaining leverage in dealing with speed UDAs. Three such technological countermeasures have been identified. The automated detection device and the operating speed recorder (countermeasure elements C-1 and C-2, respectively) perform the usually labor-intensive detection function without the need for police patrol forces and then provide the information to agencies that can apply control forces more economically than can the TLS. Further, the automatic detection device also provides a general deterrence threat without the need for police presence. The on-board speed warning system (countermeasure element C-3) also provides for low-cost detection of UDAs and for the use of punishments (and rewards) by non-TLS agencies.

The word "element" is used deliberately in conjunction with all of these countermeasure concepts. They are intended to be incorporated into existing or new countermeasure programs to interact smoothly with existing components. Three promising such total programs, each incorporating several elements, are described in the next chapter.

CHAPTER FIVE
COUNTERMEASURE PROGRAMS

Examination of the countermeasure elements described in the preceding chapter will reveal that they all rely on one or more of the following mechanisms to achieve their effects:

- detection,
- information, and
- action.

Detection elements determine when a UDA has been committed and identify the offending driver or vehicle. **Information** about the existence of the UDA is then provided to the driver and risk-management systems who take **action** to interrupt the UDA or to prevent its future occurrence. Information about the likelihood and nature of various outcomes of UDAs also is provided to drivers to influence them not to commit a UDA in the first place and to risk management systems to improve their operation. All of these mechanisms attempt to influence the utilities and disutilities a driver associates with a UDA so that a favorable decision will be made, i.e., a decision not to commit the UDA or a decision to adopt behavior patterns that will preclude the opportunity or need to commit the UDA.

A comprehensive countermeasure program against a UDA (in this case speeding) should incorporate elements that use all of these mechanisms. In this chapter we identify three such countermeasure programs that appear to have promise for a broad range of state and local jurisdictions. Factors that could affect the adoption, operation, and impact of each program are discussed. Considerations important to the test and evaluation of the three programs are treated in Chapter Six.

We emphasize that we do not represent the programs we have chosen for discussion in this chapter as "optimal" or "top priority" in any global sense. Selection and tailoring of countermeasure programs will always remain a local problem. The programs presented here are top-level descriptions of what might be implemented in some jurisdictions. Further detailed design, test, and evaluation efforts would be required prior to any such implementation of these programs or variations of them. Also, in presenting these three programs we do not imply that other combinations of countermeasure elements should **not** be considered. On the contrary, some jurisdictions may find these three programs inappropriate to their needs or conditions and may find other programs more desirable. The material presented in this chapter is intended to assist jurisdictions in constructing programs suitable to their unique needs.

PROGRAM 1--INCREASED ENFORCEMENT AND PUNITIVE SANCTIONS

Description

The target group of this program consists of drivers of heavy trucks and busses operating at high-risk speeds on limited access highways. In this case, the term "high risk" is defined as a relative-speed UDA occurring when the vehicle's speed is greater than the 95th percentile speed of traffic or an absolute-speed UDA occurring when the vehicle's speed is more than 10 miles per hour greater than the posted limit. The program combines increased police enforcement (element A-2) with more severe Traffic-Law-System (TLS) sanctions (element A-1). Three different informational elements are included:

- information to the target group on the consequences of speeding (element B-1);
- information to other drivers on where to report speed-law violations (element B-2, mode 1); and
- information to TLS personnel and others on the nature of the need for the program (element B-2, mode 2).

Detection is accomplished primarily by state-level police-enforcement units. Selective enforcement procedures are used in determining where and when to deploy patrol units (see Joscelyn and Jones 1980 for a discussion of recommended enforcement procedures against speed-related UDAs). The units are allocated as a function of the traffic crash risk that occurs at different times and places in a jurisdiction. Risk is measured by the number and severity of crashes caused by the speeding UDA as well as the incidence of the UDA. Mobile sensor systems supplemented by police-officer observations and citizen reports are the main sources of data on risk.

The sensor systems use induction loops or road tubes placed on the highway to provide signals to processing and recording units which compute and store speed distributions and vehicle types. These units are commercially available from several manufacturers (for example, Streeter Amet's TrafiCOMP(TM)) and are being used operationally.

A citizens' reporting system provides information for risk-identification as well as information for detection (discussed later). Messages telling how to report violations are placed on trucks and busses from cooperating organizations and on car bumpers. Public service spot announcements on radio and TV and notices in newspapers also provide information about the program and where to report violations. The main reporting channel is a toll-free telephone number monitored by the state police agency. Reporting motorists are asked to identify the violating vehicle and the nature, time, place, and other circumstances of the violation. This information is then stored in a computer for later processing and analysis. Data from other sources (including the mobile sensor system and accident reports) are also input into the computer.

Radar speed measuring equipment is used by the police to detect the speeding trucks and buses where laws and practices of governmental agencies permit. Stationary radar is used for primary detection in a team configuration involving separate parked patrol cars for detection and apprehension. Aircraft with stopwatches are used for detecting speeding vehicles when there are large areas to cover. The aircraft work as a part of a detection-apprehension team with patrol cars doing the apprehending.

Overt procedures are used primarily in detection operations. Highly visible, conspicuously placed patrol cars are used to advertise the threat. The cars have light bars and are distinctively colored and marked. Covert procedures are also used where statutes permit and may involve the use of unconventional "patrol" vehicles (e.g., heavy trucks). The Maryland State Police Bus and Truck Patrol (BAT) is an example of the effective use of such covert techniques (see Clark 1978).

Apprehended drivers are required to appear in court where they are charged with violating the "high-risk speeding" law. A first conviction results in a fine of $500 by the court. Court costs of $50 are added and are placed in a special fund to support the informational and citizen-reporting element of the program.

Employers of the drivers and involved insurance carriers are notified of the convictions. Citizen reports of alleged violations in which the drivers were not detected and apprehended by police units are provided to employers without comment. Such reports are not used in the court proceedings unless a formal complaint is filed by the citizen reporting the violation. The names of carriers with high rates of violations (both convictions and citizen reports) are provided to the media.

An informational element on the consequences of speeding to the target group and their employers is included in this program. All three types of appeals described under Countermeasure Element B-2 of Chapter Four are used. Appeal 1 emphasizes the impact of a police stop on travel time. Appeal 2 emphasizes the costs savings to the driver and the employer that can be realized through compliant behavior. Appeal 3 stresses the potential cost to drivers and employers of the enforcement and sanctioning activity. Appropriate media are used for the appeals, including those listed in Chapter Four. In addition, informational packets are disseminated to employers, unions, truck stops, etc.

A separate informational element is established to prepare Traffic Law Systems (TLS) staff for the program. Descriptive materials identifying the problem and outlining the material of the program and the rationale behind it are sent to key system actors (e.g., police administrators, prosecutors, judges). Individual police officers are introduced to the program through their ongoing training and education activity. Interdisciplinary, small-group seminars are held to facilitate the interaction of the various organizational elements and stakeholders that will be affected by the program. Participants include management staff from trucking companies, transit authorities, and unions, as well as influential individuals from TLS agencies (e.g., the state police, the state DMV, the state judges association).

Key Feasibility and Effectiveness Issues

Detection Elements. This countermeasure program first requires the establishment of a credible probability of detection of the UDA among the target group. This in turn requires that sufficient numbers of patrol vehicles be assigned to the selective enforcement campaign to create a threat on the selected segments of roadway. Further, this must be done without adversely affecting other enforcement activities.

This problem can be somewhat alleviated by using optimal scheduling techniques for the patrols to achieve the maximum carryover effect of police presence (Brackett and Edwards 1977). This technique, along with informational countermeasure elements, will increase a driver's **perception** of enforcement intensity at a constant level of **actual** intensity and thus reduce the additional number of patrol units required for a given effect.

Thus, resource availability and ultimately cost factors will limit the effectiveness of this countermeasure. In some jurisdictions such considerations also may affect the feasibility of the program. In such cases more "austere" detection systems may have to be employed (e.g., elimination of mobile sensor systems for risk identification).

Actions taken to circumvent detection will be an added problem because of the wide experience and "savvy" of this target group in responding to enforcement countermeasures. Such actions may be expected to include the use of radar detectors and CB radios. More indirect actions such as the use of political and economic pressures by trucking companies, trade associations, and unions, are also possible in some applications.

Informational Elements. Several factors are critical to the success of the information elements of this countermeasure program. Most of these factors affect any informational "campaign." These include designing the specific messages, determining where and when to use them, operating and maintaining the information displays, evaluation, and financing. Important precursor activities are testing and marketing the informational elements.

Problems can also be expected in the area of system integration. Interfacing this element with other elements to obtain a more-or-less systems approach greatly increases the complexity of the total program and requires a strong program management component. Coordination among the various organizations involved in this program is the key factor in building an integrated program.

The citizen reporting element presents unique problems of its own, including:

- having effective mechanisms for "selling" the countermeasure to potential user groups;
- providing suitable materials, methods, and technical assistance to user groups for designing and implementing local programs; and
- developing acceptable ways of handling driver reports to have the greatest positive effect on the driving behavior of reported violators and to avoid excessive negative reactions and "backlash" effects.

This last factor is particularly critical, but is somewhat alleviated in this application by not using the citizen reports for formal legal-system action against the drivers. Nevertheless, the possibility exists that the reporting system could be abused, both by reporters (e.g., as a mechanism for revenge against a particular driver or firm), and by users of the reports (e.g., unjustified or excessively harsh punishments against drivers).

The success of the training and education element hinges on:

- making the training program available to state and local agencies and ensuring that they understand its objectives, methods, and importance;

- having effective materials and "instructors" for the training programs; and
- ensuring that key personnel attend the program.

Development of training packages by NHTSA that could be tailored by state and local agencies to meet their needs could improve the chances of success of this element.

Action Elements. Two categories of actions will be taken against the speed-law violators: formal sanctions applied through TLS agents, and informal rewards and punishments provided by private, nongovernmental organizations. The feasibility and effectiveness of the formally applied sanction will depend on the ability of a jurisdiction to establish a suitable statutory basis for the new sanctioning program and then to persuade adjudicators and sanctioning authorities to participate in the program. Acceptance of the countermeasure by the public and special interest groups will be essential to obtaining the necessary changes to statutes and administrative regulations.

Experience indicates that prosecutors often do not prosecute for traffic offenses that have harsh sanctions and that judges often do not impose such sanctions even when they have the power to do so. These tendencies usually stem from a lack of understanding of the risk created by the accused violator, misconceptions about the effects of the sanctions on the violator, and a tendency to identify with the violator. The training and education element is designed to overcome these tendencies and is therefore critical to the success of the increased-sanctions element.

Past experience with legislative and judicial countermeasures in the area of alcohol and highway safety shows the importance of careful and systematic planning prior to implementation. A set of operating procedures must be developed and fully coordinated with all TLS elements and interfacing organizations. The procedures (and other aspects of the system design) must account for the impact of the countermeasure on all elements of this system, for example, increased caseload and increasing processing time per case. The need for additional personnel or additional capability of existing personnel could be an important factor.

The informal-actions component presents a different set of feasibility and effectiveness issues. Most important among these is gaining cooperation by key organizations, for example, fleet operators and insurance companies. Extensive contact and interaction with these groups will be required. Another issue is the identification of suitable rewards and punishments, that is, rewards that are not too generous and punishments that are not too harsh. Clearly some experimentation will be required to determine optimal informal actions, and this factor should be built into the program.

PROGRAM 2--AUTOMATIC DETECTION DEVICES WITH CIVIL-LAW SANCTIONS

Description

This countermeasure program uses an automatic detection device to detect speeders (greater than 5 mph over the limit) on expressways that operate through and around a large city (countermeasure element C-1). This program incorporates an ongoing public information component (element B-1) that describes the program and the consequences of speeding.

The automated detection devices scans license plates of speeders and records information on the plates along with the speed, time, and location of the violation. Data on traffic flow (e.g., mean speed, speed standard deviation, rate of flow) at the time of the violation also are recorded. The instruments are placed within stanchions, some of which are "decoys" and contain no instruments. An optimal ratio of decoy units to live units is maintained. The instruments are assigned to stanchions on a random basis and are changed at random times so that a maximum overall detection threat is maintained.

The automated detection devices units are monitored by individuals who are not sworn police officers and who do not require extensive training. The retrieved records are used as a basis for civil law action against the vehicle owners. The registered owner of a vehicle found to have violated a posted limit would be penalized $100 after being identified through a central record system (see Ruschmann, Greyson, and Joscelyn 1979). The penalty would have to be paid before the vehicle owner could re-register the vehicle or have the title transferred. If the civil penalty were not paid, a civil process would be used to seize and sell the vehicle.

The accompanying police information campaign would prepare the public for the new detection-action systems and would help maintain an acceptable level of awareness during steady-state operation. All three types of appeals described in Chapter Four would be used, but Appeal 3 (that the potential cost of speeding is very high) would be stressed. Roadway signs would warn motorists of the presence of the ADDs (a large fraction of which are decoys) and the penalties for law violation. Running tabulations of the outcomes of the civil actions would be presented in the mass media with impoundment actions emphasized in the media.

Key Feasibility and Effectiveness Issues

Detection Elements. The effectiveness and efficiency of this countermesure is dependent upon a number of operational factors. First, the devices must be **installed** at locations where speed violations are a problem and in sufficient numbers to provide a deterrent effect over a significant total length of highway. This could require a large number of installations in jurisdictions with many miles of applicable roadway. This requirement is reduced in this application by having dummy installations at most locations and shifting the detection units among locations. Nevertheless, the initial investment in equipment can be high.

Maintenance and replacement can be another significant category of operating costs unless system reliability and maintainability are high. A careful analysis of system failure and repair rates and associated costs is needed as an input to determining the system's feasibility in specific operating environments. Operating experience thus far indicates a relatively high level of system availability (Glauz and Blackburn 1980).

Maintaining speed measuring accuracy is another factor related to the reliability/maintainability problem.

Data collection from the devices could be time consuming in applications with a large number of installations. Replenishment and routine checkout and calibration would occur during stops to gather data packages. Processing the paperwork flowing from these data could also require considerable resources.

Actions by external agents could neutralize the devices in some applications. Such actions range from vandalism to tampering with sensors and cameras (e.g., covering lenses or making them opaque) to possible jamming equipment installations in vehicles to prevent accurate operation of sensors and cameras. CB transmissions could alert drivers to sections of the highway with nonfunctioning units. Again, limited operating experience has not found this problem to be significant.

A range of **human, public, and political** factors will be critical to the success of this countermeasure. These include the willingness of the public to accept what could be perceived as a big-brother-like monitoring of their behavior, the willingness and ability of public and private agencies to use the information to gain compliance with speed laws, and most important, the effectiveness of the information in gaining compliance. Also, user groups will have to be alert to possible adverse side-effects growing out of some uses of the information provided by the system, for example, "contests" between members of some high-risk groups to see who is mentioned most often in the news media as a violator.

Several legal factors are relevant to the feasibility of using automated detection devices. These include:

1. establishing the scientific reliability and proper working order of the device;

2. statutory prohibitions, as "speed traps," of time-distance measurements;

3. self-incrimination problems involved in compelling a vehicle owner to appear in court, testify, and possibly identify oneself as the offending driver; and

4. due-process problems involved in sanctioning a vehicle owner for violations committed by other persons using the vehicle.

A detailed discussion of these constraints appears in: Ruschmann, P.A.; Greyson, M.; and Joscelyn, K.B. 1979. An analysis of potential legal constraints on the use of speed measuring devices. Publication by the National Highway Traffic Safety Administration report no DOT-HS-805-524.

The discussion indicates that, with respect to scientific validity, radar principles have received "judicial notice" or scientific acceptance by almost every court, and automatic time-distance measuring devices (e.g., those using tubes or wires placed in the road) also have received judicial notice. However, it remains necessary to prove in court that any device was in proper working order and was correctly operated by a competent person. Regarding speed-trap legislation, only a few states will prohibit time-distance measurements, but in those states the only means of resolving this constraint is statutory change. In the application suggested here, the self-incrimination and due-process constraints might be resolved in some states because the subject speeding offenses are "decriminalized" and are punishable by a monetary penalty only.

There is evidence that radar-type speed sensors in themselves provide a deterrent threat simply by emitting electromagnetic radiation that can be monitored by radar detectors in vehicles. This can be viewed as a bonus effect of the automatic detection device countermeasure that could be used independently or in support of the device.

Informational Elements. The informational components of this program are relatively straightforward and should not cause difficult operational problems. Their most critical aspect is continuing maintenance of the informational activity. This in turn requires funds to support a permanent informational function that could be incorporated into public-information organizations in police departments. Many large police departments already have such organizations in place and could readily support an increased level of activity if given additional resources.

The funds to support such an organization could be provided by the revenues generated by the penalties paid by the speed-law violators. It is common practice in many jurisdictions to set speed limits at the 85th percentile speed of traffic which means that about 15% of all traffic exceeds the limit. Limits set lower to reduce some other societal risk (e.g., excessive consumption of energy) create still more speed-law violators. We estimated that at least eight billion speed-too-fast UDAs occur every year (Joscelyn and Jones 1980). This amounts to about 50 per licensed driver. A city of 1,000,000 population would be expected to have at least 500,000 licensed drivers committing about 25 million speed-too-fast UDAs per year. If only 10% of these UDAs were interdicted by the system and resulted in $50 penalties, $125 million would become available each year to support the information activity as well as other program elements. Reducing this number by a significant amount to allow for the smaller fraction of speed UDAs that are committed in urban areas would still leave a large amount of funds for the program.

Action Elements. Getting legislation to support the civil-law action would be the first critical task to be accomplished in implementing this program. Some states already have statutes "decriminalizing" minor traffic offenses. Such states might be more receptive to this program and would be logical locations to consider adopting it. In any case, considerable planning and advance work would be needed to establish the statutory basis for the program through a state legislature. Enabling legislation to support the expanded record system needed for the program also might be required.

A system for notifying violators and collecting fines would have to be established also. This, too, would require funding support, which could be provided from the penalties collected from violators.

PROGRAM 3--ON-BOARD DETECTION AND WARNING OF SPEED-RELATED UDAs

Description

This program is technology-based with support by informational elements. Its target group is commercial vehicles operating in a variety of highway environments. Any level of risk appropriate to local, state, or federal requirements (including the 55 mph national maximum speed limit) may be defined. Program elements are:

- an Operating Speed Recorder (OSR) in commercial vehicles, including heavy trucks, fleets of all kinds, taxis, and buses (element C-2);
- an On-board Speed Warning System (OSWS) in passenger carriers (element C-3);
- information to the target groups on the consequences of speeding (element B-1);
- information to passengers on where and how to report speed violators of vehicles in which they are riding (element B-2, mode 1); and
- information to organizations that operate the target vehicles on the nature of and need for the program (element B-2, mode 2).

Detection is accomplished by the OSRs. Speed histories are read by employer staff after each shift. Violators are defined in terms of vehicle miles traveled in excess of the speed limit. Special notice is taken of high-risk violations. Drivers with good speed records over an extended time period (e.g., a year) are eligible for special awards and recognition. Drivers with especially poor records are punished by company-imposed monetary penalties or by dismissal. Drivers are notified periodically about their performance. The names of exemplary drivers are posted in conspicuous places.

Detection is further enhanced in passenger vehicles through the use of OSWSs that provide a visual signal (e.g., a red light) to passengers when the speed limit is exceded. At ten mph over the limit an audible signal is given. The signal increases in intensity and pitch as the speed increases further.

The informational element on the consequences of speeding is split into two components, one directed at the driver and one directed at the employer. The driver-directed component stresses appeal number 3 of element B-1, that the potential cost of noncompliant behavior is very high. The emphasis is on costs that will be imposed by employers for speeding. This is further supported by information on the rewards that can be gained by not speeding. The nature of the OSR and precision and reliability are also communicated to drivers. The communications media are those appropriate to the employer organization, i.e., word of mouth through supervisors, flyers included in pay envelopes, bulletin board notices, posters, stickers on company vehicles, etc.

The employer-directed component emphasizes appeal number 2 (that compliant behavior reduces the cost of operating a motor vehicle) as well as appeal number 3. Economic costs to the employer are the main target, and the components of those costs applicable to various broad classes of employers are identified. Humanitarian and energy conservation aspects are also stressed, especially in appeals to vehicles operated by governmental agencies. These elements are combined to make a strong case for an employer's adopting the program. The cost of the OSRs themselves and other programmatic costs to the employer are shown to be small in comparison to the economic costs due to high-speed driving by employers. Communication of this information and descriptive information about the program is accomplished through personal contact and through mailout of flyers and brochures to key executives in the target organizations.

Key Feasibility and Effectiveness Issues

Detection Elements. Hardware factors are critical in this countermeasure, and include many of the same factors that were noted in the discussion of automatic detection devices (countermeasure program 2). Installation of the OSR could occur either during assembly of the vehicle, later on by authorized agents of the vehicle manufacturer or OSR manufacturers, or by the purchaser of the device. In this application, the units are installed on vehicles that are already in the employer's fleet. Reliability and maintainability for this type equipment would likely be high, although periodic checkout and, possibly calibration, might be necessary. If the device were kept simple without elaborate displays, the cost could be in the range of $50 per unit.

Actions to defeat the OSR would be a potential problem, but an electronic device would appear to be inherently more secure than the mechanical versions used in the past. Careful design and operational procedures should reduce this problem to an insignificant level.

Some opposition to the concept could be expected from certain special driver organizations and other user interest groups. For example, unions might object to the device as unwarranted management prying and refuse to cooperate unless it could be shown that use of the device were fair to their members.

We note that the OSR can be used to determine speed law violations only when the speed limit on a roadway is known during the time that the target vehicle is traveling that roadway. Thus, the device would best be used when the speed limit over the route to be traveled were a known constant value, or when one were concerned with some global maximum speed limit (e.g., the 55 mph national maximum speed limit) rather than local maxima.

The OSWS has its own unique set of problems as well as problems that are shared with the OSR. Experience with the safety belt interlock and warning system shows that unpopular devices of this type are likely to be disconnected or removed when they become too annoying. We would expect this to be more of a problem with the OSWS than with the OSR, which must maintain a continuous record of operation that is checked by employer personnel. Coupling the OSWS to the OSR so that the latter could not work if the former did not, conceivably could discourage actions to defeat the OSWS. Other means for maintaining the integrity of the device would have to be studied.

Malfunctions that result in the warning being given at speeds below 55 mph could seriously threaten the feasibility of the OSWS. A high level of reliability would be needed to reduce the frequency of such malfunctions. Cost (both initial and repair) and maintainability are also important factors.

Legal factors are important to the operation of the OSWS (e.g., civil liability of manufacturers for damage caused by malfunctioning OSWSs), but do not appear to offer any really serious obstacle to implementation. Requiring drivers to use the device as a condition for reducing a Traffic Law System sanction (not used in this application) could raise more serious legal constraints, but with care, these too probably could be overcome. Legislation requiring the installation of OSWSs on **all** vehicles would appear not to be feasible unless the device could be switched off by the driver.

Informational Elements. Two informational factors are critical to the success of this program. First, employers must be persuaded to adopt the program in their own and society's best interests. This means that strong economic and other rationale must be developed and disseminated to employers. For example, if the employer's average cost per traffic crash were $5,000 and the crash risk per vehicle per year were 0.1, then the expected cost of traffic crashes would be $500 per vehicle per year for that employer. If 20% of these crashes were caused by excessive speed, then the program would save a maximum of $100 per vehicle per year. This could significantly outweigh the cost of the program and could result in large savings over several years for companies with large numbers of vehicles. The challenge to the informational component of the program is to convey such messages effectively without excessive cost to the advocate agency.

The second factor is critical to the successful operation of the OSWS element. Here, the passengers must be persuaded to report instances of speed violations as indicated by the warning device. They must be made to understand (1) the risk asociated with such violations, (2) what the warning signal means and how and where to report violations, (3) that some useful action will be taken as a result of their reports, and (4) that they will incur minimal inconvenience and suffer no other costs after reporting a violation.

Action Elements. The critical issue here is determining how much of what kinds of rewards and punishments should be imposed under what conditions. We have suggested fines and, ultimately, dismissal for chronic speeders, but operational definitions remain to be developed. Punishment would have to be compatible with existing disciplinary practices and would have to be specific and fair, both in substance and procedure. Coordination with unions would be necessary.

Rewards would have to be sufficient to affect behavior. A few large rewards (e.g., a paid vacation, a new car) for drivers with really outstanding records would appear better than many small rewards. Periodic written and spoken recognition of drivers with good records also would help reinforce the desired behavior.

SUMMARY

Three countermeasure programs incorporating the various countermeasure elements of Chapter Four were synthesized. The programs provide examples of how elements may be fitted together to form comprehensive programs that provide the fundamental functions of detection, information, and action. While none of the programs is represented as "optimal," they do appear promising for many jurisdictions and could provide a point of departure for developing programs tailored for specific applications. Considerable detailed design work would be necessary before any of them could be implemented.

Program 1, increased enforcement and punitive sanctions, is aimed at a high-risk target group composed of heavy trucks and busses operating on limited-access highways. Detection is accomplished by state-level police-enforcement units using the best available procedures. This detection capability is enhanced by a citizen reporting network that helps police find high-risk locations and that provides information that can be used as a basis for action by employers of the violators. Violators apprehended by the police are required to appear in court and, if found guilty, receive an automatic driver-license suspension and a heavy fine. Information is provided to employers and violators on the consequences of committing this UDA, and key Traffic Law System actors and others are provided information on the need for and importance of the program.

Program 2, Automatic Detection Devices, is an alternative to existing labor-intensive police detection of speeders. The detection devices are placed on busy expressways in and around a large city and identify automatically the violating vehicle rather than the violating driver. Vehicle owners are found by matching license plate numbers with vehicle registrations and are subjected to civil-law action consisting of a monetary penalty. A public information campaign prepares the public for the new program and continues to function throughout the operation of the program.

Program 3, on-board detection and warning of speed-related UDAs, uses operating speed recorders (OSR) in commercial vehicles to provide information to employers about the speed-violation history of drivers of company-operated vehicles. Commercial passenger vehicles (i.e., buses and taxis) have on-board speed warning systems (OSWS) that provide visual and audible signals to alert passengers to speed violations. Information is provided to passengers to encourage them to report such violations to a centrol telephone number. Actions against drivers identified as speeders by the OSR and the OSWS are taken by the drivers' employers. Drivers with consistently good records are rewarded by their employers. Drivers with poor records are punished. Information on the consequences of speeding is provided to drivers and their employers.

Several factors will influence the effectiveness and, in some cases, even the feasibility of these programs. For example, hardware factors are critical to the success of Programs 2 and 3, which rely on automatic detection devices, operating speed recorders, and on-board warning systems to detect speed-law violators. The citizen reporting schemes must have the support of those who would do the reporting and must contain safeguards against abuse. Legal factors, including the necessity for new legislation, are critical in many areas. Cost factors are crucial in all of the programs as are the acceptibility of programs to the public and to existing risk-management systems. All of the programs will require further detailed design and testing prior to widespread implementation. The next chapter discusses some major requirements for testing the feasibility and effectiveness of the programs.

CHAPTER SIX
TEST AND EVALUATION REQUIREMENTS

The value or effectiveness of the countermeasure elements and programs described in the two preceding chapters will depend on their ability to reduce the incidence of speeding and speeding-related traffic crashes among their target groups. Their feasibility for use in an operational setting will depend on their ability to meet the constraints imposed by the environment in which they will operate. Such constraints include resource availability (including funds), legal factors, and the acceptability of the countermeasures to the public, special interest groups, and risk-management agencies.

Our preliminary analysis indicates that the countermeasures identified here appear promising, both in achieving acceptable levels of effectiveness and in meeting operational constraints. Further assessment ultimately will require that they be implemented and operated under conditions of actual use. Laboratory experiments and simulations are not feasible for such assessments because of the complexity of the interactions of involved societal and technological factors.

This chapter discusses some of the more important general requirements for field testing and evaluations, countermeasure programs of the type outlined in this volume. Detailed test and evaluation requirements cannot be specified until detailed designs of countermeasure programs for specific applications have been developed. However, especially important requirements relevant to the three countermeasure programs of Chapter Five are indicated where appropriate to provide examples of the kind of detail needed in planning specific evaluation efforts (henceforth we use the term "evaluation" to encompass all field-test and evaluation activities).

Three general categories of evaluation requirements are discussed in this chapter:

- measures of effectiveness,
- evaluation design, and
- efficiency considerations.

The discussion of **measures of effectiveness** identifies variables that should be used to measure effects of the countermeasure program in achieving program objectives. The discussion of **evaluation designs** deals with methods for determining the extent to which the countermeasure program rather than other factors was responsible for observed results. **Efficiency considerations** are concerned with ways of relating countermeasure results to the resources expended to obtain those results.

MEASURES OF EFFECTIVENESS

The first step in designing an evaluation effort is to define explicitly the objectives of the countermeasure program. Both ultimate highway safety objectives and intermediate or functional objectives must be identified. Highway safety objectives are stated in terms of risk reduction sought among the target group. The degree to which these objectives are met is called the **impact** of the countermeasure program. Intermediate objectives are stated in terms of program output or activity. The ability of a program to achieve its intermediate objectives is often referred to as its **performance.**

Top-level impact measures for Program 1 (Increased Enforcement and Punitive Sanctions) should include:

- number of crashes of various types caused by high-risk speeding by the target group of drivers (i.e., truck drivers and bus drivers) on the target highways, and
- cost of such crashes.

Impact measures for Programs 2, Automatic Detection Devices with Civil-Law Sanctions, and Program 3, On-Board Detection and Warning of Speed-Related UDAs, should be stated similarly but in terms of the specific high-speed driving behavior, the specific target groups, and the specific locations and circumstances where countermeasure effect is desired.

The issue of causation should be addressed to the extent permitted by available resources in the test jurisdictions. The simultaneous use of clinical and statistical methods will give the most reliable estimates. (See Volume III of this report, Jones, Treat, and Joscelyn (1980) for a discussion of methods for assessing causation.) Jurisdictions with accident investigation teams operated under NHTSA's National Accident Severity Study (NASS) may be able to provide support in causation assessment.

When such resources are not available, less sophisticated assessments and even alternative or "proxy" measures may have to suffice. For example, most police accident reports include judgments about the causal factors in a traffic crash. These judgments plus associated data from the reports may be further analyzed by the evaluation team to provide better assessments of causation. Such judgments may be supported by data on involvement of the target behaviors and target drivers in traffic crashes and by data on the incidence of these behaviors among target drivers in the traffic stream. The latter data may be obtained through the use of speed measuring devices and will be provided automatically in Program 2.

Performance measures must be attached to each operational function of the program. In Chapter Five we identified three generic top-level functions: detection, information, and action. Detection performance for all countermeasure programs against the speeding UDA is measured at the highest level by the number of UDAs detected per UDA committed. However, because detection methods tend to differ among countermeasure programs, performance measures for lower-level detection functions also will differ. Thus, a lower-level performance measures for Program 1 will be the number of enforcement units operating at given times and places, while the number of operable automatic detection devices will be a lower-level performance measure for the detection function of Program 2.

The top-level performance measures for the action function also will tend to be invariant among countermeasure programs. In all three programs, the measure will be the number of actions taken per UDA detected. The measures will begin to differ at the next lower level of detail, for example, when considering what **kinds** of actions. Thus, for

Program 1, a measure of performance for action would be average penalty paid per violation charged, while for Program 3, measures would be number of problem-driver dismissals per problem-driver identified and number of rewards given per exemplary driver identified.

The performance of the information function will vary among programs and even among program elements, depending on what is being attempted. For elements that are attempting knowledge transfer, the change in knowledge is the obvious measure, while change in attitudes is the measure for attitude-change elements. Changes in particular behaviors will be appropriate for some educational elements, for example, for the seminars of Program 2, where the objective may be to have participants fulfill certain commitments made at the seminars.

EVALUATION DESIGN

The second step of evaluation design is to select an experimental method for the evaluation. The objective is to specify the best way of determining the extent to which the countermeasure program, rather than some other factor, is responsible for observed changes in performance and impact. An **experimental design** leaves the least doubt about cause-and-effect relationship, but is the most difficult to implement in evaluating societal programs. In effect, it amounts to operating two risk-management systems at the same time. One system includes the program being studied while the other system remains unchanged. The two systems are then allowed to operate long enough for sufficient performance, and impact data can be collected for calculating an acceptably precise estimate of the probability that the observed changes in results were due to the new programs.

We recommend that an approximation to the experimental design be adopted for evaluating the countermeasure programs that are of concern here. The particular form of this approximation or **quasi-experimental design** most appropriate to these programs is the time-series design with one or more comparison jurisdictions or comparison sites. For Program 1, a statewide effort, the comparison area should be one or more other states matched as closely as possible with the test state with respect to target-group involvement in the UDA-caused crashes and with respect to important environmental factors, for example, enforcement practices, traffic laws, highway types, court system, etc. For Program 2, a local effort, the comparison jurisdiction should be another city similarly matched with the test city. Program 3 would best be designed as a statewide or regional effort with corresponding comparison areas.

Of course, laboratory and field testing of the hardware used in Program 2 and 3 should precede any field evaluation of the total program. In addition, Program 3 probably would require some preliminary feasibility testing because of uncertainties about the degree to which key groups (e.g., trucking companies, unions) would participate in the program. An alternate approach to testing Program 3 would be to compare the impact and performance between two similar groups of trucking and/or bus companies, one group adopting the program and one group not adopting the program.

Regardless of the details of the evaluation design, impact and performance data must be collected over a large enough period of time to allow program activities to reach and maintain a steady-state condition. The requirement for a large enough sample size to enable relatively small changes in effectiveness measures to be detected will also have a strong effect on the length of the data collection. Experience indicates that at least two years should be allocated to the operational or "treatment" phase of the program. This should be preceded by a pretest period of about one year duration and followed by posttest period also lasting one year.

An interrupted time-series model is recommended for analyzing the test data (see, for example, Box and Jenkins 1970). Program effects are seen as changes in the effectiveness measures over time and are related to various parameters thought to be associated to these changes (for example, number of arrests in Program 1). A similar time series is constructed for the comparison area(s), and the statistical significance of the differences between the values of the measures for the test and comparison areas are calculated.

Informational countermeasure elements are critical to any general risk-management strategy for the subject UDA and have explicitly been included in the three example programs described in the preceding chapter. Thus, the program evaluation effort should monitor the values of intermediate informational variables thought to be related to the desired highway-safety effects. These variables will, in general, be of two types, those that measure knowledge, and those that measure attitudes. Examples of the former include knowledge about the consequences of speeding, including the economic cost of high-speed travel (all three programs), and knowledge about where and how to report observed speed-law violations (Programs 1 and 3). Attitudinal variables include those that measure risk perception (all three programs) and the importance of the actions being taken to reduce risk (for example, stronger sanctions).

These factors should be measured through surveys also conducted before, during, and after the program. Questionnaires should be administered to populations from the comparison areas as well as the test areas and analyzed to identify any significant differences that may exist between the two with respect to relevant knowledge and attitudes.

EFFICIENCY CONSIDERATIONS

The test and evaluation effort should provide information on the efficiency as well as the effectiveness of the countermeasure program. Efficiency is defined as impact or performance per unit of resources expended to obtain the impact or performance. Thus, each effectiveness measure will, in general, have one or more counterpart efficiency measures.

To compute efficiency measures, one needs to know the resources that are expended for the program as a function of time. The best way to keep track of resources is to develop and maintain an up-to-date functional description of those elements the UDA risk-management system that are affected by the countermeasure program. This involves breaking down the program into a hierarchy of components or functional elements. Each functional element is then described with respect to:

1. how it is performed (e.g., what enforcement procedures are used in detecting speed-law violators in Program 1);

2. what it needs to accomplish its objectives (e.g., number of patrol units); and

3. what it produces as a result of its operation (e.g., number of citations issued).

Item 3 encompasses the **output** of the functional element. Output is described by the performance measures as discussed earlier in this chapter. Item 1 is a description of the **methods or procedures** that are followed in each functional element. Item 2 provides the **functional resource requirements** of the program which are used in developing measures of resource expenditures. These measures become the denominator of the efficiency measures.

Three categories of resource requirements should be tracked during the test and evaluation program:

- personnel,
- equipment, and
- facilities.

Personnel requirements are expressed in terms of how many people with what training, experience, and skills. **Equipment** requirements are stated in terms of types and amounts of such items as patrol cars and speed-measuring devices. Requirements for **facilities** are expressed in terms of types and amounts of such things as office space, courtrooms, equipment repair shops, etc. The funds needed to pay for personnel, equipment, and facilities are also an important measure of resource requuirements and form the basis of one of the most commonly used efficiency measures, cost-effectiveness.

Data or resource requirements should be collected before, during, and after the countermeasure program. Both the test area and the comparison area(s) should provide such data, but the data from the latter will be less extensive than the data from the former. Comparison-area data should be limited to those that describe levels of activities in functional areas that would be expected to have an effect on impact and performance, for example, number of patrol units used in surveillance and detection of speeders.

SUMMARY

Three types of top-level requirements for testing and evaluating countermeasure programs of the type described in Chapter Five were identified. The first type of requirements are those related to ways of measuring the ability of the program to accomplish highway-safety and intermediate objectives.

Measures of highway safety effect (i.e., **impact measures**) should be stated in terms of crash risk reduction among an identified target group(s). Risk should be defined as specifically as possible, including the speed threshold defining the UDA, and the environmental and situational variables accompanying the UDA. Indirect or proxy measures of program impact should also be used to provide additional information on the value of the program. A simple count of the number of UDAs, UDA-hours, or UDA-miles is the most important of the indirect measures.

Measures of the program's effect on intermediate objectives (i.e., **performance measures**) are needed for each of the functional elements that make up the program. Top-level measures of performance are stated in terms of detection, informational, and action objectives. Lower-level measures of performance are dependent upon how the many detection, information transfer, and action functions are accomplished.

The second major category of top-level requirements for evaluating countermeasure programs deals with the design of the test and evaluation activity. The purpose of the evaluation design is to select and describe a test procedure that will maximize the likelihood of determining the extent to which the countermeasure program rather than other factors were responsible for observed changes in impact and performance variables. A quasi-experimental, time-series design is recommended. In this design, the time varying impact and performance in a test area that operates the program is compared to that in a similar area that does not operate the program. Statistical tests are performed on the data to determine the significance of any differences in impact or performance between the test area and the comparison area. Past experience with highway-safety countermeasure programs of the type considered in this volume indicates that the evaluation should be conducted over a period of at least four years, including a two-year operational period and two one-year periods to monitor effectiveness and activity before and after the operational period. Longer operational periods are desirable.

The last category of test and evaluation requirements is concerned with the efficiency of the countermeasure program. Program efficiency is defined as impact or performance per unit of resources expended to obtain the impact or performance. We recommend the development of a comprehensive **system description** to provide up-to-date information about resource expenditures. The system description is also a valuable tool for monitoring the procedures used in the program to help ensure that planned procedures are actually being followed.

CHAPTER SEVEN
CONCLUSIONS AND RECOMMENDATIONS

Three unsafe driving actions (UDAs) were examined in this study to develop operational definitions of the UDAs and to identify the traffic crash risk they present. The UDAs were:

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

It was found that only the speeding UDA should be given high priority by risk management agencies. Violations of statutes relating to the other two UDAs should be enforced when observed, but the UDAs should not become the target of large-scale countermeasure programs. Accordingly, subsequent efforts in the project to identify countermeasure concepts were directed at the speeding UDA.

Seven countermeasure elements have been identified as having promise for reducing the incidence of speeding UDAs (see Table 7-1). The countermeasures include Traffic Law System, informational, and technological approaches, and employ all of the four basic strategies for influencing driver behavior described in Chapter Two. Target groups range from the very broad to the very specific, and include drivers who exceed the 55 mph national maximum speed limit and drivers who exceed other absolute and relative speed limits. User groups include various agencies of the Traffic Law System, other governmental agencies, private sector organizations (e.g., businesses, unions), other special groups (e.g., fraternal groups, automobile clubs), and private citizens.

Our initial assessment indicates that these concepts appear feasible, but will need additional study prior to implementation. All of the concepts have elements that could make them unacceptable to the general public, to special sectors of the public, or to potential user groups. Many of the

TABLE 7-1

SUMMARY OF COUNTERMEASURE ELEMENTS

	COUNTERMEASURE ELEMENTS	STRATEGIES	PRIMARY TARGET GROUPS	PRIMARY USER GROUPS	KEY FEASIBILITY ISSUES
A-1:	Increase the severity of sanctions against convicted violators of speed laws.	III	High-risk drivers	TLS sanctioning components	• Statutory basis • Public acceptability • TLS acceptability
A-2:	Increase police enforcement of speed-law violations by selected target groups	III	Drivers of trucks and buses exceeding 55 mph NMSL and other speed limits	Police agencies at the state level	• Resource availability • Efficient procedures • Actions to defeat • Public acceptability
B-1:	Provide information to drivers on the consequence of speed-related UDAs	I, II, III	Drivers of vehicles exceeding 55 mph NMSL	Highway safety agencies, police agencies, private sector agencies	• Message design • Media selection • Message maintenance • Coordination • Public acceptability
B-2:	Provide information to others to influence drivers' decisions about committing speed-related UDAs	I, II, III, IV	• Moderate to high-risk drivers • Drivers of vehicles exceeding 55 mph NMSL	Highway safety agencies, police agencies, private sector agencies	• Acceptability to user groups • Suitable materials • Public acceptability
C-1:	Automated Detection Device	I, II, III, IV	Drivers of vehicles exceeding 55 mph NMSL	Law enforcement agencies	• Hardware design and cost • Actions to defeat • Public acceptability • Legal factors
C-2:	Operating Speed Recorder	II, III	Drivers of vehicles not owned by the driver (55 mph NMSL)	• Private and public sector • Parents of dependent children drivers	• Hardware design and cost • Actions to defeat • Public acceptability
C-3:	On-board Speed Warning System	II, III	Drivers of vehicles exceeding 55 mph NMSL and other speed limits	Private and public sector	• Hardware design and cost • Actions to defeat • Public acceptability • Effects on driving behavior

concepts are potentially vulnerable to actions to defeat them, and the feasibility of the technological countermeasures (C-1, C-2, and C-3) hinges on the availability of reliable, maintainable, accurate, and economical hardware. Legal factors are important to the feasibility of some of the countermeasures (e.g., A-1 and C-1).

To be effective and efficient, these countermeasure elements should be carefully integrated into the ongoing activity of existing risk-management systems. A comprehensive program of countermeasures should contain elements that perform the primary detection, informational, and action functions of such systems. Three possible such programs were identified in this report:

> **Program 1:** Increased enforcement and punitive sanctions against drivers of heavy trucks and buses operating at high-risk speeds on limited-access highways.
>
> **Program 2:** Automatic detection devices with civil-law sanctions against moderate-to-high-risk speeders on expressways and around large cities.
>
> **Program 3:** On-board detection and warning of speed-related UDAs committed by commercial vehicles.

These programs are illustrative of the ways in which countermeasure elements can be combined into promising programs of wide applicability. Variations of these programs or completely new programs using other countermeasure elements could be generated to meet the unique needs and conditions of specific jurisdictions.

We recommend that NHTSA perform a design study of the above three programs. The objective of the study would be to develop detailed program designs for application in specific jurisdictions. Key feasibility issues (e.g., hardware cost and reliability, statutory requirements) would be addressed, and operational requirements (e.g., procedures, personnel, equipment, facilities, cost) would be set forth.

The study would be performed in two phases for each program. Phase I would develop a preliminary design and determine the general requirements and overall feasibility of the program. Several jurisdictions would be considered as candidate sites for the program. One of these jurisdictions would be selected for the development of the detailed design for the program. This would occur in Phase II.

The results of the design study would be used to determine whether the programs should be implemented and evaluated. A decision to proceed would lead to a test-and-evaluation phase. We recommend the use of a quasi-experimental, time-series design with comparison areas for evaluating the programs. The design study would provide the system descriptions needed as a baseline for the evaluation.

The amount of time required for the design study would depend on the outcome of Phase I of the study. For example, it might be determined that additional time were needed for hardware development or refinement, or that new legislation were required. Time for meeting these needs would have to be allowed for in Phase II or an intermediate phase.

We emphasize that all of the countermeasure concepts recommended here are directed at driving acts or omissions that are conscious and intentional. The UDAs are the result of decisions made almost entirely through a nondeliberate, informal process. Understanding this process is essential to developing effective countermeasures against speed-related and other UDAs. Yet, very little research has been directed toward developing an understanding of human decision-making processes vis-a-vis traffic crash risk. A recent NHTSA contract entitled, "Identification of Motivations for Unsafe Driving Actions and Potential Countermeasures" is a step toward this end, but much more is needed. We recommend that NHTSA develop a research program area dealing explicitly with this topic. Such a program should be carefully coordinated with other federally sponsored research in this area, for example, programs at the Department of Defense and the National Science Foundation.

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