DOT HS-801 346

URBAN PEDESTRIAN ACCIDENT COUNTERMEASURES EXPERIMENTAL EVALUATION

Volume I - Behavioral Evaluation Studies

Contract No. DOT-HS-190-2-480
February 1975
Final Report

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
FEDERAL HIGHWAY ADMINISTRATION
WASHINGTON, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS-801 346		

4. Title and Subtitle	5. Report Date
Urban Pedestrian Accident Countermeasures Experimental Evaluation Vol. 1. Behavioral Evaluation Studies	February 1975
	6. Performing Organization Code
7. Author(s) Wallace G. Berger	8. Performing Organization Report No.
9. Performing Organization Name and Address BioTechnology, Inc. 3027 Rosemary Lane Falls Church, Virginia 22042	10. Work Unit No.
	11. Contract or Grant No. DOT-HS-190-2-480
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration and Federal Highway Administration U.S. Department of Transportation Washington, D.C. 20590	13. Type of Report and Period Covered June, 1972 to Jan., 1974 Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A series of site and accident specific pedestrian safety countermeasures had been developed in a previous study, but the effectiveness of these countermeasures had not been empirically evaluated. This project focused on the determination of the effectiveness of nine safety countermeasures. A series of behavioral studies was conducted to determine the extent to which the proposed countermeasures inhibit undesirable vehicular and pedestrian behaviors. These studies, conducted in eight cities, evaluated the behavioral effects associated with the installation of a countermeasure by means of pairing each experimental site with a control site in a pre-post design. Data collection methods included mechanical recording of vehicle speed and headway, and time-lapse photography, and manual coding of pedestrian and vehicle behavior. During the 204 days of data collection, the crossing behavior of over 16,000 pedestrians were characterized. The accident reduction potential of the various countermeasures was assessed. Additionally, the design and implementation problems associated with the countermeasures were also discussed.

17. Key Words	18. Distribution Statement
Pedestrian Safety Pedestrian Countermeasures Pedestrian Behavior	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	122	

Form DOT F 1700.7 (8-69)

ACKNOWLEDGEMENTS

Any large scale data collection effort depends on the coordinated efforts of a number of people. This particular study, dealing as it did with traffic engineering changes in an operational context, was indebted to a variety of Government employees, city officials, and city residents.

BioTechnology would like to express its special appreciation to the participating cities. In addition to installing experimental countermeasures, each city provided considerable assistance in the site and countermeasure selection process, and in the data collection effort. The cities and the cognizant city officials were:

Washington, D.C.
John E. Hartley
H. A. Mike Flanakin

New York City
John M. Kaiser
James Mazzaferro

Miami, Florida
Eugene L. Simm
Alvin A. Acton

San Diego, California
Donald O. Robbins
Bruce F. Herms

San Jose, California
Edwin B. Louis

Akron, Ohio
David G. Fielder

Columbus, Ohio
James V. Musick
Joseph A. Ridgeway

Toledo, Ohio
C. E. Riser
Michael J. White

We would also like to acknowledge the assistance and support provided by the Department of Transportation and its personnel:

National Highway Traffic Safety Administration
Monroe B. Snyder
Alfred J. Farina, Jr.

Federal Highway Administration

Julie A. Fee
Walter S. Adams
F. J. Daniels, III

A number of BioTechnology personnel made significant contributions to the project. These individuals maintained a high quality of performance under the grueling schedule and adverse weather conditions encountered during data collection:

Gerald R. Vallette
Margaret J. Forsythe
Thomas P. Brown
John V. Warren
Christopher Nerone

We would also like to thank Gerald R. Vallette and Margaret J. Forsythe who performed the near impossible task of reducing the mountain of raw data.

Finally, we would like to thank the local residents of the eight participating cities for their cooperation:

The 50 individuals who permitted us to use the roofs of their buildings during the data collection effort.

The 2,300 individuals who took the time to talk to our field teams.

The 50,000 motorists and pedestrians who unknowingly provided the behavioral data for the evaluation.

Abstract

This Volume describes the procedures and results associated with the first Task of a three-task study. Task 1 consists of the behavioral evaluation of nine pedestrian countermeasures. The behavioral evaluation study required the determination of accident related behaviors and countermeasures having a high likelihood of impacting on these behaviors. The accident associated behaviors and candidate countermeasures were derived fron a review and analysis of previous research efforts; in particular, the Snyder and Knoblauch (1970) report.

Eight accident types, representing over 55% of all urban pedestrian accidents, were selected for study. The driver and pedestrian behavior associated with the occurrence of these accident types formed the target behaviors for evaluating the effectiveness of the countermeasures. The following list briefly describes the eight accident types in terms of their behaviors:

1. Dart-Out (First Half) – nonintersection, in first half of roadway, sudden appearance of pedestrian, running in the road.
2. Dart-Out (Second Half) – nonintersection, second half of roadway, sudden appearance of pedestrian, running in the road.
3. Intersection Dash – intersection, sudden appearance of pedestrian.
4. Vehicle Turn/Merge With Attention Conflict – driver hits pedestrian while attending to traffic during the process of turning or merging.
5. Pedestrian Strikes Vehicle – pedestrian ran or walked into vehicle.
6. Multiple Threat – pedestrian is struck after walking in front of a stopped vehicle by a second vehicle going in the same direction.
7. Bus Stop Related – crossing in front of bus at a bus stop.
8. Vendor-Ice Cream Truck – like Dart-Out with an ice cream truck being the object of the pedestrian's crossing.

A list of countermeasures assumed to impact on these accident related behaviors was available from the Snyder and Knoblauch study. The selection of specific countermeasures was, however, not possible without the inputs from the participating cities.

City and site selection comprised a major portion of the early project effort. Contact with approximately 15 candidate cities resulted in commitments from Washington, D.C., New York City, Miami, San Diego, San Jose, Akron, Columbus, and Toledo. After conferring with these eight cities and assessing the existing political, economic, and engineering constraints, the following nine pedestrian countermeasures were selected for evaluation:

1. Preventive Markings ("Caution" painted on pavement)

2. Median Barriers (chain link fence on median)
3. Crosswalk Setbacks (crosswalk moved 20 feet toward midblock)
4. Midblock Crosswalk (a painted crosswalk in the midblock area)
5. Diagonal Parking (30° or 45° diagonal parking)
6. Meter Post Barriers (barriers extending some 3 to 9 feet in each direction from a meter)
7. Stop Line Relocation (moved back from crosswalk)
8. Vendor Warning Lights (flashing signal with silhouette of child placed on top of ice cream trucks)
9. Bus Stop Relocation (moving bus stop to far side of intersection)

Within each of the eight cities, locations were sought which would present a suitable preparation for the testing of each of the countermeasures. The most important consideration was the frequency of accident related pedestrian and vehicle behaviors at the site. It was also necessary to determine whether the site could physically support an appropriate countermeasure, was amenable to instrumentation, and was similar to other sites that could be used for control purposes.

A series of measurement techniques was developed to assess the effectiveness of the countermeasures on pedestrian and vehicle behavior. These procedures include the use of manual onsite recording, time-lapse photography, still photographs, the Traffic Evaluator System, and in-house film interpretation and scoring. In addition, several interview protocols were constructed in order to determine the economic and attitudinal impact of the countermeasures. In general, the types of data that were collected fell into one of the following eight categories:

1. Site Characteristics
   - A. Environmental Setting
   - B. Physical Layout
2. Traffic Characteristics
   - A. Flow (i.e., volume, speed, turning)
   - B. Parking
3. Pedestrian Characteristics
   - A. Flow (i.e., volume, origin – destination)
   - B. Biographical (i.e., age, site familiarity, sex)
4. Traffic Behavior
   - A. Speed
   - B. Headway
5. Pedestrian Behavior
   - A. Countermeasure Specific Behavior
   - B. Other Potentially Hazardous Behavior

6. Pedestrian Attitudes
   A. Pedestrians Exhibiting Countermeasure Specific Behavior
   B. Pedestrians Not Exhibiting Countermeasure Specific Behavior
7. Community Reaction
   A. Merchants
   B. Residents
8. Maintenance and Engineering Data
   A. Countermeasure Damage
   B. Effects on Other Required Services

The paradigm was basically a pre/post design with a control group. Replication of countermeasures was obtained by testing each of the nine countermeasures in at least two locations -- generally different cities. The data collection program involved two days of data collection in the "Before" and two days in the "Post" study (just prior to and at three months after the installation of the countermeasures). In addition, two acclimation studies were conducted on the five countermeasures tested in the District of Columbia (at one week and one month after the installation of the countermeasure). All data were simultaneously collected at the control and experimental sites.

During the 204 days of data collection, over 2,000 rolls of time-lapse film were taken. The resulting data represented a characterization of the behavior of over 16,000 pedestrian crossings. An additional 2,100 pedestrians were interviewed at the study sites as were 200 residents and merchants. Finally, some 35,000 vehicles were observed to determine vehicle speeds.

An analysis of the above noted data base indicated that 17 of the 30 tested behaviors were significantly modified by the experimental countermeasures. Table A presents a summary of the behavioral results.

By relating these modified behaviors to the behaviors defining the eight accident types, the potential applicability of each of the countermeasures was suggested. Inputs from merchants, residents and city traffic engineers were also used to identify potential installation, maintenance and design problems. These topics are discussed in the body of the report.

Table A
Countermeasures and Their Behavioral Impact*

Behavioral Category	Countermeasures: Preventive Markings	Median Barrier	Crosswalk Set-Back	Midblock Crosswalk	Diagonal Parking	Meter Post Barriers	Stop Line Relocation	Vendor Warning Signals	Bus Stop Relocation
Pedestrian/Vehicle Separation				↑					
Pedestrian Scanning					↑		↑		
Vehicle Speed			↑	↓	↓				
Abort Crossing						↓			
Entry in Front of Stopped Bus									↓
Pedestrian Hesitation in Traffic Lane				↓					
Pedestrian Backing up in Parking Lane		↓				↓			
Pedestrian in Front of Parked Vehicles		↓		↓		↓			
Running in Roadway		↓	↑	↓	↓				
Sudden Appearance					↓				
Crossing Outside of Crosswalk		↓		↓					
Vehicle Stop Line Violations			↑				↑		
Vehicle Crosswalk Violations			↑						
Vehicle/Crosswalk Separation							↑		
Mid Block Crossings		↓							
Crossings in Crosswalk Area				↑					
Vehicle Speed			↑		↓				
Veh/Ped Turning Conflict(% of Peds Involved)									
Veh/Ped Turning Conflict(% of Peds That Stop)									
Veh/Ped Turning Conflict(% of Vehicles Involved)									
Bus Stop Related									
Crossing Against Light									
Crossing One-Half Against Light									
Running into Roadway									
Running into 2nd Half									
Trapped on Median									
Walking on Median									
Leaving Crosswalk									
Outside Crosswalk									
Vehicle Overtaking									
Pedestrian Hesitation in Parking Lane									
Pedestrian Backing up in Traffic Lane									
Intersection Run(Against Light)-1st Half									
Intersection Run(Against Light)-2nd Half									

*An increase in a particular behavior is designated by a" ↑ " while a decrease is " ↓ "
Shaded boxes indicate those behaviors that were expected to be affected.

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CHAPTER 1
INTRODUCTION

In 1973, approximately 400,000 pedestrians were involved in accidents with motor vehicles. About 10,000 of these accidents resulted in pedestrian fatalities, with 64 percent of these fatalities occurring in urban areas.

As a result of the consistently high incidence of urban pedestrian accidents, a DOT accident investigation study was initiated in 1969.* During the course of this study, over 2,000 accidents in 13 large cities were investigated. The findings indicated that certain pedestrian accidents shared a similar set of behavioral antecedents. In addition, these different accident "types" characteristically occurred in well defined urban areas (e.g., multifamily residential, commercial, etc.).

Given the ability to characterize the accident and the accident environment, it was hypothesized that specific countermeasures might yield a considerable payoff. In fact, a series of site and accident specific countermeasures had been identified in this previous study, but the effectiveness of these countermeasures was not empirically evaluated.

The present project focuses on three aspects of countermeasures and countermeasure effectiveness. First, a series of behavioral studies were conducted to determine the extent to which the proposed countermeasures inhibit those undesirable vehicular and pedestrian behaviors most often associated with a particular type of pedestrian accident. The conduct and results of the behavioral evaluation study is presented in this Volume of the final report.

Second, an accident data base was established in several cities. In order to establish this data base, the accident report forms of the participating cities were expanded to reveal the behavioral antecedents associated with the pedestrian accident. The resulting data base will serve as input in the design of a large scale countermeasure-accident study which will be conducted under a separate contract. The procedures and results of the accident data collection process are presented in Volume II of the final report.

Third, a survey of pedestrian safety information was conducted and recommendations for improving the effectiveness of safety materials were made. The results and recommendations relative to the surveyed safety programs are presented as Appendix A to Volume II.

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*Snyder, M.B., Knoblauch, R.L. Pedestrian safety: The identification of precipitating factors and possible countermeasures. Volumes I and II. Final Report Operations Research Inc., Contract DOT FH-11-7312, NHTSA January 1971.

The remainder of this Volume is devoted to the behavioral studies undertaken to determine the safety potential of the experimental countermeasures.

Literature Survey

The survey of relevant research began with a rather general search of pedestrian safety-related items.

No attempt was made to present a comprehensive review of all pedestrian safety-related literature as this has been recently done by others (Shapiro & Mortimer, 1969; Cleveland, 1969). Instead, the review was concentrated on those research efforts that have relevance to the research methodology of this project. In light of the above considerations, it soon became apparent that there were three distinct categories of literature that should be considered in this Volume.*

The first set of studies were of interest because they employed a variety of potentially applicable data collection procedures and techniques. This type of article was particularly important in the planning stages of the behavioral evaluation. These articles provided a means of reviewing potential data collection methods as well as identifying potential dependent measures for the behavioral evaluation.

The second group of articles included accident studies that attempted to describe the pedestrian accident problem as well as a few that attempted to measure the accident effectiveness of various experimental treatments. This type of literature was useful in deriving the data elements for the accident data collection effort.

The third group of articles was oriented toward a particular countermeasure or countermeasure concept. These documents tended to describe the experiences of a particular jurisdiction with countermeasures similar to the ones currently under consideration. In some cases, an evaluation of the effectiveness of the countermeasure was also included and reported.

Methodological Procedures

The literature was found to contain articles which reported a variety of data collection techniques and procedures used to measure or describe pedestrian and vehicular behavior. Most of these studies involved either the manual coding of observed behavior or the use of motion picture cameras to provide a permanent record of the field observation.

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*Another group of articles included those which concerned public information and education programs. These articles are discussed in Appendix A to Volume II (Review of Education and Public Information Materials).

Acutarial Studies

Actuarial studies were generally concerned with the collection and analysis of accident data. The majority of the actuarial studies consist of the after-the-fact descriptions of pedestrian accidents, including such factors as pedestrian age, sex, etc. Mueller and Ronkin's (1970) summary article presented the types of information that are readily available from existing data sources. The Road Research Laboratory report by Garwood and Moore (1962) carried the type of analysis one step further by looking at pedestrian accident rates relative to roadway mileage, and location of the pedestrian crossing in terms of crosswalk configuration. Other studies have examined in detail smaller facets of the pedestrian accident problem. Bartholomew (1967) looked at the "before – after" accident rates in areas served by city recreation facilities. Not surprisingly, a significant reduction was found in areas up to one-quarter mile from these facilities. The city of San Diego (1968) examined the accident rates in painted versus unpainted crosswalks. This body of literature will be explored more fully in Volume II of this report.

Smeed (1968) reviewed the pedestrian accident statistics in more than ten countries, including the U.S. He then discussed measures to reduce casualties, the economic costs of pedestrian accidents and delay, the effects of weather and darkness, and the effects of police presence on driver and pedestrian behavior relative to the statistical characteristics of the accidents.

Observational/Experimental Studies

The observational/experimental studies reviewed generally employed a single data collection procedure. The majority utilized manual observation and hand-coding of pedestrian and vehicular activities. Some used manual tallies of vehicular and pedestrian volumes as their major data source, while still others used real-time and/or time lapse photography to record vehicular and pedestrian behavior. Relatively few reports were located in which pedestrians and/or drivers were interviewed to determine their attitudes toward or reasons for their behavior. The remainder of this section will be devoted to a more in-depth discussion of the literature grouped into these four data collection categories.

1. Manual Counts (Tallies)
2. Manual Observation and Coding
3. Video Recording
4. Interviews

Manual Counts. One of the most simple, reliable, and commonly used data collection techniques involves tallying the number of pedestrians or vehicles performing a given action or passing by a given point.

Herms (1970), in a comparison study of painted and unpainted crosswalks, tallied the number of pedestrians using each crosswalk and the number of vehicles passing through the intersection. Individuals can be trained to perform such field work with a minimum of effort and, since only one coder is needed per site, data can be collected for long periods of time for relatively low cost.

Kaiser (1959) evaluated the effect of pedestrian indication signals on pedestrian behavior. In so doing, he tallied vehicular flow by direction through the intersection as well as pedestrian movements "with" and "against" the light. Other work (Garwood & Moore, 1962; Malo et al., 1971; Jacobs & Wilson, 1967) reported simple vehicular and pedestrian tallies in combination with other manual observation and coding techniques.

Manual Observation and Coding. A number of studies both in this country and abroad have used various manual observation and coding techniques to record pedestrian activities. Cleveland (1969) presented a comprehensive compilation of techniques for recording information about pedestrian behavior at crosswalks. Utilizing the procedures set forth by Cleveland, Malo et al. (1971) evaluated a number of crosswalk information systems. They collected vehicular data on intersection volume, spot speeds, travel time, gaps access point volumes, and the drivers' response to the crosswalk configuration. The study determined pedestrian volumes, personal characteristics, crossing time, gap acceptance, as well as various behavioral items at signalized intersections.

A number of pedestrian studies have been performed in England, most frequently under the auspices of the Road Research Laboratory, Jacobs (1965 and 1968), Jacobs and Wilson (1967), Mackie and Jacobs (1965) Wilson and Older (1970). These studies were primarily concerned with determining pedestrian and vehicular behavior at various types of crossing configurations. A wide variety of parameters were measured including:

- Driver response to crosswalk signals, with and without pedestrian present.
- Pedestrian flow at or near the vicinity of the crosswalk.
- Delay of pedestrians waiting at curb.
- Pedestrian crossing time.
- Vehicle time to pass through crosswalk sites.
- Total vehicular volumes.

Each of these studies involved the strict adherence to a data collection schedule (sampling plan) and the manual recording of selected categories of behavior.

Fleig and Duffy (1967) consulted police accident records to determine what unsafe behaviors were associated with accidents. They found that (1) crossing against the signal, (2) crossing away from the crosswalk, (3) coming from behind parked cars, and (4) standing in the roadway when the pedestrian signal is red were "unsafe" behaviors under the pedestrian-vehicle signal system being evaluated. They then used activity sampling to determine the number of "unsafe" acts being performed before and after the installation of pedestrian traffic signals at the intersection being studied. They found no significant change in the number of unsafe acts observed; however, their methodology suggests that activity sampling might be a promising way to collect large quantities of data in a short time, and thus avoid confounds associated with changes in time.

An interesting methodology for studying the characteristics of traffic conflicts was described by Harris and Perkins (1968). They defined over 20 objective traffic conflict situations and related them to four basic types of intersection accidents. The procedure serves to measure the danger of traffic maneuvers by simultaneously counting both traffic conflicts and volumes, and, as such, is suited to the measurement of the effectiveness of traffic engineering changes through before and after studies.

Reading (1973) used manual tallies in an interesting study of behavior modification techniques as used on school age pedestrian crossing behavior. Using an intermittent reinforcement schedule, he reported a dramatic increase in safe crossing behavior at intersections near an elementary school in Salt Lake City.

Video Recording. A number of more recent studies have used 8 and 16mm movie cameras to film vehicular and pedestrian activities. The filming has been both real-time and time-lapse. Filming provides a permanent record of the data and permits the verification of the reliability of the film observers who reduce the films to a usable data format.

Heimstra et al. (1969) filmed 200 school children pedestrians and developed a detailed behavioral analysis consisting of social conditions, approach behavior, and curb behavior.

Older (1968) filmed pedestrian flow on the sidewalks of shopping areas. He filmed at 10 frames/second and developed a relationship between the walking speed and density of pedestrians. Jacobs (1965) filmed pedestrian and vehicular traffic before and after the installation of a zebra crossing. Filming from a roof top, he was able to determine pedestrian delay times, crossing utilization as well as vehicle speeds. Singer (1969) filmed pedestrians at intersections in three cities and found no consistently significant effect of enforcement campaigns or pedestrians' compliance to traffic signals.

Older and Gregson (1972) analyzed the perceptual processes and decision-making involved in the pedestrians' crossing behavior in terms of a task flow. The task flow provided an interesting theoretical framework against which the results of many of the observational studies might be compared. However, as the authors themselves caution, their results are based on a small number of sites and more field studies are needed covering a wider range of behavior over a variety of different conditions. However, it is apparent that if effective countermeasures are to be developed, future research should focus on explanations as well as descriptions of pedestrian behavior.

Welke (1968) filmed pedestrian and traffic flow at an intersection using a 16mm camera set to operate at .5 frames per second. The number of pedestrians crossing during each signal cycle and the pedestrian-incurred vehicle delay was tallied from the filmed record. However, Welke does mention that a great deal of additional data could have been taken from the film including:

- Pedestrians delays caused by different control devices.
- Pedestrian adherence to traffic signals.
- Pedestrian walking speed.
- Pedestrian adherence to marked crosswalks.
- Vehicle speed.
- Cycle-to-cycle variations in both vehicular and pedestrian volumes.

Unlike all of the other filming efforts which used a stationary camera, Jacobs (1968) filmed pedestrians using a motion picture camera mounted in a moving automobile. He was primarily interested in the effect of vehicle lighting on pedestrian movement.

Interviews

Surprisingly, very few research studies have involved interviewing pedestrians either to determine the reasons for their behavior or to trace the factors that led to unsuccessful behaviors and subsequent accidents. Snyder and Knoblauch (1970) performed an in-depth evaluation of over 2,000 urban pedestrian accidents and obtained interviews with a number of involved pedestrians and involved drivers. These interviews were structured around determining the predisposing and precipitating factors that were involved in the accidents.

Countermeasure-Relevant Studies

Some work has already been performed on several of the countermeasures being evaluated in this project. (See Chapter 2 for a description of the countermeasures under investigation.) For example, Terry and Thomas (1971) evaluated the effects of relocating bus stops to the farside of the intersection. They measured route operations timing, passenger processing timing, number of passengers and vehicle queues formed at the bus stops behind buses and concluded that farside bus stops are better. Although they were not specifically concerned with the pedestrian safety aspects of bus stop relocation, the study does indicate that bus stop relocation can be an operationally effective procedure. Zeigler (1971) evaluated "flat angle" parking arrangements on urban streets. Although he was not concerned with the pedestrian safety-related aspects, he did conclude that the flat angle parking arrangement offers some definite driver visability advantage over parallel parking. Some of the advantages he cites also might hold for the diagonal parking countermeasure being evaluated in the present study.

Katz et al. (1972) studied pedestrian behavior at locations with guardrails. In a preliminary report, they concluded:

1. Safety guardrails help to decrease the pedestrian accident rate.
2. Guardrails aid in guiding pedestrians to cross at a marked crossing.

The Los Angeles County school district published an interesting report (1973) involving an in-depth study of ice cream truck-related accidents occurring between July 1969 and June 1973. This type of accident was reported to account for five percent of the traffic accidents involving school age children in Los Angeles. Perhaps most interesting was the fact that 78 percent of the children were struck *after* making their purchase and were leaving the truck. (Ten percent were going to the truck and the data was not known in 12 percent of the cases.) Also of interest was the report that some 51 percent of the colliding vehicles approached from the same side of the street. (Twenty-seven percent were approaching from the opposite side, while the direction of approach was unknown in 22 percent of the cases.)

Mortimer and Magamachi (1969) used a 16mm camera to evaluate the effect of roadway markings on vehicle stopping position relative to pedestrian crosswalks. They found the number of crosswalk encroachments to be smallest at intersections marked both with a crosswalk and a stop line. This has several implications on the stop line relocation countermeasure.

A large number of articles and documents that dealt with pedestrian grade separation (i.e., Fruin, 1972, ITE Project Committee 4E-A, 1972) as a means of promoting traffic safety and traffic capacity were located. Since countermeasures such as pedestrian overpasses and pedestrian underpasses are not included in the scope of the present project they will not be discussed in this review.

Accident Studies

No effort was made to review the large number of studies that dealt with pedestrian accidents on a descriptive level. Instead the orientation was to determine the types of data currently collected and, more importantly, what types of data should be collected if a meaningful analysis of accident causation is to be performed. The majority of the accident studies have used information from existing data sources, most often police accident reports, relatively few have collected additional information either from the pedestrian, the drivers or other possible sources.

Blumenthal and Wuerdemann (1969) specified the basic information elements to be included in "recommended" and "optional" crash investigation reporting programs. These elements were developed for uniform statewide crash reports and as such represent the information which ideally would be uniformly "defined, interpreted, collected, and analyzed" by each state. However, only a single item was devoted to pedestrian actions. The following response categories were listed:

- Crossing at intersection
- Crossing not at intersection
- Walking in roadway with traffic
- Walking in roadway against traffic
- Standing in roadway
- Playing in roadway
- Working in roadway
- Getting on/off vehicle
- Not in roadway

These data items are nearly identical to those reported by the National Safety Council in Accident Facts (1972). The use of these data items, plus time of day, day of week, pavement condition, and direction of travel information permit, at best, a very skeletal reconstruction of how the accident actually happened. Plummer (1972) noted the need for reporting some additional information if accident patterns are to be identified. He stressed the need for identifying noninvolved vehicles and reporting driver intent. Noninvolved vehicles are those that are present and which contributed to the accident but were not physically involved in the actual collision. Driver intent is the intent on the part of the drivers (and/or pedestrian) prior to the collision. It included both planned and executed maneuvers. Unfortunately this report by Plummer, and an article by Box (1970), only suggest the importance of such data items and there appears to be no widespread application of the concept.

Only one reference was uncovered which collected information on pedestrian accidents in addition to that normally gathered by the regular police investigation. As mentioned previously Snyder and Knoblauch (1971) collected data on over 2,000 pedestrian accidents in 13 major U.S. cities. They conducted interviews with pedestrians, drivers, and witnesses in an effort to establish casual factors. A number of predisposing and precipitating factors were uncovered.

CHAPTER 2

STUDY OBJECTIVES AND DESIGN

Selection of Countermeasures

In order to provide a framework for the selection of countermeasures, it is necessary to clearly specify the behaviors to be countered. In addition to being amenable to modification, these behaviors must be demonstrably associated with pedestrian accidents. Thus, an analysis of the behavioral antecedents of pedestrian accidents must precede the identification of countermeasures.

Fortunately, most of the accident analysis was performed in the previously referred to Snyder and Knoblauch study. By using the accident typology developed in that report and the frequency of each accident type, we can select a subset of accident types that represent the bulk of the identified problem. The eight frequently reported types of accident do, in fact, account for over 55% of the pedestrian accidents studied. A brief description of the eight types of pedestrian accidents identified by Snyder and Knoblauch follows:

1. *"Dart-Out (First Half).* A pedestrian, not in an intersection crosswalk, appears suddenly from the roadside. His quick appearance and short-time exposure to the driver are the critical factors. The pedestrian often may be running, and parked cars often obstruct vision, but neither need be present if the basic condition of sudden appearance to the driver's view is met. The prime example of the dart-out is a school-age child running out from between parked cars on his own block, in a residential area in the center city in the afternoon after school. He heads straight across the relatively narrow street, looking where he is going and is struck less than halfway across. The driver, traveling at a normal rate of speed, did not have enough time to stop after detecting the child."

2. *"Dart-Out (Second Half).* This is the same as the dart-out described for the first half above, except that the pedestrian covers half of a normal crossing before being struck. The distinction was made because of the possible differences in the opportunities or problems relative to driver detection and recognition of danger if the roadway is clear. However, this type was assigned even if traffic obscured the driver's vision. It may be used even if the pedestrian crosses a medium-size median strip of a boulevard."

3. *"Intersection Dash.* This category covers cases similar to dart-outs with regard to pedestrian exposure to view, but the incident occurs in or near a marked or unmarked crosswalk at an intersection. Cases are included if the pedestrian is running across the intersection even though his exposure to possible driver view is not extremely short. (His speed will, in effect, limit his actual exposure to the driver.)"

4. *"Vehicle Turn/Merge With Attention Conflict.* The driver is turning into or merging with traffic; the situation is such that he attends to auto traffic in one direction and hits the pedestrian who is in a different direction from his attention. A critical feature is that the attention conflict is built into the situation. Usually the driver directs his attention in a given direction to determine an acceptable gap into which he will enter."

5. *'Pedestrian Strikes Vehicle.* This classification covers crashes *not* covered by other clear types (e.g., dart-out), in which it has been determined that the pedestrian ran or walked into the car."

6. *'Multiple Threat.* The pedestrian is struck by car x after other cars blocking the vision of car x stopped in other lanes going the same direction, and avoided hitting the pedestrian. For example, cars in lanes one and two stop and permit the pedestrian to cross; car x in lane three going the same direction hits the pedestrian as he steps out in front of the car in lane two. This classification is not used if the striking vehicle is going in the opposite direction from the stopping cars. (In that situation, the stopping cars would not block the driver's vision.)"

7. *"Bus Stop Related.* This type includes cases in which the location or design of the stop appears to be a major factor in the causation; e.g., the pedestrian crosses in front of the bus standing at a stop on the corner, and the bus blocks the view of cars. It does not include those cases that may be considered as exiting from a vehicle, nor does it include cases in which the stop is only an attraction or distraction."

8. *"Vendor-Ice Cream Truck.* The pedestrian is struck going to or from a vendor in a vehicle on the street. This is usually similar to a dart-out, with ice cream trucks being the most frequent attraction. This specific classification was given precedence over dart-out when assigning cases to types."

Table 2-1 further defines these accident types in terms of some of their locational (e.g., block location, environmental settings, etc.), and behavioral (e.g., running into roadway, between parked cars, etc.) characteristics.

A preliminary set of countermeasures assumed to impact on the behavioral complex associated with pedestrian accidents was available from the Snyder and Knoblauch study.

This preliminary set of countermeasures was reviewed in light of certain operational criteria:

1. Each countermeasure had to involve relatively minor installation costs (i.e., less than $2,000 per block of installation).

Table 2-1

Pedestrian Accident Description*

Accident Type	Characteristics						
	% of Ped. Acc.	% That Are Fatal	Time of Day	Ped. Age	Block Location	Area	Accident-Related Behavior
1. Dart-out First Half	24.1	8.3	Day (79.5)**	5-9 (52.5)	Nonintersection (96.7)	Residential (63.4)	Running into the roadway Failure to look for traffic Entry between parked vehicles
2. Dart-out Second Half	8.9	10.4	Day (71.7)	5-9 (49.7)	Nonintersection (74.1)	Commercial (35.4)	Running into second half of roadway Midblock crossing Entering between parked vehicles
3. Intersection Dash	8.4	6.7	Day (76.8)	5-9 (39.9)	Intersection (98.9)	Commercial (48.5)	Failure to look for traffic Crossing against the light Running into the roadway
4. Vehicle Turn/Merge with Attention Conflict	6.4	8.8	Day (70.9)	All	Intersection (95.5)	Commercial (73.7)	Vehicle turning in proximity of pedestrians Failure to look for traffic Failure to detect pedestrians
5. Ped. Strikes Vehicle	4.0	2.3	Day (81.6)	5-9 (34.2)	Intersection (57.5)	Commercial (40.7)	Running into the roadway Failure to look for traffic Entry between parked vehicles
6. Multiple Threat Situation	3.2	5.8	Day (83.6)	10-14 (20.9)	Intersection (79.7)	Commercial (65.2)	Entry from in front of standing vehicle Small separation between stopped vehicle & pedestrian Running in roadway Failure to detect pedestrian
7. Bus Stop Related	2.6	17.9	Day (80.4)	10-14 (17.0)	Intersection (81.1)	Commercial (61.8)	Entry from in front of stopped bus Failure to detect pedestrian
8. Vendor-Ice Cream Truck	1.5	12.4	Day (97.0)	5-9 (69.0)	Nonintersection (81.8)	Residential (78.3)	Running into the roadway Failure to look for traffic Excessive vehicle speed Failure of driver to detect potential threat

*Data based on Snyder & Knoblauch (1970).

**% So Classified.

2. Each countermeasure had to be self-explanatory or require a minimum of public reeducation or police enforcement.
3. Each countermeasure had to be applicable to a substantial proportion of the sites exhibiting accident-related behaviors.

Of those countermeasures reviewed, nine met the above criteria.*

Initially, it was assumed that the countermeasures would, through the modification of selected accident-related behaviors, have their primary impact on one or more of the eight types of pedestrian accidents listed in Table 2-1. Although the assumed relation between countermeasures and accident types provided an initial structure for the study, the ultimate evaluation of a countermeasure was based on the extent to which it modified *any* of the accident-related behaviors. In light of this orientation, a set of expected behavioral changes was hypothesized for each countermeasure. These expected changes were based on a review of the literature and the design characteristics of the countermeasure. Furthermore, the hypotheses were not confined to the behaviors associated with the accident type(s) for which the countermeasure was originally designed. Thus, it was conceivable that a countermeasure might impact on behaviors other than those for which it was designed.

Table 2-2 presents a brief description of the nine countermeasures. Also included in this table is a list of the expected behavioral changes (Behavioral Objectives) and a listing of the accident type(s) for which the countermeasure was originally designed.

It should be noted that the specification of expected outcomes interacted with the development of the measurement procedures. In particular, changes in some accident-related behaviors were not hypothesized (e.g., failure to detect pedestrians) simply because we did not have the capability to effectively or efficiently measure these variables.

Development of Behavioral Measures

Several factors guided the development of the measures for the behavioral study. First and foremost were considerations of the potential pedestrian, traffic, and community impact of the proposed countermeasures. Another major consideration was the desire to devise a core (or basic) set of measures and measurement techniques that could be uniformly applied at all the study sites. It will later be shown that uniformity, as used in this context, does not preclude the collection of countermeasure-specific data.

*The Preventive Markings, Crosswalk Set-Back and Midblock Crosswalk countermeasures were not suggested by the Snyder and Knoblauch study. They were included in the present effort because they appeared to be a relatively inexpensive and popular procedure for addressing the Intersection Dash type of accidents.

Table 2-2

Hypothesized Applicability of the Countermeasures to the Various Types of Behavioral Objectives and Accident Types

Countermeasure	Expected Outcomes	Initial Accident Focus
Preventive Markings—Word "CAUTION" painted on the curb or road. Also signs stating "Watch out for Vehicles".	Increase looking in direction of traffic Reduce crossing against the light Increase vehicle/pedestrian separation Reduce running into the roadway Reduce proportion of pedestrians involved in turning conflicts Reduce proportion of vehicles involved in turning conflicts	Intersection Dash
Median Barrier — A barrier located on the median of a road.	Reduce running from the median into second half of the roadway Reduce midblock crossings Reduce entry in front of parked vehicles Reduce running in the roadway	Dart-Out (Second Half)
Crosswalk Set-Back — Moving the crosswalk toward midblock. May include the installation of pedestrian barrier at the corners.	Reduce proportion of vehicles involved in turning conflicts Reduce proportion of pedestrians involved in turning conflicts	Vehicle Turn/Merge With Attention Conflict
Midblock Crosswalk—Pedestrian crosswalk installed at or near midblock	Increase proportion of midblock crossings occurring within the crosswalk area Increase vehicle/pedestrian separation Reduce entry in front of parked vehicles Reduce running in the roadway	Dart-Out (First Half)
Diagonal Parking — Parking of vehicles at an angle to the curb in the direction of traffic flow.	Reduce running into the roadway Increase looking in direction of traffic Reduce entry in front of parked vehicles Reduce running into the roadway from infront of parked vehicles	Dart-Out (First Half)
Meter Post Barriers — A barrier attached and extending along the sidewalk from a parking meter.	Reduce running into the roadway Increase looking in direction of traffic Reduce entry in front of parked vehicles	Dart-Out (First Half), Ped Strikes Vehicle
Stop Line Relocation — Moving the vehicle stopline away from the crosswalk beyond the standard 4-foot separation.	Increase separation between stopped vehicles and pedestrians Reduce proportion of vehicles involved in turning conflicts Reduce proportion of pedestrians involved in turning conflicts	Multiple Threat
Vendor Warning Signal — Flashing symbolic signal mounted on top of vendor truck.	Decrease vehicle speeds in the vicinity of stopped vendors Increase conspicuity of vehicle vendor signals	Vendor-Ice Cream Truck
Bus Stop Relocation — Moving of the bus stop to the far side of the intersection.	Reduce entry in front of stopped bus	Bus Stop Related

Data were collected via real time and time-lapse photography, manual observation and coding, pedestrian and community surveys, and by means of the Traffic Evaluator System. Each of the data gathering techniques was directed at securing information on either pedestrian or vehicle behavior, or the interaction of pedestrians and vehicles. The data gathered on each of these components of the traffic environment was collected at various levels of detail and by various data collection procedures. For example, pedestrian data were collected at three levels of specificity: (1) aggregate pedestrian flow, (2) Pedestrian Activity Sampling (PAS), and (3) Behavioral Sequence Records (BSR). Aggregate pedestrian flow is simply a hand coded summary of the location and frequency of pedestrian crossings and sidewalk usage.

Pedestrian activity sampling consists of time-lapse photography and manual records of pedestrian crossing activities, which are designed to reveal hazardous or countermeasure-specific behavior. The PAS data collection mode presents a time sample of the activities occurring in the entire site area. The pedestrian activities captured on the PAS film were then coded in order to characterize the pedestrians' crossing behavior.* However, a pedestrian was never coded more than once in any single behavioral category (see Table 2-3 for a list of the behavioral coding categories).

Additional site- and countermeasure-specific categories were added as data needs were determined.

In order to describe the degree of hazard associated with each pedestrian studied under the PAS mode, an operational definition of hazard was required. Vehicle speed and proximity were the two primary considerations used to determine the degree of hazard. The following simplifying assumptions make the Hazard Index operational:

1. a pedestrian's walking speed was taken as 4.0 feet per second;
2. the distance between a pedestrian and vehicle was estimated at the time when the pedestrian entered the vehicle's lane;
3. the distance was measured in vehicle lengths and a vehicle length was taken to be 20 feet; and
4. all the lanes of the road were assumed to be the same width at any one crossing point.

Given the above assumptions, the lane width, and the operating speed of the road, we calculated the "Hazard Distance" associated with any site. For example, if the lane width (w) is 10 feet and the operating speed (s) is 25 mph, we find that:

$$\begin{aligned}\text{Hazard Distance (Vehicle Lengths)} &= (w/4 + 1)\ (s \times 1.46)/20 \\ &= (10/4 + 1)\ (25 \times 1.46)/20 \\ &= 6.3\end{aligned}$$

*The inter-rater reliabilities of these behavioral categories are presented in Attachment A at the end of this document.

Table 2-3

Coding Categories for the Pedestrian Activity Sampling (PAS) Data Mode

1. Abort – Return to the curb after having both feet on the roadway
2. Turning Conflict (1) – Number of turning vehicles involved in Turning Conflict (3)
3. Turning Conflict (2) – Number of pedestrians who hesitate because of a turning vehicle
4. Turning Conflict (3) – Number of pedestrians who pass within one car length in front of a turning vehicle
5. Trapped on Median – Pedestrian hesitates or stops while on median waiting for the passage of at least one vehicle
6. Walking on Median – Two or more steps parallel to the roadway while on the median
7. Leaving Crosswalk – Pedestrian leaves crosswalk area into a traffic lane
8. Outside Crosswalk – Pedestrian crosses all traffic lanes outside painted crosswalk
9. Bus Stop Related – Pedestrian crosses in front of stopped bus (at bus stop) into traffic lane
10. Vehicle Overtaking (Intersection) – Pedestrian enters roadway and moves in front of stopped or standing vehicle (not a parked vehicle) into a lane of traffic moving in the same direction (against signal)
11. Vehicle Overtaking (Midblock) – Pedestrian enters roadway and moves in front of stopped or standing vehicle (not a parked vehicle) into lane of traffic moving in the same direction
12. Crossing Against Light – Entry into and exit from roadway while vehicles are still moving and/or making a complete crossing before waiting pedestrians start across
13. Crossing ½ Way Against Light – Vehicle passes pedestrian as he gets to center line; stopped vehicle begins to move before pedestrian has taken 2 steps beyond center line into 2nd half of roadway
14. Vehicle Induced Hesitation (Traffic lane) – Pedestrian hesitates or stops in traffic lane waiting for the passage of at least one vehicle
15. Vehicle Induced Hesitation (Parking lane) – Pedestrian hesitates or stops in parking lane waiting for the passage of at least one vehicle
16. Backup Movement (Traffic lane) – Momentary reversal in pedestrian direction of travel in the traffic lane, i.e., 1 or more steps in opposite direction
17. Backup Movement (Parking lane) – Momentary reversal in pedestrian direction of travel in the parking lane, i.e., 1 or more steps in opposite direction
18. In Front of Parked Vehicles – Pedestrian enters roadway between vehicles parked less than one car length apart or within one car length in front of a parked vehicle
19. Running into Roadway – Pedestrian traveling over 6.6 feet/second when entering the first traffic lane.
20. Running in Roadway – Pedestrian traveling over 6.6 feet/second in traffic lane
21. Sudden Appearances – Pedestrian runs into roadway from between parked vehicles or within one car length in front of a parked vehicle
22. Running into 2nd Half – Pedestrian runs into second half of roadway
23. Intersection Run – (1st Half) – Running into 1st half of the roadway against the light signal
24. Intersection Run – (2nd Half) – Running into 2nd half of the roadway against the light signal

As a convention, we round *down* to the nearest vehicle length when making our field estimate; thus, the above distance would be translated as six vehicle lengths. Three hazard levels are derived from the above calculations and an estimate of the vehicle speed:

1. If a vehicle appears to be going *at or above* the operating speed of the road and is *less* than six vehicle lengths away from the pedestrian as he enters the lane, then a Hazard Index of *A* is assigned to that crossing. (Pedestrian will clear a traffic lane by one second or less before a vehicle occupies that space.)

2. If a vehicle appears to be going *below* the operating speed of the road and is *less* than six vehicle lengths away from the pedestrian, then a Hazard Index of *B* is assigned to that crossing. (Pedestrian will clear a traffic lane by 1 to 2.5 seconds before a vehicle occupies that space.)

3. If the vehicle is *more* than six vehicle lengths away regardless of speed (also if the vehicle is *stopped or moving very slowly,* i.e., less than 10 mph), then a Hazard Index of *C* is assigned to the crossing. (Pedestrian will clear a traffic lane by more than 2.5 seconds before a vehicle occupies that space.)

It should be noted that only the most severe hazard associated with a pedestrian crossing was recorded.

Finally, Behavioral Sequence Records (BSR) are detailed photographic and manual records of an individual pedestrian crossing. The records from the BSR film and manual coding were reduced and combined in order to yield a narrative type description of the entire crossing episode. This description included the pedestrian's gait, scanning behavior, and an indication as to the presence and proximity of vehicles in each lane the pedestrian entered.

Vehicle data were collected at two levels of specificity: (1) aggregate vehicle flow and (2) vehicle speed data. Aggregate vehicle flow is simply a hand coded summary of the traffic patterns existing at the intersections defining or bounding the study sites. It includes through and turning vehicle movements sampled over several random periods during the day. Vehicle speed data was collected via time-lapse photography and, in some instances, the Traffic Evaluator System (TES).*

In addition to the above noted data collection techniques, a series of surveys were also employed. These surveys were directed at determining the pedestrians', merchants', and residents' opinions of the various countermeasures, both in terms of presumed effectiveness and acceptance.

Table 2-4 presents a summary of the data collection procedures used in the behavioral evaluation of the countermeasures.**

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*For a description of the TES, see: Sanders, J.H., & Ganslaw, M.J. Diagrammatic guide signs for use on control access highways. Volume III: Traffic Engineering Evaluation of Diagrammatic Guide Signs, Part 2, I-495 (Capital Beltway)/I-70S Field Study, Appendix A: The Traffic Evaluator System. Prepared for FHWA, by BioTechnology, Inc., under Contract DOT-FH-11-7815. Washington, D.C., December 1972.

**A detailed description of the data collection techniques is presented in Appendix B "Data Collection and Analysis Procedures."

Table 2-4

Summary of Data Collection Procedures

Data Item	Definition	Purpose	Data Collection Procedures
1. Behavioral Sequence Records (BSR)	A detailed description of the entire crossing episode of a pedestrian	To reveal the crossing characteristics of pedestrians that perform undesired actions (e.g., midblock crossing, against signal, etc.)	Simultaneous filming (18 fps) and manual recording
2. Pedestrian Activity Sampling (PAS)	A record of pedestrian behaviors in a defined area of the roadway	To characterize pedestrian activities as a) hazardous, and b) countermeasure specific (e.g., sudden appearances, intersection runs, etc.)	Time-lapse photography of the area under study (2 fps)
3. Traffic Behavior (TB)	A measure of vehicle speed and headway within the site area by lane	To characterize vehicle behavior in order to determine possible interactions with, and effects of, the countermeasures	Film records of vehicles traversing a standard measurement area (18 fps)
4. Filming Special Studies (SS)	A record elaborating on a particular aspect of a countermeasure	To obtain further information on a countermeasure and its affects on pedestrian behavior	Dependent upon the countermeasure
5. Traffic Flow Tallies	A measure of vehicular volume and turning activity	To characterize the "level of service" of the streets comprising the site in order to determine possible interactions with, and effects of, the countermeasures	Manual counts taken during one green light interval per intersection leg or for a random one-minute interval at non-signalized intersections
6. Pedestrian Flow Tallies	A measure of pedestrian usage of marked and unmarked crosswalks	To characterize the "level of service" of the site and the direction of pedestrian movement in order to determine possible interactions with, and effects of, the countermeasures	Manual counts taken for five minutes at each corner of an intersection starting with the onset of the green light (or walk signal) if present
7. Timing of Light Signals	A measure of traffic and pedestrian light signal intervals	To characterize the signal timing and thus determine its possible effect on traffic and pedestrian flow	Manual timing of all light signals (vehicle and pedestrian) at an intersection
8. Manual Special Studies (SS)	A detailed description of the effects of a particular countermeasure	To elaborate on the specific effects that a particular countermeasure might have on traffic and/or pedestrian behavior	Dependent upon the countermeasure
9. Pedestrian Attitude Survey	A measure of pedestrian attitude toward, and justification for, desired and undesired behaviors (as defined by the countermeasure)	To obtain information on the motivational factors associated with desired and undesired pedestrian behavior and the conditions under which each occurs	"On-the-street" survey administration

Table 2-4 (Continued)

Summary of Data Collection Procedures

Data Item	Definition	Purpose	Data Collection Procedures
10. Merchant Survey	A measure of the perceived importance of pedestrian safety and the perceived effectiveness of the countermeasure	To determine the economic impact of and inconveniences associated with the countermeasure; to assess merchant awareness of pedestrian safety	"In-the-store" survey administration
11. Resident Survey	A measure of the perceived importance of pedestrian safety and the perceived effectiveness of the countermeasure	To assess community awareness of pedestrian safety and to elicit comments about the desirability of the countermeasure	"On-the-street" survey administration

City Participation

Several considerations directed the selection of participating cities. First, an attempt was made to secure cooperation from cities representing different geographic regions. Second, the study design required testing each of the nine countermeasures at two or more locations. In reality, the major determinant of city participation was a commitment of cooperation. Each of the cities was requested to make substantial technical and administrative contributions to the study effort. In addition, since no contract funds were available for the installation and maintenance of the countermeasures, most cities were required to install the experimental countermeasures at their own expense.

In all, eight cities participated in the experimental evaluation of the countermeasures. Needless to say, this study would have been impossible without their enthusiastic support. Table 2-5 indicates which countermeasures were tested in each of the participating cities.

Selection of Behavioral Study Sites

The selection of a site for inclusion in the study was based upon a number of factors. First, the site had to display the target behavior(s) of interest. Second, the site must have been able to physically support an appropriate countermeasure (e.g., median barrier). Finally, a location with similar characteristics must have been available for use as a control site.

Table 2-5

Countermeasure Type By City

PARTICIPATING CITIES	Preventive Markings	Median Barrier	Crosswalk Set-Back	Midblock Crosswalk	Diagonal Parking	Meter Post Barriers	Stop Line Relocation	Vendor Warning Signals	Bus Stop Relocation
D.C.	●	●		●		●	●	●	
N.Y.C.		●				●			
Miami				●	●				●
San Diego	●				●				●
San Jose							●		
Akron			●				●		
Columbus			●				●		
Toledo				●		●			

The entire site selection process generally began with a frank discussion with city highway and traffic officials. The discussion's aims were to explain the countermeasures and the extent of the city's involvement in the evaluation program. In addition, the city personnel were encouraged to explicitly state their preferences for particular countermeasures and provide insight into the political, aesthetic, legal, and social problems associated with the installation of the countermeasures.

The next step involved isolating areas in the city where the behaviors of interest might be found. Two considerations were of paramount importance at this point in the selection process. First, the city areas to be surveyed must be reduced to a manageable size and secondly, the target behaviors should occur in the same environmental setting as the associated pedestrian accidents. The considerations of area size and behavioral relevance were both addressed by reviewing the city's pedestrian accident data. Those city locations experiencing a high rate of pedestrian accidents were selected to serve as the initial survey areas. At the same time, this delineating procedure provided the city officials with some reassurance that the behavioral study was related to the safety orientation of the local highway and traffic departments.

A two-person survey team was then sent into each of the pedestrian accident areas. The team conducted a "drive-by" survey of these sites looking for one or more of the accident related behaviors of interest.

A follow-up survey of the promising sites was then conducted. Several activities occurred during this second site survey. First, the site was studied to determine the prevalence of the various behaviors of interest. Next, the site was inspected to determine if it could support one or more of the appropriate countermeasures. A further inspection was then made in order to assure that the site can provide adequate data collection opportunities (e.g., unobstructed view of the pedestrian, i.e., few tall trees, appropriate rooftop, or window observation points, etc.). If a site "passed" all of the above requirements, the survey team recorded and photographed the salient site characteristics (e.g., parking facilities and usage, roadway geometrics and design, adjacent commercial/residential mix, traffic control devices, etc.). With the site description in hand, the survey team then attempted to identify a similar site. The team proceeded along one of the streets that defined the previous site until a likely candidate was located; then the above procedures were repeated. To minimize the interaction between the Experimental and Control sites, the survey team attempted to select sites that were at least one-fifth of a mile apart. If all checked out and the sites did share the same physical and behavioral characteristics, they were designated as a candidate site pair.

After the site survey team had selected twice as many candidate site pairs as required, they summarized their findings and discussed them with city officials. After noting the recommendations emerging from the meeting, a formal site selection request was prepared.

Since we expected to employ the evaluation as a design tool, an attempt was made to vary both the specific characteristics of the countermeasure and the characteristics of the sites at which they were installed. Table 2-6 summarizes the distinctive aspects of each of the countermeasure applications in terms of design and location.*

*A detailed characterization of the behavioral study site is presented in Appendix A "Site Description."

Table 2-6

Distinctive Site and Countermeasure Characteristics

COUNTERMEASURE TYPE	SITE CHARACTERISTICS	COUNTERMEASURE CHARACTERISTICS
1. Preventive Markings	1. Number of Lanes A. 3 lanes each way B. 2 lanes each way 2. Safety Island A. Safety island present B. No safety island present 3. Type of Signals A. Traffic light but no pedestrian signals B. No signals present 4. Environmental Setting A. Commercial/residential B. Commercial – small business	1. Placement of Message A. On curb and island B. In roadway 2. "Watch for Vehicles" Sign Present A. Yes B. No
2. Median Barrier	1. Number of Lanes A. 2 lanes each way B. 3 lanes each way 2. Width of Median A. 4' wide B. 9' wide 3. Number of "T" intersections in Site A. No "T" intersections B. 4 "T" intersections 4. Environmental Setting A. Residential B. Commercial – small business	1. Height of Barrier A. 4' high B. 6' high 2. Length of Barrier A. 570' long B. 724' long 3. Continuity of Barrier A. Continuous B. Two 6' gaps at "T" intersections
3. Crosswalk Set-Back	1. Direction of Traffic Flow on Intersecting Streets A. Two 2-way roads B. One 2-way and one 1-way road 2. Left Turn Lane Present A. Yes B. No 3. Pedestrian Signals Present A. No B. Yes	1. Barriers Present A. Yes B. No 2. Number of Crosswalks Set-Back A. 2 crosswalks set back B. 3 crosswalks set back 3. "Stop Here on Red" Signal Present A. No B. Yes
4. Midblock Crosswalk	1. Number of Lanes A. 1 lane each way B. 2 lanes each way C. 3 lanes one way 2. Left Turn Lane Present A. No B. Yes C. No 3. Length of Block A. 600' long B. 360' long C. 500' long	1. Signal Present at Crosswalk A. No B. Yes C. No
5. Diagonal Parking	1. Traffic Control at Boundary Intersection A. Traffic signals B. Stop signs 2. Number of "T" Intersections in Site A. 1 "T" intersection B. No "T" intersections	1. Angle of Parking A. 30° parking angle B. 45° parking angle

Table 2-6 (Continued)

Distinctive Site and Countermeasure Characteristics

COUNTERMEASURE TYPE	SITE CHARACTERISTICS	COUNTERMEASURE CHARACTERISTICS
6. Meter Post Barriers	1. Number of Lanes A. 2 lanes each way B. 2 lanes each way C. 3 lanes one-way 2. Length of Block A. 280' long B. 296' long C. 506' long	1. Number of Meter Posts A. 6 on one side B. 9 on one side, 10 on the other C. 8 on one side 2. Type of Construction A. 1 chain B. chain link 36" high C. 3 chains
7. Stop Line Relocation	1. Pedestrian Signals Present A. Yes B. Yes C. No D. Yes 2. Crosswalk Present A. Yes B. Yes C. Yes D. No 3. Environmental Setting A. Commercial/residential B. Commercial C. Commercial D. Residential	1. Number of Stop Lines Set-Back at Intersection A. 4 stop lines set back B. 4 stop lines set back C. 2 stop lines set back D. 4 stop lines set back 2. Number of Feet set back A. 16' from crosswalk B. 16' from crosswalk C. 12' from crosswalk D. 30-36' from corner 3. "Stop Here on Red" Sign Present A. No B. No C. No D. Yes
8. Vendor Warning Signal	1. Number of Lanes A. 2 lanes each way B. 1 lane each way 2. Environmental Setting A. Commercial/residential B. Residential	1. Signal Design A. Black figure, illuminated background B. Black background, illuminated figure
9. Bus Stop Reloaction	1. Direction of Traffic Flow on Intersecting Streets A. Two 2-way roads B. One 2-way road and one 1-way road 2. Type of Signals A. No signals present B. Traffic and pedestrian signals present 3. Left Turn Lane Present A. Yes B. No 4. Environmental Setting A. Commercial/residential B. Commercial	1. No Distinctive Countermeasure Characteristics

Experimental Design

Simply stated, the experimental paradigm was of pre-post design with a control group. Data were collected at both the Control and Experimental (installation) site before the installation of the countermeasure and then again three months after the installation. The data were collected simultaneously at both sites in the "Before" phase and then in the "Post" phase. Data were collected on the same day of the week at the same time of day, in both the Before and Post studies. The Before and Post studies each consisted of two days of data collection. Table 2-7 indicates the type and amount of data collected during each of these data collection days. Although the preliminary focus of the evaluation was aimed at determining the long range behavior effects of the countermeasure, the stabilization or transition period following the installation of the countermeasure was also of import. For example, the novelty effect associated with the countermeasure may indicate the need for an enforcement and information campaign, or shed some light on the design characteristics of the countermeasures. Because of the potential social and economic impact of these transient phenomena, a refinement was added to the basic experimental design.

Table 2-7

Data Collected by Day Per Site

Day	Data Type	# Collection Periods Per Day	Length of Collection Period (minutes)	Total Time Per Day (minutes)	% Time Sample Per 8-Hour Day
1	BSR	35	5	175	36
	PAS	21	5	105	22
	Traffic Speed	7	5	35	7
	Traffic Flow	7	5	35	7
	Ped Flow	7	20	140	29
2	BSR	12	5	60	13
	PAS	16	5	80	17
	Traffic Speed	4	5	20	4
	Special Studies Camera	4	10	40	8
	Special Studies Manual	4	25	100	21
	Interviewing	1	240	240	50
	Traffic Evaluator (opt.)	1	180	180	38

At each of the Washington, D.C. sites, acclimation data were taken approximately one week and one month after the installation of the countermeasures. Both of these Acclimation phases consisted of one day of data collection (Day 1). This data collection day corresponded to the same day of the week as Day 1 of the Before and Post studies. The Acclimation data were also simultaneously collected at the Control and Experimental sites.*

Analysis Procedures

The data analysis is a direct outgrowth of the experimental design described in the preceeding sections. The basic analysis design was, therefore, a two by two factorial as illustrated in Figure 2-1. This structure may be somewhat misleading from a statistical standpoint, since it implies the prospect of the use of the F-test, the availability of a within-cell variance as an error term, and the prior aggregation of scores across sites. In fact, an overall Analysis of Variance design is inappropriate for the simple reason that, in every case, either the experimental treatment varied or there were substantial differences in site factors. What we do have is a series of separate experiments, the results of which can be aggregated at the level of the direction of gross outcome, but not at the microanalytic level of the Analysis of Variance.

	BEFORE	POST
EXPERIMENTAL	1	2
CONTROL	3	4

Figure 2-1. Basic experimental and analytic structure.

*On occasion, the data collection schedule and procedures departed form those indicated in the preceding discussion. In such cases, the changes are indicated at the appropriate point in the text.

For each experiment, three types of comparisions could be made as follows:

1. 1 versus 3: this provides a check against the accuracy of the site configuration matching procedure.
2. 1 versus 2: this provides a gross indication of the impact of the intervention.
3. 3-4 versus 1-2: this comparison provides a rigorous indication of the impact of intervention with the time element effectively factored out and the effects of confounding variables minimized.

Our major effort involves the type "3" comparison because this analysis utilizes most of the available data. However, not all of the collected data were considered during the analysis. In computing the statistics, only those data collection periods common to the Control and Experimental sites in both the Before and Post phases were used. If, for example, PAS periods 20 and 21 were lost at the Control site in the Before phase, these periods would be deleted from the Control-Post, Experiment-Before, and Experimental-Post, before making any comparison.

In most cases, the behavioral data were converted to proportions, i.e., the proportion of vehicles or pedestrians performing a particular activity. The conversion to proportions reduced the likelihood of spurious results due to unpredictable changes in vehicle or pedestrian volumes. A "Z" test for uncorrelated proportions was employed to determine the statistical significance of the data. The "Z" test treated the difference in the Control site (Post-Before) as anticipated population changes and, therefore, effectively adjusted the changes in the Experimental site by the appropriate value. In several instances, "t" tests for uncorrelated means were employed. Here, once again, the mean difference at the Control sites were used to reduce or augment the mean differences obtained at the Experimental sites. In the case of both the "Z" and "t" tests, population variances were estimated on the bases of the sample variances for the Experimental sites. Occasionally, a "X^2" test, with Yates correction, was performed on frequency data. These "X^2" corresponded to the two by two table in Figure 2-1 (1 degree of freedom).

For the purposes of these analyses, the definition of statistical significance was confined to differences beyond the .05 level (two-tailed for "Z" and "t" tests).

CHAPTER 3

DATA ANALYSIS AND RESULTS

This chapter is divided into nine major sections. Each section deals with a particular countermeasure. These major sections are further subdivided into the following subsections:

1. Salient Site and Countermeasure Characteristics
2. Behavioral Changes
3. Pedestrian Motivational Factors
4. Merchant/Resident Reaction

The organization of several subsections deserves special comment. In subsection 2 (Behavioral Changes), a set of "Expected" outcomes were enumerated for each of the countermeasures. The outcomes were developed to reflect the fact that the countermeasures were hypothesized to impact on quite specific accident-related behaviors. The verification of these behavioral outcomes was viewed as *a priori* evidence of the effectiveness of the countermeasure. A second category of outcomes entitled "Post Hoc" was also considered. The "Post Hoc" outcomes were those unanticipated results that emerged from the data analyses. Often, these "Post Hoc" outcomes were indicative of perturbance in traffic or pedestrian flow and, as such, had a tenuous relation to pedestrian safety. On occasion, however, accident-related behaviors were unexpectedly modified by the countermeasure and these cases were also included in the "Post Hoc" category.*

The behavioral data were reported in a series of tables. These tables indicate, by the use of an arrow, the statistically significant findings of the evaluations. The tables are divided into two parts: "Expected" outcomes for a countermeasure; and "Post Hoc" outcomes that demonstrated a statistically significant change. The statistical tests were based on the net change in the percent of a particular behavior. Calculating this change involved the following:

Net Change = (Post Experimental-Before Experimental) –
(Post Control-Before Control)**

*The division of behavioral changes into "Expected" and "Post Hoc" hopefully will not obscure the fact that the utility of the countermeasures should be based on their successful modification of accident-related behaviors and not on whether these modifications were predicted by the author.

**The actual percent values in the formula are presented in Attachment B.

In those cases where the Net Change was statistically significant, the cell was shaded. The direction of a significant change can be determined by the direction of the arrow: a "↑" indicates the behavior increased, while a "↓" indicates a decrease in that behavior.

Subsection 3 (Pedestrian Motivational Factors) focuses on the frequent (>5%) responses to the pedestrian surveys administered as part of the behavioral evaluation. The survey results are presented in a series of tables. Each table was divided into two major components. The first component consists of the responses of all those pedestrians who crossed in a particular manner before the installation of the countermeasure (aggragated across Control and Experimental sites at all locations).* A second component of the tables represents the responses of the pedestrians who crossed in a particular manner at the Experimental sites after the installation of the countermeasures.

Subsection 4 (Merchant/Resident Reaction), also divided into two parts, consists of a summary of the frequent (>5%) responses of business managers and local residents to the countermeasure. All of the merchant/resident surveys were conducted after the installation of the countermeasure. Part 1 of the tables consists of the aggregated data for the Control locations, while Part 2 is the aggregated data for the Experimental locations. The merchants/residents at the Control location were shown a picture of the countermeasure and asked to speculate on the effects of such a roadway treatment.

Table 3-1 provides some indication of the type and scope of the data used in the analyses. The reader will note that, although approximately 15,000 pedestrians were scored in the PAS data mode, 1,600 in the BSR mode, and 2,300 interviewed, some sites had few subjects due to light pedestrian volume. The reader should consider the results of the statistical tests in light of the intersite differences in sample size.

Preventive Markings

Salient Site and Countermeasure Characteristics

The Preventive Markings countermeasure was tested at two locations: Washington, D.C. and San Diego.** The Control and Experimental sites in D.C. were located at the intersection of two main urban arterials. The more heavily traveled street was a two-way, four-lane roadway on one approach to the intersection and a two-way, six-lane roadway on the other approach

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*Since the responses across sites were relatively consistent, the aggregation of the survey data was deemed justifiable.

**A detailed characterization of the sites is presented in Appendix A, "Site Descriptions".

Table 3-1

Summary of Field Data Collected

Countermeasure Types and City	Experimental (E) or Control (C)	# of Data Days	TES Used	# of Usable Surveys Ped (Residents/Merchants)	#of Usable BSR's	# of Pedestrians in PAS	# of Veh. for Speed
1. Preventive Marking							
Washington, D. C.	E	8	Yes	140 (—)	36	835	6441
	C	8	Yes	58 (—)	46	578	3327
San Diego	E	4	No	58 (—)	59	59	100
	C	4	No	20 (—)	31	63	100
2. Median Barrier							
Washington, D. C.	E	8	Yes	41 (14)	29	104	3038
	C	8	Yes	37 (13)	49	158	2360
New York City	E	4	No	68 (12)	56	169	100
	C	4	No	22 (13)	73	181	100
3. Crosswalk Set-back							
Akron	E	4	No	54 (6)	20	78	100
	C	4	No	21 (4)	21	64	100
Columbus	E	4	No	64 (8)	20	154	100
	C	4	No	36 (6)	34	173	100
4. Midblock Crosswalk							
Washington, D. C.	E	8	Yes	91 (—)	142	575	1811
	C	8	Yes	34 (—)	84	507	1502
Miami	E	4	No	104 (15)	64	91	100
	C	4	No	31 (15)	28	169	100
Toledo	E	4	No	116 (—)	78	243	100
	C	4	No	41 (—)	72	169	100
5. Diagonal Parking							
Miami	E	4	No	— (—)	55	381	100
	C	4	No	— (—)	53	930	100
San Diego	E	4	No	12 (15)	15	27	100
	C	4	No	6 (15)	19	18	100
6. Meter Post Barriers							
Washington, D. C.	E	8	Yes	83 (15)	34	118	1929
	C	8	Yes	54 (8)	37	126	2097
New York City	E	4	No	103 (6)	73	84	100
	C	4	No	52 (4)	69	238	100
Toledo	E	4	No	87 (14)	44	58	100
	C	4	No	57 (6)	35	180	100
7. Stop Line Relocation							
Washington, D. C.	E	8	Yes	64 (—)	17	515	4540
	C	8	Yes	47 (—)	8	406	3313
San Jose	E	4	No	47 (—)	18	79	100
	C	4	No	22 (—)	21	81	100
Akron	E	4	No	102 (—)	59	2235	100
	C	4	No	40 (—)	40	870	100
Columbus	E	4	No	89 (—)	39	86	100
	C	4	No	42 (—)	34	73	100
8. Vendor Warning Signal							
Washington, D. C. Site 1	E & C	1	Yes	48*	—	—	880
Washington, D. C. Site 2	E & C	1	Yes	50*	—	—	134
9. Bus Stop Relocation							
Miami	E	4	No	4 (1)	0	85	100
	C	4	No	4 (5)	0	44	100
San Diego	E	4	No	54 (9)	5	2127	100
	C	4	No	33 (4)	15	1783	100
TOTALS	(E) = 22 (C) = 22	204 (408 people days)	14 (Yes) 30 (No	2136 (208)	1632	14909	34392

*Driver Surveys

(parking prohibited during the day). The word "CAUTION" was printed in six-inch yellow letters on the curb and on the raised median in one of the crosswalk areas of the more heavily traveled street. A black on white sign reading "Watch For Vehicles" was affixed to the utility poles adjacent to the crosswalk. The buildings abutting the D.C. sites were commercial and multi-story apartments.

In San Diego, the treated crosswalk was on a two-way, four-lane urban arterial, with metered parking on both sides. At the Experimental site, the intersecting street was a one-way, three-lane street leaving the intersection and a two-way, two-lane street on the other side of the intersection. The word "CAUTION" was painted in six-inch white letters in the roadway several feet from the curb. The buildings abutting the sites were small store front businesses. The pedestrian and vehicle volume at the San Diego sites were substantially lower than the D.C. sites. Unlike the D.C. sites, the San Diego sites were not signalized.

Behavioral Changes

In this section, we will first present a verbal summary of the expected and obtained behavioral changes and then attempt to explain each of the results in terms of causal factors. Table 3-2 indicates the Post versus Before behavioral changes associated with the Preventive Markings countermeasure. As indicated in Chapter 2, the Post data were collected approximately three months after the installation of the countermeasure. A synopsis of the behavioral data follows:

Expected

1. Pedestrian scanning of traffic – no significant change (an increase was expected).*
2. Crossing entirely against the traffic signal – no significant change in D.C. where the intersections were signalized (a significant decrease was expected).
3. Vehicle/pedestrian separation – no significant change (an increase in gap was expected).**
4. Running from the curb or parking lane into the first traffic lane – no significant change (a decrease was expected).
5. Vehicles turning within one car length of a pedestrian, where the pedestrian is in the direct path of the vehicle. (Turning Conflict –1) – a significant decrease at the D.C. location.
6. Pedestrians in the path of and within one car length in front of a turning vehicle (Turning Conflict –3) – significant decrease in D.C.

*See Attachment B for the actual percentages.

**This measure consisted of the percent of pedestrians assigned a Hazard Index of "C" for their entire crossing (see page 2-6).

Table 3-2

Behavioral Changes by Countermeasure Installation Preventive Markings*
(Post – Before)

	Countermeasure Location:	D.C.	San Diego
Expected	SCANNING TRAFFIC	**	**
	CROSSING AGAINST LIGHT SIGNAL		N/A
	VEHICLE/PEDESTRIAN SEPARATION		
	RUNNING INTO ROADWAY		
	TURNING CONFLICT–1 (VEHICLES)	↓***	***
	TURNING CONFLICT–3 (PEDESTRIANS)	↓	
Post Hoc	TRAPPED ON MEDIAN	↓	
	LEAVING CROSSWALK	↓	
	NUMBER OF OBSERVATIONS	752	115

*A significant increase in a particular behavior is designated by a "↑" while a significant decrease is "↓".
**Based on 76 observations in D.C. and 232 in San Diego.
***Based on 302 turning vehicle observations in D.C. and 104 in San Diego.

Post Hoc

1. Vehicle induced pedestrian hesitation on the median – significant decrease in D.C.

2. Leaving crosswalk in one of the traffic lanes – significicnat decrease in D.C.

Pedestrian scanning data were derived from the BSR film records. The computation of the percent was derived as follows. Each pedestrian could have scanned once before entering each traffic lane (scanning opportunity). If there were 15 pedestrians filmed in a particular study phase on a four-lane road, there would be 60 scanning opportunities (15 x 4). The values in the tables are based on the percent of scanning opportunities utilized. Although there was a slight positive change at both the D.C. and San Diego locations, no significant increase in overall scanning was detected at either site. A more detailed analysis of the scanning data indicated that neither scanning before entering the first traffic lane nor scanning before crossing into the second half of the roadway was significantly increased by the addition of the countermeasure.

Crossing entirely against the traffic light was not significantly reduced at the signalized location (D.C.). No true test of this variable was possible due to the near zero occurrence of the behavior in the Before phase. The behavioral studies conducted throughout this project indicated the relatively low rate of crossing against the signal at all 14 signalized intersections.

The vehicle/pedestrian separation, or gap, accepted by pedestrians did not significantly increase. The definition of vehicle/pedestrian separation was based on the Hazard Index discussed in Chapter 2. The percent of pedestrians whose crossing did not entail any appreciable hazard (Hazard Index of C) was the proportion utilized for this test. We also hypothesized that the Preventive Markings would decrease the percent of pedestrians running into the first traffic lane; no such decrease was detected.

Significantly smaller percent of vehicles in D.C. were involved in turning conflicts with pedestrians. These results were not due to changes in pedestrian or vehicle volumes. This significant decrease is consistent with the decrease in the percent of pedestrians involved in turning conflicts with vehicles (Turning Conflict –3).

The reader should note that turn/merge conflicts could only occur in that half of the crosswalk spanning the eastbound traffic lanes. An analysis of the PAS films indicated that the countermeasure's influence on turn/merge conflicts depended on the direction of the pedestrian's travel. There was a larger decrease (approximately twice as great) for those pedestrians who crossed the median in order to enter the turn/merge area. These pedestrians were exposed to the countermeasure at the curb and again at the median. Pedestrians traveling in the opposite direction encountered the countermeasure only once before entering the turn/merge area. In San Diego, the countermeasure was located near the curb in the roadway and thus was probably only seen once during the pedestrians' crossing. The possible reinforcing effect associated with the second exposure may also account for the significant increase in the number of pedestrians who hesitated on the median waiting for the passage of at least one vehicle.

In D.C., a significantly smaller percent of pedestrians left the crosswalk after the installation of the countermeasure. Once again, leaving the crosswalk generally occurred in the second half of the crossing and, as such, the pedestrians would have encountered the Preventive Markings on two occasions.

A few comments relative to Table 3-2 are in order. First, we should note that the significant behavioral changes were restricted to the D.C. location. The lack of replication is probably due to a combination of the following factors: (1) the spurious nature of some of the D.C. results, (2) site- and countermeasure-specific factors that differentially affected behavior, and (3) low statistical power of our tests in San Diego (small sample size).

Table 3-3 reveals the behavioral changes occurring between the Before and each of the two Acclimation phases in D.C. As previously indicated, Acclimation 1 data were collected approximately one week after the installation of the countermeasure and Acclimation 2 data were collected approximately one month later. The results from the two Acclimation studies were not consistent.

Table 3-3

Behavioral Changes by Countermeasure Installation
Preventive Markings: Washington, D.C.
(Acclimation – Before)

	Phase:	Acclimation 1	Acclimation 2
Expected	SCANNING TRAFFIC	↑ *	*
	CROSSING AGAINST LIGHT SIGNAL		
	VEHICLE/PEDESTRIAN SEPARATION		
	RUNNING INTO ROADWAY		
	TURNING CONFLICT–1 (VEHICLES)	**	**
	TURNING CONFLICT–3 (PEDESTRIANS)		
Post Hoc	LEAVING CROSSWALK	↓	
	NUMBER OF OBSERVATIONS	443	510

* Based on 60 observations in Acclimation 1 and 92 in Acclimation 2.
** Based on 181 turning vehicle observations in Acclimation 1 and 262 during Acclimation 2.

Significant changes in scanning and leaving the crosswalk were found in the first Acclimation study. The decrease in the percent of pedestrians leaving the crosswalk was consistent with the Post-Before data previously discussed. Although an increase in scanning was predicted for the Preventive Marking countermeasure, this increase was only detected in the Acclimation

1-Before comparison and is therefore somewhat suspect as a long term effect. No significant differences were found in the Acclimation 2-Before comparisons.

The effects of the Preventive Markings on vehicle speed was evaluated by collecting speed data before and after the installation of the countermeasure at both the Experimental and Control sites. As expected, the Preventive Markings did not significantly affect vehicle speed.

Pedestrian Motivational Factors

Table 3-4 is a summary of the frequent responses given to our pedestrian survey. The table represents those pedestrians who crossed the street in a desired manner, i.e., in the crosswalk (and waited for the signal in D.C.).

Table 3-4

Frequent Survey Responses for Pedestrians
Performing Desired Actions
Preventive Markings

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 181)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 181)	REASON FOR DESIRED ACTION (N = 66)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N =66)
34% Safer	29% If lighter traffic	27% Safer	73% Did not notice it
19% Illegal to cross elsewhere	28% Usually not or never (at this location)	21% Illegal to cross elsewhere	17% Had no effect
9% Heavy traffic	15% If in a hurry	18% So not to be hit	5% Were more alert
9% Habit		15% Habit	5% Were more aware of dan---
		11% Heavy traffic	
		9% Convenience	
		5% To ensure right of way	

*Crossing within the boundaries of the marked crosswalk with the pedestrian signal.
**Crossing against the pedestrian signal outside of the marked crosswalk boundaries. (No signal is present in San Diego.)

Before the installation of the countermeasure, safety (34%) and legality (19%) were the most frequently stated reasons for crossing in a desired manner. The respondents also indicated that they would only consider crossing outside the crosswalk and/or against the signal if traffic was lighter (29%). Most of the individuals noted that the high traffic volumes and small vehicle gaps precluded them from crossing in any other manner. Another large segment of the respondents (28%) stated that they would not cross in other than the desired way at these study locations. Fifteen percent (15%) volunteered that they would cross outside of the crosswalk and/or against the signal if they were in a hurry.

After the installation of the countermeasure, the most frequent reasons for performing the desired actions was still safety (27%) and legality (21%). When specifically queried about the effect of the countermeasure on their crossing behavior, 73% of the respondents stated that they had not noticed the markings. While 17% indicated that although they had seen the markings, they had no effect on the pedestrians' crossing behavior. A small percent of the sample said that the markings made them more alert to traffic (5%) and more aware of potential dangers (5%).

Table 3-5 is a summary of the frequent responses given by those pedestrians who crossed outside of the crosswalk (and/or against the signal in D.C.). The most frequent reasons for performing the undesired actions prior to the installation of the countermeasure were that the pedestrian was in a hurry (50%) or that the pedestrian saw and accepted a gap in the traffic (23%). Twelve percent (12%) of pedestrians thought that the traffic signal had changed and another 12% anticipated that the signal was about to change and began to cross. Both of these signal-related responses were obtained at the D.C. sites where the intersection was signalized. (However, no pedestrian signal was present.)

Each of the pedestrians crossing in an undesired manner (before installation) was questioned as to the conditions which would cause him to cross at the crosswalk and/or with the traffic signal. Thirty-five percent (35%) stated that they generally do cross in a desired manner, 31% indicated they would do so if the traffic were heavier, 19% would if not in a hurry, and 12% would if it was unsafe to cross in an undesired manner.

Unfortunately, because of poor weather conditions, only three pedestrians performing the undesired action after the countermeasure was installed were interviewed. None of these three pedestrians notice the markings.

A comparison of the individuals using the crosswalk and/or crossing with the signal versus those individuals who violated the crosswalk and/or signal provides some interesting insights into the motivational factors underlying various pedestrian actions. A picture emerges of a safety conscious subpopulation of pedestrians who consistently perform the desired action versus a subpopulation of pedestrians whose behavior is more contingent on convenience. An analysis of the characteristics of these two groups indicates no significant sex differences. The group performing the undesired actions was, on the average, slightly younger (33 versus 37 years old), perhaps indicating a greater propensity for risk taking on the part of the young.*

Table 3-5

Frequent Survey Responses for Pedestrians Performing Undesired Actions Preventive Markings

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 26)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 26)	REASON FOR UNDESIRED ACTION (N = 3)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 0)
50% In a hurry	35% Usually does	67% In a hurry	Countermeasure was not noticed by anyone interviewed
23% Break in traffic	31% If heavier traffic	33% Break in traffic	
12% Did not see lights changing	19% If not in a hurry		
12% Thought lights about to change	12% If unsafe to cross otherwise		
8% Convenience	4% If pedestrian signals were present		
8% Signal too short			

*Crossing against the pedestrian signal outside of the marked crosswalk boundaries. (No signal is present in San Diego.)
**Crossing within the boundaries of the marked crosswalk with the pedestrian signal.

Merchant/Resident Reaction

The merchant and resident interviews were designed to reveal the social and economic impact of the countermeasure. Because of the relatively nonreactive nature of Preventive Markings, there appeared to be no reason to survey the merchants and residents.

*This difference was significant at the .1 level (1 tail) and was computed on the basis of the 198 surveys administered at the D.C. sites.

Median Barrier

Salient Site and Countermeasure Characteristics

The Median Barrier countermeasure was tested at two locations: Washington, D.C. and New York City. Both the Washington, D.C. and New York City sites were located along high volume urban arterials in close proximity to private and public elementary schools.

The Washington, D.C. site (Control and Experimental) were two-way, four-lane roadways (with unrestricted parking on both sides) divided by a four-foot wide curb-height median. Buildings abutting the sites were single and multi-family row houses. The barrier was continuous 532-foot long, chain link fence four feet in height. The sites were bounded by signalized intersections.

In New York City, the sites were two-way, six-lane streets (with metered parking on both sides) divided by a nine-foot wide curb-height median. Each site included several one-way streets that intersected with the study area. Through movements on these intersecting streets were restricted by the presence of a continuous median. The study areas were bounded on both sides by signalized intersections. The barrier was a 697-foot long, chain link fence six feet in height. Two seven-foot openings in the barrier permitted pedestrians to cross the median at the two intersecting streets. Buildings abutting the sites were store front businesses.

Behavioral Changes

Table 3-6 indicates the Post versus Before behavioral changes associated with the Median Barrier. A verbal synopsis of the expected and achieved changes follows:

Expected

1. Running from median into the second half of the roadway – no statistically significant change.*
2. Midblock (nonintersection) crossings – significant decrease at both locations.
3. Entering roadway in front of parked vehicles – significant decrease at both locations.
4. Running in the roadway – significant decrease in NYC.

*See Attachment B for the actual percentages.

Table 3-6

Behavioral Changes by Countermeasure Installation
Median Barrier
(Post – Before)

	Countermeasure Location:	D.C.*	N.Y.C.
Expected	RUNNING INTO 2nd HALF		
	CROSSING IN MIDBLOCK	↓	↓**
	IN FRONT OF PARKED VEHICLES	↓	↓
	RUNNING IN ROADWAY		↓
Post Hoc	VEHICLE/PEDESTRIAN SEPARATION		↑
	TRAPPED ON MEDIAN	↓	↑
	VEHICLE INDUCED HESITATION(PARKING LANE)		↓
	NUMBER OF OBSERVATIONS	193	300

*Due to low pedestrian crossing volume after installation of the countermeasure, X^2 tests, instead of the test of proportions, were made on the Washingtion, D.C. data.

**The median barrier in New York City was constructed with two gaps at intersecting side streets (see site diagram). Based on 482 observations, there was a significant decrease in the proportion of pedestrians crossing to the median in midblock between the intersecting side streets. The D.C. data are based on 102 observations.

Post Hoc

1. Vehicle/pedestrian separation – significant increase at the NYC site.
2. Trapped on median – significant decrease in D.C. and a significant increase in NYC.
3. Vehicle induced hesitations (parking lane) – significant decrease in NYC.

Running into the second half of the roadway was not statistically reduced as expected. The initial low incidence of this behavior in D.C. and NYC (in fact, at all of the 42 locations studied during the course of this project) reduced the likelihood of detecting a change. Additionally, there were spontaneous reductions of this behavior at the D.C. Control site during collection of the Post data. It is intuitively obvious that a properly constructed, continuous barrier would reduce the number of pedestrians running into the second half of the roadway.

In D.C., for example, six cases of running into the second half were observed before installation and zero after installation. By tripling our sampling time, we would have been able to detect a difference of this magnitude.

Nonintersection crossings were reduced at both locations as anticipated. In D.C., there were 83 midblock crossings in the Before phase and seven in the Post phase (all seven crossed half way and then walked down the median to one of the crosswalks). In NYC, this change was less pronounced due to the presence of the two intersecting streets and openings in the barrier. Those pedestrians who entered the roadway 20 feet or more from the intersecting streets were scored as making nonintersection crossings.

Entering in front of parked vehicles was reduced at both locations as expected. In D.C., most pedestrians did not cross the roadway midblock and, consequently, did not enter in front of parked cars. Once again, the change in NYC was smaller due to the intersecting streets and vehicle parking in the vicinity thereof.

The percentage of pedestrians running in the roadway decreased in NYC. This decrease appeared to be related to the increased incidence of hesitations on the median and the net increase in vehicle/pedestrian separation. A nonsignificant decrease was also noted in D.C. (from six cases to one case).

The vehicle/pedestrian separation unexpectedly increased at the NYC site. The net increase was the result of a decrease in the size of accepted gaps at the Control site.

Fewer pedestrians stood on the median and waited for the passage of at least one vehicle at the D.C. installation. This decrease in hesitations is related to the overall decrease in pedestrians crossing the median. In NYC, there was an increase in the percent of pedestrians who hesitated on the median. Most of the pedestrians in NYC hesitated in the vicinity of the openings in the barrier before entering the second half of the roadway.

In NYC, the Median Barrier reduced the percentage of pedestrians who waited in the parking lane for the passage of at least one vehicle. After the installation of the barrier, the pedestrians more frequently hesitated on the sidewalk near the corners rather than in the parking lanes. Although not statistically significant, a decrease from eight to zero hesitations was noted at the Experimental site in D.C.

Table 3-7 presents the behavioral changes occurring during the Acclimation periods at the D.C. site pair. As can be seen, the results were consistent with the Post-Before data. Entry in front of parked vehicles, and trapped on the median were both significantly reduced. Running into the second half of the roadway and running in the roadway were not significantly modified.

Table 3-7

Behavioral Changes by Countermeasure Installation
Median Barrier: Washington, D.C.
(Acclimation – Before)

	Phase:	Acclimation 1 *	Acclimation 2 *
Expected	RUNNING INTO 2nd HALF		
	CROSSING IN MIDBLOCK	N/A **	N/A **
	IN FRONT OF PARKED VEHICLES	↓	↓
	RUNNING IN ROADWAY		
Post Hoc	TRAPPED ON MEDIAN	↓	↓
	NUMBER OF OBSERVATIONS	117	134

*Due to low pedestrian crossing volume after installation of the countermeasure, X^2 tests, instead of the test of proportions, were made on these data.

**Special Studies were not collected during the Acclimation phases.

In D.C., a significant increase in vehicle speed was detected (net change of 0.99 mph), while no significant change was noted in NYC. The speed increase in D.C. was entirely attributable to a –0.95 mph decrease at the Control site. On the bases of the above findings, we could conclude that the installation of the Median Barriers did not significantly inpede traffic flow.

Pedestrian Motivational Factors

Table 3-8 indicates that a substantial number of the pedestrians using the crosswalks (desired behavior) believed that this was the safest way to cross (26%) before the installation of the barrier. The majority of the crosswalk users also stated that they seldom if ever consider crossing elsewhere (52%). On the other hand, 17% of the pedestrians indicated that they would cross midblock if they were in a hurry. After the installation of the barrier, most pedestrians (61%) identified the barrier as the reason for using the crosswalk. When asked whether the barrier affected the *manner* in which they crossed the street, 52% stated that it had no effect, while 48% indicated that the only effect was that it forced them to cross at the corner.

Table 3-8

Frequent Survey Responses for Pedestrians
Performing Desired Actions
Median Barrier

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 23)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 23)	REASON FOR DESIRED ACTIONS (N = 44)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 44)
26% Safer	52% Usually not or never (at this location)	61% Because of fence	52% Had no effect
17% Illegal to cross elsewhere	17% If in a hurry	11% Habit	48% Had to go to corner
17% Conveneince	9% If lighter traffic	7% Convenience	
13% Is not in a hurry	9% Elsewhere		
9% So not to be hit			
9% Set an example for children			
9% Habit			

*Walking through the site area and then crossing at the corner at right angles to the median.
**Crossing at other than the corner.

Table 3-9 indicates that the majority of pedestrians (61%) crossing midblock (undesired behavior) before the installation of the barrier did so out of convenience. Thirty-three percent (33%) indicated that they would only use the crosswalks if midblock traffic was extremely heavy. Another 20% of the pedestrians indicated that they would use the crosswalks if it was convenient to do so. After the installation of the barrier, 32% of the pedestrians making mid-block crossings stated that inconvenience was the major factor, with heavy turning traffic at the corners coming in a close second (23%). Generally, older pedestrians were more concerned about this problem and many cited accidents involving turning vehicles in the recent past. Fifty percent (50%) of the respondents indicated that the barrier did not affect the manner in which they crossed, while 23% indicated that they had to walk along the median until they reached the end of the barrier or an opening before completing their crossing.

Table 3-9

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Median Barrier

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 80)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 80)	REASON FOR UNDESIRED ACTION (N = 22)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 22)
61% Conveneince	33% If heavier midblock traffic	32% Conveneince	50% Had no effect
13% Heavy corner traffic	20% If convenient	23% Heavy traffic at corner	27% Had to walk to corner
8% Habit	15% Usually not or never (at this location)	9% Habit	23% Had to walk along the median
8% Light midblock traffic	9% Usually does	9% In a hurry	
8% In a hurry	5% If not in a hurry		
5% Signal too short			

*Crossing at other than the corner.
**Walking through the site area and then crossing at the corner at right angles to the median.

Once again, a picture emerges of a safety conscious subpopulation of pedestrians who consistently use the crosswalks versus a subpopulation of pedestrians whose behavior is more contingent on convenience. A closer look at these two subpopulations did not reveal significant age or sex differences.

Merchant/Resident Reaction

Table 3-10 is based on the survey responses of the merchants at the NYC sites. This table indicates that the merchants at the Control site generally did not identify any specific conditions adversely affecting business or causing inconvenience to customers or employees (73% and 82%, respectively). When shown a picture of the barrier, 73% of these merchants indicated that they would not expect the countermeasure to hinder their business. Eighteen percent (18%), however, specifically stated that the barrier would discourage business by making it more difficult to cross the street.

At the Experimental site (Table 3-10), 42% of the merchants singled out the barrier when asked about traffic or roadway problems. In addition, 17% of the merchants specifically stated that the barrier blocks direct access to the business. Similarly, when asked about inconveniences caused by traffic or roadway conditions, 25% stated that the barrier hindered customers from crossing the street, 8% stated that customers would not walk around the barriers, and 8% stated that customers could not locate the openings in the barriers. When specifically asked about the barrier, 58% of the merchants indicated that its major effect was to discourage customers from shopping both sides of the street.

Table 3-10

Frequent Survey Responses for Merchants
Median Barrier

CONTROL SITE			EXPERIMENTAL SITE		
Conditions Affecting Business (N = 11)	Conditions Causing Inconvenience (N = 11)	Perceived Effect of the Countermeasure (N = 11)	Conditions Affecting Business (N = 12)	Conditions Causing Inconvenience (N = 12)	Perceived Effect of the Countermeasure (N = 12)
73% None	82% None	73% None	42% The barrier	33% None	58% More difficult to cross street
9% Speeding traffic	9% Not enough parking	18% More difficult to cross street	33% None	25% People want to cross street	42% None
9% Unsynchronized traffic lights	9% Unsynchronized traffic lights	9% Would block vision of store	17% Barrier blocks direct route across street	8% People won't walk around barrier	
9% Trees block view of business				8% People can't find gaps in barrier	
				8% Ped. signals too short at corner	
				8% Too many accidents at corner	
				8% Not enough parking	

From the above results, it appears that the Median Barrier presents formidable problems, whether real or imagined, for the merchant. In general, the merchants felt that the barrier would inhibit trade. Several merchants specifically stated that they had received complaints from customers. These complaints were from customers who had to carry parcels around the barrier in order to get to their vehicles. It is also interesting to note that the merchants at the Control sites did not foresee many of the problems that arose at the Experimental site.

Table 3-11 indicates that the majority (64%) of the residents at the Experimental site in D.C. did not mention the barrier when queried about adverse traffic or roadway conditions. Sixty percent (60%) of the residents at the Control sites and 69% at the Experimental sites felt that the barrier would reduce pedestrian accidents. Additionally, the vast majority of the respondents at the Control and Experimental sites did not state any misgivings about the barrier (93% and 86%, respectively). It is interesting to note that several parents voiced their approval of the countermeasure to a D.C. maintenance crew repairing the barrier. Although no residents were surveyed at the NYC sites, many of the pedestrians in NYC did live on, or near, the site area. Some of these pedestrians complained about the inconvenience and unsightly appearance of the barriers.

Table 3-11

Frequent Survey Responses for Residents
Median Barrier

CONTROL SITE			EXPERIMENTAL SITE		
Traffic Conditions Disliked (N = 15)	Reduction of Pedestrian Accidents (N = 15)	Countermeasure Related Dislikes (N = 15)	Traffic Conditions Disliked (N = 14)	Reduction of Pedestrian Accidents (N = 13)	Countermeasure Related Dislikes (N = 14)
80% None	60% Yes	93% None	64% None	69% Yes	86% None
7% Speeding traffic	27% No	7% Barrier would be too long	29% Not enough parking	23% No	7% Inconvenience
7% Traffic too heavy	13% Not sure	7% Barrier would not be necessary	7% Speeding traffic	8% Probably	7% Want it taken out
7% Too noisy		7% Peds would hop over it anyway			

It would appear from the above responses that most residents do not perceive the barrier as a significant problem and consider the countermeasure to have some redeeming social value (i.e., accident reduction potential).

Crosswalk Set-Back

Salient Site and Countermeasure Characteristics

The Crosswalk Set-Back countermeasure was tested at two locations: Akron and Columbus. The Akron Experimental site was located at the intersection of a two-way, six-lane roadway with a two-way, three-lane roadway. No parking was permitted on either street. The Control site was located at the intersection of a two-way, five-lane street and a two-way, three-lane street. The intersections were signalized, but did not have pedestrian signal heads. Vehicle traffic was moderate on the larger street and light on the three-lane roadway. Pedestrian activity was light most of the day with a noticeable increase around noon. The two crosswalks and stop lines across the major street were moved back 20 feet from their original positions. A 40-inch high barrier was placed at the apex of each corner to restrict pedestrian crossings. One- and two-story small businesses abutted on both sites.

In Columbus, the study sites (Control and Experimental) were located at the intersection of a two-way, four-lane street with a one-way, two-lane street. The intersections were signalized and pedestrian heads were present. Parking was permitted on both sides of the major street and one side of the one-way street to within 25 feet of the intersection. Traffic volume through the intersection was moderate. Pedestrian activity was light throughout the day. The three crosswalks and stop lines at the Experimental site (no crosswalk on the one-way leg leaving the intersection) were set back 20 feet from their original positions. The crosswalks were striped (zebra), but barriers were not erected. Adjacent to each stop line was a black on white "Stop Here on Red" sign. The buildings bordering the study sites were one- and two-story businesses.

Behavioral Changes

Table 3-12 indicates the Post versus Before behavioral changes associated with the Crosswalk Set-Back. A verbal synopsis of the expected and achieved changes follows:

Expected

1. Vehicles involved in turning conflict with pedestrians (Turning Conflict-1) – significant decrease in Columbus.*
2. Pedestrians involved in turning conflict with vehicles (Turning Conflict-3) – significant decrease in Columbus.

Post Hoc

1. Outside crosswalk (traversing all traffic lanes outside the boundaries of the marked crosswalk) – significant increase in Columbus.
2. Vehicle induced pedestrian hesitations in the parking lane – significant decrease in Columbus.
3. Running in the roadway – significant increase in Akron.
4. Vehicle violations of the stop line (vehicles coming to an initial full stop with their front tires on or beyond the stop line) – significant increase in Akron and Columbus.
5. Vehicle violations of the crosswalk – significant increase in Akron.

*See Attachment B for the actual percentages.

Table 3-12

Behavioral Changes by Countermeasure Installation
Crosswalk Set-Back
(Post – Before)

	Countermeasure Location:	Akron	Columbus
Expected	TURNING CONFLICT–1 (VEHICLES)	*	↓ *
	TURNING CONFLICT–3 (PEDESTRIANS)		↓
Post Hoc	OUTSIDE CROSSWALK		↑
	VEHICLE INDUCED HESITATION (PARKING LANE)		↓
	RUNNING IN ROADWAY	↑	
	VEHICLE STOPLINE VIOLATIONS	↑ **	↑ **
	VEHICLE CROSSWALK VIOLATIONS	↑ **	**
	NUMBER OF OBSERVATIONS	127	247

* Based on 893 turning vehicle observations in Akron and 210 in Columbus.
** Based on 222 stopped vehicle observations in Akron and 17 in Columbus.

A reduction in the percent of Turning Conflicts 1 and 3 was expected in both cities. The decrease was detected in Columbus but not in Akron. A detailed analysis of the Columbus films indicate that the set-back served to increase the separation between the turning vehicle and the crossing pedestrian; thus permitting the pedestrian to traverse the conflict area before the vehicle arrived. In Akron, the Experimental location experienced a near zero initial rate for these behaviors. The failure to find the expected decrease in Akron for Turning Conflicts 1 and 3 should, therefore, be interpreted as a shortcoming in the sampling plan, rather than as an indication of the effectiveness of the countermeasure.

In Columbus, the countermeasure was instituted without the use of barriers. A review of the crossing patterns indicated that 97% of the pedestrians crossed outside of the crosswalk after the set-back. Most pedestrians continued to walk to the corner and cross. At the Akron location, the use of barriers restricted pedestrian movement and crossing outside of the crosswalk was not increased.

In Columbus, there was a small but statistically significant decrease in the percent of pedestrians who hesitated in the parking lane. This decrease was partially attributable to a small increase at the Control site, coupled with the occurrence of a small decrease at the Experimental site.

A significant increase in the percent of pedestrians running in the roadway was found in Akron. Once again, the detected change was attributable to a simultaneous increase at the Experimental site and decrease at the Control site. It is likely that the increase in running was associated with the significant increase in speeds of left turning vehicles through the crosswalk. After the installation of the countermeasure in Akron, the speed of left turning vehicles through the crosswalk area increased by 1.94 mph.

Not surprisingly, the proportion of vehicles violating the stop line significantly increased at the Experimental sites in both Akron and Columbus. There appears to be a tendency for vehicles to pull up to the corner before coming to a complete stop and this behavior did not appear to be modified by the existence of a "Stop Here on Red" sign adjacent to the relocated stop line at the Columbus site.

An increase in the vehicle violations of the crosswalk was also detected in Akron. In Columbus, a .41 increase in the proportion of vehicles invovled in this violation did not achieve statistical significance because of the small number of scorable vehicles (17) and the resulting low power of our statistical test.

Pedestrian Motivational Factors

Tables 3-13 and 3-14 present a summary of the frequent responses given to the pedestrian survey. Table 3-13 consists of the responses from those pedestrians who performed the desired action, i.e., crossed with the signal and within the boundaries of the crosswalk. Fear of being hit (29%), legality (26%), and general safety (22%) were the major reasons cited for crossing in a desired manner before the relocation of the crosswalk. When questioned as to the conditions under which they would cross outside of the crosswalk or against the traffic signal, 56% stated "never at this location" and 29% said "if the traffic volume was lighter."

Table 3-13

Frequent Survey Responses for Pedestrians
Performing Desired Actions
Crosswalk Set-back

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 86)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 86)	REASON FOR DESIRED ACTION (N = 24)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N =24)
29% So not to be hit	56% Usually not or never (at this location)	25% So not to be hit	46% (Barrier) made me use crosswalk
26% Illegal to cross against signal	29% If lighter traffic	25% Habit	21% Had no effect
22% Safer	9% If in a hurry	25% Heavy traffic	17% Did not notice it
13% Habit		13% Safer	8% Felt unsafe

*Crossing with the signal within the boundaries of the marked crosswalk.
**Crossing against the signal and/or outside of the old crosswalk.

Table 3-14

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Crosswalk Set-back

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 21)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 21)	REASON FOR UNDESIRED ACTION (N = 42)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 42)
38% In a hurry	38% If heavier traffic	45% Habit	50% Did not notice it
24% Traffic light was still green	29% If not in a hurry	29% Not aware that stripes were a crosswalk	33% Had no effect
10% Break in traffic	24% If traffic light was red	10% In a hurry	7% Not aware stripes were a new crosswalk
10% Too long a wait for signal		7% Felt safer (in area of old crosswalk)	5% Cars stop in new crosswalk
10% Bad weather			

*Crossing against the signal and/or outside of the old crosswalk.
**Crossing with the signal within the boundaries of the marked crosswalk.

After the installation of the Crosswalk Set-Back, no pedestrian was observed performing the desired behavior during the survey period at the Columbus location. Therefore, the responses discussed in this paragraph refer to the Akron location exclusively. Twenty-five percent (25%) of the pedestrians indicated that they crossed in a desired manner in order to avoid being hit, 25% mentioned habit as the major factor, and 25% stated that heavy traffic volume was the determining factor. When asked about the effect of the countermeasure on their crossing behavior, 46% noted that the barrier made it more convenient to use the new crosswalk while 21% indicated that the countermeasure had no effect on them, and 17% said that they did not even notice the countermeasure.

Table 3-14 presents a summary of the responses given to the survey by those individuals who crossed in an undesired manner, i.e., against the traffic signal and/or crossed outside the marked crosswalk. Before the relocation of the crosswalk, the majority of the pedestrians indicated that they crossed in an undesired manner because they were in a hurry (38%). Twenty-four percent (24%) stated that they crossed because the traffic light was still green. These responses all came from the Columbus site where a pedestrian signal was present. Evidently, many individuals were crossing on the traffic light rather than on the pedestrian signal. Finally, 10% stated that they saw a break in the traffic, or it would be too long to wait for the light to change, or they crossed because the weather was bad. When queried as to the conditions under which they would perform the desired action, 38% responded "if traffic was heavier," 29% said "if not in a hurry," and 24% responded "if the traffic light was red."

After the installation of the countermeasure, 45% of the respondents indicated that they performed the undesired action out of habit. Twenty-nine percent (29%) of all pedestrians stated that they did not recognize that the striped area was a crosswalk. The pedestrians in Columbus thought that the crosswalk was a wide stop line for vehicles. Because of this misinterpretation, most of the pedestrians in Columbus continued to cross at the corner. Ten percent (10%) of the pedestrians indicated that they performed the undesired action because they were in a hurry.

When asked whether the countermeasure affected the way they crossed the street, 50% stated they did not see the countermeasure. It should be noted that 92% of those surveyed in Akron recalled seeing the countermeasure whereas only 31% of those surveyed in Columbus said they saw the countermeasure before crossing. Apparently, the barriers at the Akron location were the primary cues as to the presence and purpose of the countermeasures. Thirty-three percent (33%) stated that although they saw the countermeasure, its presence did not affect their crossing behavior.

Merchant/Resident Reaction

The commercial nature of the Akron and Columbus sites obviated the collection of surveys from residents. Merchants at the Control and Experimental locations were, however, interviewed in both cities. (See Table 3-15) Most merchants (90%) at the Control locations indicated that they were not aware of any traffic problems that currently cause inconvenience or adversely influence business. None of these merchants believed that the set-back would affect business.

Table 3-15

Frequent Survey Responses for Merchants
Crosswalk Set-back

CONTROL SITES			EXPERIMENTAL SITES		
Conditions Affecting Business (N =10)	Conditions Causing Inconvenience (N = 10)	Perceived Effect of the Countermeasure (N = 10)	Conditions Affecting Business (N = 14)	Conditions Causing Inconvenience (N = 14)	Perceived Effect of the Countermeasure (N = 14)
90% None	90% None	100% None	93% None	43% None	93% None
10% Drivers cutting through gas station to beat traffic signal	10% Bus stop in front of bank should be parking zone		7% Road could be resurfaced	29% Lack of left turn only signals	7% Loss of parking due to setback crosswalk
				7% Not enough parking	
				7% Cars often block the setback crosswalk causing peds inconvenience	
				7% Rush hour traffic	
				7% No parking allowed during rush hour	

The merchants at the Experimental sites were also queried as to impact of the countermeasure. One respondent (7%) volunteered that cars often stopped in the set-back crosswalk, thus causing pedestrians to cross outside of the crosswalk. When specifically asked about the effect of the countermeasure, one merchant (7%) stated that the set-back resulted in a loss of parking spaces.

In general, the merchants did not voice any serious objections to the Crosswalk Set-Back.

Midblock Crosswalk

Salient Site and Countermeasure Characteristics

The Midblock Crosswalk countermeasure was tested at three locations: Washington, D.C., Miami, and Toledo. The D.C. Experimental site was located on a two-way, two-lane street which was 612 feet in length. Parallel parking was permitted on both sides of the street. Parking was controlled by meters and signs and was permitted during the time that data was being collected. The Control site had metered parking on one side of the street while no parking was permitted on the opposite side of the street. The buildings fronting the sites were mainly Government office buildings; with a retail grocery warehouse at the Control site. Pedestrian traffic was heavy throughout most of the day. Vehicle traffic was generally light at both sites (approximately 140 vehicles/hour). A 15-foot wide zebra crosswalk was installed near the center of the site area. The crosswalk connected the entrances of two Government buildings and utilized an "existing pedestrian path."

The Miami sites were located on two-way, four-lane streets. There was metered parallel parking on both sides of the street. A left turn channel was present at both sites. The Experimental site area was 363 feet in length. The buildings fronting on the sites were small retail businesses. Both sites experienced moderate to heavy vehicle and pedestrian activity. At the Experimental site, an 11-foot wide crosswalk was installed near a midblock bus stop. A traffic signal and stop lines were also included in this installation. The stop lines were installed 35 feet from the crosswalk in either direction.

The Toledo sites were located on one-way, three-lane streets. Metered parking was permitted on both sides of the street at the Experimental site and one side of the street at the Control site. The Experimental street was 500 feet in length. The buildings fronting on the sites were Government office buildings. Both sites had moderate pedestrian and vehicle activity throughout the day. A 14-foot wide crosswalk was installed approximately 200 feet from one end of the site area. The crosswalk utilized an existing pedestrian path between two Government buildings.

Behavioral Changes

Table 3-16 displays the Post versus Before behavioral changes associated with the Midblock Crosswalk. A verbal synopsis of the expected and achieved changes follows.

Expected

1. Crossing in crosswalk area – significant increase in D.C. and Miami.*

*See Attachment B for the actual percentages.

2. Vehicle/pedestrian separation – significant increase in D.C. and Miami.
3. Entering roadway in front of parked vehicles – significant decrease in D.C. Miami, and Toledo.
4. Running in the roadway – significant decrease in D.C. and Toledo.

Table 3-16

Behavioral Changes by Countermeasure Installation
Midblock Crosswalk
(Post – Before)

	Countermeasure Location:	D.C.	Miami	Toledo
Expected	CROSSING IN CROSSWALK AREA	↑*	↑*	*
	VEHICLE/PEDESTRIAN SEPARATION	↑	↑	
	IN FRONT OF PARKED VEHICLES	↓	↓	↓
	RUNNING IN ROADWAY	↓		↓
Post Hoc	SCANNING TRAFFIC	**	↓**	↓**
	VEHICLE INDUCED HESITATION (TRAFFIC LANE)	↑	↓	↓
	RUNNING INTO 2nd HALF	↓		N/A***
	NUMBER OF OBSERVATIONS	771	238	315

* Based on comparison of Before and Post data at the experimental site only.
** Based on 280 observations in D.C. and 79 in Toledo. All observations are of pedestrians entering the roadway within the crosswalk boundaries. The Miami data is based on 224 observations of pedestrians entering the roadway within the crosswalk boundaries and crossing <u>with</u> the pedestrian light signal. No significant change occurred for those Miami pedestrians crossing in the crosswalk, but against the signal.
*** Not applicable because of one-way traffic.

Post Hoc

1. Scanning traffic – significant decrease in Miami and Toledo.
2. Vehicle induced hesitation in the traffic lane – significant decrease in Miami and Toledo. However, a significant increase in D.C. was also found.
3. Running into second half – significant decrease in D.C.

The percent of pedestrians using the Midblock Crosswalk in the Before and Post phases was compared. "Using the crosswalk" was defined as a crossing that resulted in a pedestrian being within, or entering, the crosswalk during his crossing of a traffic lane. In the Before st..., the crosswalk was superimposed on the projected films and the pedestrians were coded as if a crosswalk was present. In two of the cities, the presence of the crosswalk tended to channel the pedestrians into the crosswalk area. In Toledo, the countermeasure did not have this funneling effect. This discrepancy in results is attributable to the presence of a walkway in Toledo which terminated at the location of the proposed crosswalk. This walkway resulted in high pedestrian utilization of the crosswalk area during the Before study. It should be noted that the greatest increase in crosswalk utilization occurred in Miami where a traffic signal was part of the installation.

A significant increase in vehicle/pedestrian separation was found in D.C. This change was probably due to the decrease in vehicle speed in the vicinity of the crosswalk. The speed of the vehicles approaching the crosswalk was collected via the TES. The results indicate that there was an average speed decrease of 3.11 mph after the installation of the crosswalk, thus increasing the time gap between pedestrians and oncoming vehicles. In Miami, the increase in vehicle/pedestrian separation was attributable to the traffic signal. Fifty-three percent (53%) of the pedestrians in the Post study crossed entirely with the traffic signal and, therefore, had a large vehicle/pedestrian time gap (Hazard Index of C). In Toledo, the initially high percent of large vehicle/pedestrian gaps (87%) precluded obtaining a significant improvement.

As expected, each of the installations decreased the percent of pedestrians crossing between, or in front of, parked vehicles. The largest decrease was found in Miami, where several parking meters were removed and parking was restricted in the vicinity of the crosswalk. In D.C., the countermeasure-related restriction (which consisted of the placement of "No Parking" covers on two of the parking meters) was ignored by the motorists. The D.C. films were, however, scored as if the restrictions were enforced. In Toledo, no changes in parking regulations accompanied the installation of the countermeasure. The small but significant decrease in Toledo was, however, attributable to the increased pedestrian usage of the crosswalk and the reduction in vehicles violating the existing "No Parking" zone near the crosswalk.

Running in the roadway was reduced at the D.C. and Toledo sites. In D.C., the necessity for running was probably decreased with the decrease in vehicle speed. In addition, it is possible that the pedestrians using the Midblock Crosswalks at both the D.C. and Toledo sites felt they had the right-of-way and running into the second half of the roadway was also significantly reduced at the D.C. site. In Miami, no decrease in overall running was detected. It should be noted, however, that the only pedestrians who were observed running in the crosswalk were those who crossed against the signal.

An unexpected decrease in scanning was noted in Miami and Toledo. In Miami, this decrease was restricted to those pedestrians who crossed with the signal. For those pedestrians who crossed against the signal, there was no significant change in scanning. Scanning in preparation to entering the first traffic lane was always noted for this group of violators. In Toledo, the pedestrians just appeared to scan less throughout their crossing, perhaps because of the psychological security of the crosswalk coupled with the one-way traffic flow. In D.C., no significant change in scanning was noted. The extremely low traffic volume in D.C. and the intially low rate of scanning (67%) may have precluded obtaining a decrease in scanning.

The percent of pedestrians who hesitated in the parking lane for the passage of at least one vehicle significantly changed at each site. A decrease was noted in Miami and Toledo. In Miami, the decrease was attributable to the traffic signal. In Toledo, the change was mostly the result of an unexplained increase in hesitation at the Control site. The increase of hesitation in D.C. was probably due to the fact that, with the completion of roadway construction in the area, traffic almost doubled at the Experimental site during the Acclimation and Post studies.

Table 3-17 presents the results of the two Acclimation studies. Crossing in the crosswalk area did not significantly change one week and then one month after the installation of the crosswalk. Our survey of the pedestrains conducted during the Post study sheds some light on this topic. First, most pedestrians were not aware that the crosswalk had been installed until just before the Post study. Additionally, a number of pedestrians indicated that they would not go out of their way to cross at the crosswalk if the weather was bad. It was, in fact, relatively cold and nasty during the two Acclimation periods (42° and 38°, respectively at noon).

The vehicle/pedestrian separation, in front of parked vehicles, and running in roadway data support the Post-Before data during one of the two Acclimation periods.

The significant net increase in scanning found in Acclimation 1 appears to be attributable to a sharp, unexplainable decrease in scanning at the Control location. Vehicle induced hesitations were significantly higher during both Acclimation studies, probably because of the increased traffic volume previously noted. Vehicle induced hesitations in the parking lane increase in the first Acclimation study, and running into the second half of the roadway decreased (partially confirming the Post-Before findings).

Pedestrian Motivational Factors

Table 3-18 indicates the survey responses of those pedestrians who crossed at the corner crosswalks after passing through the site area. Since none of the pedestrians observed in Toledo crossed in this manner during the Before study, the reported behavior reflects interviews conducted in D.C. and Miami. An equal number of pedestrians noted legality (32%) and safety (32%) as the major reasons for using the corner crosswalks. Avoiding an accident and habit were also frequently noted factors (14% and 13%, respectively). When queried as to the conditions under which they would cross elsewhere, the majority of the pedestrians (52%) said they would generally not consider crossing elsewhere. Sixteen percent (16%) indicated that they would consider crossing at other than the crosswalk if they were in a hurry, and 14% would if it was more convenient.

Table 3-17

Behavioral Changes by Countermeasure Installation
Midblock Crosswalk: Washington, D.C.
(Acclimation – Before)

	Phase:	Acclimation 1	Acclimation 2
Expected	CROSSING IN CROSSWALK AREA	*	*
	VEHICLE/PEDESTRIAN SEPARATION		↑
	IN FRONT OF PARKED VEHICLES	↓	
	RUNNING IN ROADWAY	↓	
Post Hoc	SCANNING TRAFFIC	↑ **	**
	VEHICLE INDUCED HESITATION (TRAFFIC LANE)	↑	↑
	VEHICLE INDUCED HESITATION (PARKING LANE)	↑	
	RUNNING INTO 2nd HALF	↓	
	NUMBER OF OBSERVATIONS	348	298

*Based on comparison of Before and Acclimation 1 and 2 data at the Experimental site only (168 observations in Acclimation 1 and 131 in Acclimation 2).
** Based on 294 observations in Acclimation 1 and 263 in Acclimation 2.

After the installation of the countermeasure, convenience became the dominant reason for utilization of the Midblock Crosswalk, with 40% of the pedestrians noting this factor and approximately the same percentage (33%) considering safety to be a major factor in their selection of crossing locations. However, only 13% specifically noted the illegality of crossing elsewhere.

When asked about the effect of the countermeasure on their crossing behavior, 27% indicated it had no effect, while 19% indicated that its effect was that they used it. Sixteen percent (16%) noted that it made crossing the street more convenient because they did not have to go to the corner, and 15% felt safer since a crosswalk had been installed.

Table 3-18

Frequent Survey Responses for Pedestrians
Performing Desired Actions
Midblock Crosswalk

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 56)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 56)	REASON FOR DESIRED ACTION (N = 86)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N =86)
32% Illegal to cross elsewhere	52% Usually not or never (at this location)	40% Convenience	27% Had no effect
32% Safer	16% If in a hurry	33% Safer	16% Not necessary to go to corner
14% So not to be hit	14% If convenient	13% Illegal to cross elsewhere	19% People are using it
13% Habit	7% If lighter traffic	7% Habit	15% Felt safer
5% Convenience			14% Did not notice it
			7% Would be more convenient
			6% Expect traffic to be influenced

*Crossing the roadway within the boundaries of a marked crosswalk (midblock crosswalk only in the Post phase).
**Crossing more than twenty (20) feet from a marked crosswalk.

Table 3-19 presents the survey responses of those pedestrians who crossed outside of the existing crosswalks in the Before study and between the corner and Midblock Crosswalk in the Post study. Most pedestrians (64%) indicated that convenience was the major reason for not using the corner crosswalk prior to the installation of the countermeasure. After its installation, only 33% noted convenience, while 24% said they were in a hurry and 15% were not aware of the existence of the crosswalk. When we asked the pedestrians in the Before study when they would cross at the corner, 34% stated never. Most felt that the traffic was so light that it did not present a hazard to cross midblock. Twenty-one (21%) of the pedestrians noted that they would go to the corner if the traffic was heavier and another 21% would do the same if it was more convenient. When, in the Post study, the pedestrians were asked about the effect of the Midblock Crosswalk on their behavior, 45% indicated it had no effect, while 43% were not even aware of its existence.

Table 3-19

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Midblock Crosswalk

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 184)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 184)	REASON FOR UNDESIRED ACTION (N = 88)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 88)
64% Convenience	34% Usually not or never (at this location)	33% Convenience	45% Had no effect
7% Habit	21% If heavier traffic	24% In a hurry	43% Did not notice it
5% Break in traffic	21% If convenient	15% Not aware of mid-block crosswalk	
	11% Usually does	8% Break in traffic	

*Crossing more than twenty (20) feet from a marked crosswalk.
**Crossing the roadway within the boundaries of a marked crosswalk (midblock crosswalk only in the Post phase).

Merchant/Resident Reaction

No merchant or resident surveys were conducted in D.C. or Toledo because of the predominance of State and Federal office buildings at the sites. In Miami, the site areas were exclusively commercial and, therefore, only merchant interviews were conducted. Therefore, the results presented in Table,3-20 represent the merchant surveys conducted in Miami.

When questioned about local traffic problems that affect business, 47% of the merchants at both the Control and Experimental sites indicated that there were none. Likewise, 47% at the Control site and 53% at the Experimental site indicated that there were no traffic conditions that inconvenienced their employees or customers. Sixty percent (60%) of the Control site merchants and 53% of the Experimental site merchants felt that the countermeasure would have no adverse effect on business.

The major problem raised by both groups of merchants pertained to parking. About one-third of the merchants questioned believed that the lack of parking was a factor that does adversely affect business. And 47% of merchants at the Experimental location felt that the removal of several parking meters in the vicinity of the Midblock Crosswalk had adversely affected their business. It is interesting to note that parking removal was not recognized as a potential probelm during the discussion with the merchants at the Control site.

Table 3-20

Frequent Survey Responses for Merchants
Midblock Crosswalk

CONTROL SITE			EXPERIMENTAL SITE		
Conditions Affecting Business (N = 15)	Conditions Causing Inconvenience (N = 15)	Perceived Effect of the Countermeasure (N = 15)	Conditions Affecting Business (N = 15)	Conditions Causing Inconvenience (N = 15)	Perceived Effect of the Countermeasure (N = 15)
47% None	47% None	60% None	47% None	53% None	53% None
33% Not enough parking	40% Not enough (nearby) parking	13% No need for it	33% Not enough parking	33% Not enough (store-front) parking	47% Removal of meters for crosswalk reduced available parking
13% Double parked cars	7% Loading zone in front of store	7% May be help if not directly in front of store	7% The midblock crosswalk	7% Midblock crosswalk is dangerous	
13% Too much traffic	7% Hard for customers to cross street	7% Would tie up traffic	7% Increase in accidents due to crosswalk signal	7% Meters cost too much	
		7% Would cause accidents	7% Bus stop in front of store causes loitering	7% Need more buses to reduce volume of loitering peds.	

Diagonal Parking

Salient Site and Countermeasure Characteristics

The Diagonal Parking countermeasure was tested at two locations: Miami and San Diego. The Miami sites were located on one-way, two-lane streets. Parallel parking was permitted on both sides of the Control and Experimental sites during the period when data were collected. The experimental site contained a court which formed a 'T' intersection near the the middle of the site area. The buildings abutting the sites consisted of small stores and multi-family residences and the intersections forming the boundaries of the two sites were signalized. Twelve parking spaces were installed at the 34-foot wide Experimental site. Each space provided for the diagonal parking of a vehicle at a 30° angle. Furthermore the street was converted to a single lane of traffic and parking was prohibited on the side of the street opposite the diagonal parking spaces. Pedestrian and vehicle activity was moderate.

In San Diego the sites were located on two-way, two-lane streets with unrestricted parallel parking on both sides. The buildings abutting the sites consisted of single and multi-family houses with numerous private driveways. The bounding intersections of both sites were controlled by stop signs. Twenty-six diagonal parking spaces were installed at an angle of 45° on one side of the 30 foot wide street. Parking was restricted on the other side and the street was converted to one lane of one-way traffic. Pedestrian and vehicle activity was very light throughout the entire day. No vehicle capacity problems were present at either of the experimental locations.

Behavioral Changes

Table 3-21 presents the Post versus Before behavioral changes associated with the Diagonal Parking countermeasure. A verbal description of the expected and achieved changes follows.

Expected:

1. Running into roadway – no statistically significant change, a decrease was expected.*
2. Pedestrian scanning of traffic – significant increase in the percent of pedestrians scanning traffic at both locations.
3. Entry into roadway in front of a parked vehicle – significant decrease in Miami.
4. Sudden appearance (entry into the roadway in front of a parked car *and* running into the first traffic lane) – significant decrease in Miami.

Post Hoc:

1. Abort (returning to the curb after putting both feet in the roadway) – a significant increase in Miami.
2. Vehicle induced pedestrian hesitation while in a traffic lane – significant increase in Miami.
3. Pedestrian backup movement while in a traffic lane – significant increase in Miami.
4. Running in roadway – significant decrease in Miami.

Before discussing the specific results of the Diagonal Parking study it is appropriate to make some general comments. First and foremost, the reader will note that there were only 45 observations made during the four days of data collection in San Diego.** The small sample

*See Attachment B for the actual percentages.

**Unfortunately, the design of our data collection plan precluded the possibility of varying the observation period in order to obtain a larger sample.

size greatly reduces the likelihood of detecting a behavioral change. Therefore, it is not surprising that the only one of the Miami findings was replicated in San Diego. A second point to be noted is that removing the parking on one side of the street at the Experimental site decreased *a priori* the opportunity for entering the roadway between parked vehicles. Finally, in the Post study scanning behavior at the Experimental site was only recorded for those pedestrians entering the roadway from between *diagonally parked vehicles.*

Table 3-21

Behavioral Changes by Countermeasure Installation
Diagonal Parking
(Post – Before)

	Countermeasure Location:	Miami	San Diego
Expected	RUNNING INTO ROADWAY		
	SCANNING TRAFFIC	↑*	↑*
	IN FRONT OF PARKED VEHICLES	↓	
	SUDDEN APPEARANCE	↓	
Post Hoc	ABORT	↑	
	VEHICLE INDUCED HESITATION (TRAFFIC LANE)	↑	
	BACKUP MOVEMENT (TRAFFIC LANE)	↑	
	RUNNING IN ROADWAY	↓	
	NUMBER OF OBSERVATIONS	1035	45

*Based on 77 observations in Miami and 22 in San Diego.

No significant decrease in running into the roadway was noted at either of the Experimental locations. An analysis of the films indicated that running into the first traffic lane did not seem to be affected by the parking configuration. In fact, in Miami children ran into the roadway twice as frequently on the diagonal parking side than on the side with no parking. (The reader is cautioned that this does not represent a significant difference and is only mentioned as an area for future research.)

Scanning traffic was significantly increased at both locations. The diagonally parked vehicles directed the pedestrians into the roadway at such an angle that looking in the direction of traffic was universal. The size of the behavioral change should however, be interpreted with caution. In the Before study there were two scanning opportunities – one for the first and one for the second traffic lane. During the Post study there was only the one opportunity – the single traffic lane. Traditionally we have found scanning to be greatest in the first traffic lane and then to rapidly decline, especially on one-way streets. Thus we might anticipate an increase of 10% in the number of scanning opportunities utilized if we had simply eliminated one of the traffic lanes or alternately had only scored the first lane during the Before study.

The percent of pedestrians entering the roadway from between parked vehicles was significantly reduced in Miami. We might expect that the removal of parking from one side of the street would alone reduce the opportunity to enter the street between parked vehicles by around 50%. Every pedestrian who completely crossed the street at the Experimental site during the Post study in San Diego crossed from between the diagonally parked vehicles. Several pedestrians who did enter the street from the opposite side, did so to gain access to their parked vehicles and thus did not make a complete crossing. The significant difference appearing in Table 3-21 reflects the fact that there was a sharp increase in pedestrians entering between parked vehicles at the Control site.

In Miami there was a significant decrease in the percent of pedestrians who ran into the first traffic lane from between parked vehicles. The reduction in sudden appearences was essentially attributable to a decrease in the proportion of entries between parked vehicles.

There was a significant increase at the Miami locations in the percent of pedestrians who aborted their crossing, hesitated in the traffic lane, and backed up in the traffic lane. all of these results can be attributed to those pedestrians who entered the roadway from the side of the street opposite the diagonal parking spaces. It appeared that the pedestrians were more cautious when crossing into the diagonal parking area.

Running in the roadway was significantly reduced in Miami. The reduction was noted for pedestrians entering the roadway from either side. One possible explanation for this effect is the observation that vehicle speed was significantly decreased (-5.03 mph) after the installation of the countermeasure.

Pedestrian Motivational Factors

At the suggestion of the police, no pedestrian or resident interviews were conducted in Miami. Furthermore during the eight hours devoted to the survey portion of the study only one person in San Diego was observed walking through the site area and then crossing at right angles to the roadway. Therefore, no data will be reported relative to pedestrians performing the desired action.

Table 3-22 presents the San Diego data for those pedestrians who entered the roadway in front of parked vehicles and crossed in midblock. Before the installation of Diagonal Parking most pedestrians (55%) indicated that they would seldom if ever go to the corner to cross. After the installation of the countermeasure the majority of the pedestrians (83%) still indicated that convenience was the major factor in determining their crossing behavior. When queried as to the effect of the countermeasure on their crossing behavior 50% stated that it had no effect.

Table 3-22

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Diagonal Parking

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 11)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 11)	REASON FOR UNDESIRED ACTION (N = 6)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 6)
55% Convenience	45% Usually not or never (at this location)	83% Convenience	50% Had no effect
18% In a hurry	18% If heavier traffic	17% Break in traffic	17% Easier to scan traffic due to angle
18% Bad weather	18% Somewhere else		17% Only had to look in one direction
18% Break in traffic	9% If unsafe to cross otherwise		17% Could walk in street parallel to sidewalk
	9% Usually does		

*Entering the roadway in front of a parked vehicle and crossing in midblock.
**Walking through the site area and then crossing at the corner at right angles to the roadway.

Merchant/Resident Reaction

This section reports the responses of the San Diego residents to Diagonal Parking (See Table 3-23). Merchants were not present in the San Diego site areas and therefore no merchant surveys were conducted. Most of the residents surveyed at the Control site (73%) indicated that they had no current traffic problems, while 27% stated that speeding traffic presented a hazard. At the Experimental site 73% also indicated no traffic problems. However, 13% of the residents at the Experimental site specifically noted the parking removal on one side of the street as a serious problem.

Table 3-23

Frequent Survey Responses for Residents
Diagonal Parking

CONTROL SITE			EXPERIMENTAL SITE		
Traffic Conditions Disliked (N = 15)	Reduction of Pedestrian Accidents (N = 15)	Countermeasure Related Dislikes (N = 15)	Traffic Conditions Disliked (N = 15)	Reduction of Pedestrian Accidents (N = 15)	Countermeasure Related Dislikes (N = 15)
73% None	60% Yes	80% None	73% None	33% Yes	40% Not enough parking
27% Speeding traffic	36% No	7% Increased risk of being hit while pulling out into traffic lane	13% Parking on only one side of street	33% Undecided	33% None
7% Not enough parking (at night)		7% One-way street	7% Not enough parking	27% No	20% Traffic going wrong way on one-way street
		7% Wouldn't want it	7% Lack of sign indicating one-way street	7% Probably	7% Parking space size is reduced
					7% Driver's view of oncoming traffic prior to pulling out is reduced
					7% One-way street

When queried about the accident reduction potential of the countermeasure 69 percent of the Control site residents said they felt diagonal parking would reduce accidents. At the Experimental site however, only 33% felt that the countermeasure would reduce accidents and another 33% were undecided.

Eighty percent (80%) of the residents at the Control site had no misgivings about the countermeasure. In contrast 67% of the residents surveyed at the Experimental site voiced some complaint about the countermeasure. Specifically, 40% noted the removal of parking as a problem and 20% stated that wrong way traffic had become a problem.

It appears that the residents' perception of Diagonal Parking is greatly modified by their exposure to the countermeasure. Those living with the countermeasure were generally less favorable especially relative to the loss of parking.

Meter Post Barriers

Salient Site and Countermeasure Characteristics

The Meter Post Barrier countermeasure was tested at three locations: Washington, D.C., New York City, and Toledo. The Control and Experimental sites in D.C. were located on two-way, four-lane streets. Parallel metered parking was permitted on one side of the street at both sites. In addition the Experimental site had two metered parking spaces on the other side of the street. Parking at the meters was permitted during the hours data were collected and parking utilization was heavy throughout the day. The buildings abutting the sites were store-front businesses, one or two stories in height. Pedestrian and vehicle activity was heavy during the entire day. Six Meter Post Barriers were installed at the Experimental site on one side of the street. The barriers consisted of two pipes, one nine feet upstream and the other three feet downstream from the meter. The pipes were connected to the meter by a single chain near the top of the pipes some three feet above the pavement.

In New York the Control and Experimental sites were located on two-way, four-lane streets. Parallel metered parking was permitted during the hours of data collection at both sites on both sides of the street. Parking utilization was heavy throughout the day. The buildings facing the sites were small businesses and one large department store was also present at each of the sites. Pedestrian and vehicle activity was heavy during the entire day. Nineteen Meter Post Barriers were installed at the Experimental site, nine on one side of the street and ten on the other side. The Barriers consisted of two pipes, one nine feet downstream and the other three feet upstream from the meter. The pipes extended three feet above the pavement and were connected to the meter by two, three foot wide sections of chain link fence.

The sites in Toledo are both one-way, three-lane streets. Parallel metered parking was permitted during the hours of data collection on one side of the street. Parking utilization was moderate to heavy. The buildings facing the sites were small shops and department stores. Pedestrian and vehicle activity was moderate during the day. Eight barriers were installed at the Experimental site on one side of the street. The Toledo barriers were similar in configuration to the New York barriers, except that three chains connected the pipes to the meter.

Behavioral Changes

Table 3-24 indicates the Post versus Before behavioral changes associated with the Meter Post Barrier countermeasure. A synopsis of the behavioral changes induced by the countermeasure follows.

Expected

1. Running into roadway – significant decrease in D.C.*
2. Pedestrian scanning of traffic – significant decrease in Toledo. An increase was expected.
3. Entry into roadway in front of a parked vehicle – significant decrease in New York.

Table 3-24

Behavioral Changes by Countermeasure Installation
Meter Post Barrier
(Post – Before)

	Countermeasure Location:	D.C.	N.Y.C.	Toledo
Expected	RUNNING INTO ROADWAY	↓		
	SCANNING TRAFFIC	*	*	↓ *
	IN FRONT OF PARKED VEHICLES		↓	
Post Hoc	ABORT	↓	↓	
	VEHICLE INDUCED HESITATION (PARKING LANE)	↓	↑	↓
	BACKUP MOVEMENT (TRAFFIC LANE)		↓	
	BACKUP MOVEMENT (PARKING LANE)	↓	↓	
	NUMBER OF OBSERVATIONS	182**	334	208

*Based on 139 observations in D.C., 248 in New York City, and 86 in Toledo.
**Due to low pedestrian volume during the initial Before phase data collection, additional PAS periods were taken. These observations are included in the Before data although no comparable data were collected in the Post phase.

Post Hoc

1. Abort – significant decrease in both D.C. and New York.
2. Vehicle induced pedestrian hesitation – significant decrease in both D.C. and Toledo, and significant increase in New York.

*See Attachment B for the actual percentages.

3. Pedestrian backup movement while in a traffic lane – significant decrease in New York.
4. Pedestrian backup movement while in a parking lane – significant decrease in both D.C. and New York.

Before proceeding to discuss these results we should make a few introductory comments. The Before and Post data at the Experimental sites were scored so as to include only those pedestrians who entered the roadway from between the cars parked at the Meter Post Barrier spaces. Thus, individuals crossing at other locations or crossing into the Meter Post Barrier spaces (in D.C. and Toledo where the barriers were all located on one side of the street) were not included in the data presented in Table 3-24.

We expected the countermeasure to reduce the incidence of pedestrians running into the roadway. In fact running into the roadway was only significantly changed in D.C., where the percent of pedestrians engaged in running at the Experimental site was reduced to zero. The inability to detect a modification of the behavior in question in the other two cities was most likely due to a combination of factors. First, the incidence of running into the roadway was initially small and therefore highly subject to fluctuations as a result of chance factors. A second factor, compounding the first, is the relatively small number of scorable pedestrians at the Experimental sites (101 in D.C., 114 in New York, and 53 in Toledo).

Scanning traffic was not modified as expected. We hypothesized that the barriers would make the pedestrians slow down before entering the roadway and therefore provide additional time for scanning activities. However, an increase in scanning at the Control site in Toledo resulted in a net decrease in scanning for the Post-Before comparison presented in Table 3-24. It is interesting to note that all of the pedestrians entering the first lane at the Experimental site scanned traffic during the Before *and* Post studies. The above noted scanning pattern was also found at the Experimental site in D.C. In New York all but one pedestrian conformed to this pattern of scanning. Therefore, there was little or no opportunity to increase the proportion of pedestrians who scanned the first lane of traffic.

In New York the Meter Post Barriers significantly reduced the percent of pedestrians entering the roadway from between parked vehicles. A similar decrease was not detected in the other two cities. It is possible that the presence of barriers on both sides of the street presented a more formidable perceptual and physical obstacle to crossing. People about to enter the roadway in New York were confronted with the observation that they would have to negotiate another set of barriers upon arriving on the other side of the street. It is significant to note that at all the Experimental locations about twice as many drivers entered their parked vehicles via the curb side rather than going around the barrier and entering the vehicle from the street side.

Decreases in the percent of abortive crossings and backup movements in the parking lane were detected in D.C. and New York. These decreases are, of course, dependent since aborts almost invariably result in the pedestrian backing up in the parking lane. The reason for these changes is not obvious. We might conjecture that those pedestrians who would have aborted their crossings were, after the installation of the barriers, less likely to attempt a crossing. They might have perceived the barriers as indicating that the locations presented a serious safety problem.

Vehicle induced hesitations in the parking lane also significantly decreased at the D.C. and Toledo sites, possibly for the same reasons noted above. In New York, however, this behavior increased. This increase in New York was accompanied by a decrease in the percent of backup movements in the traffic lanes. It appears as if the New Yorkers spent more time in the parking lane waiting for an acceptable gap and then crossed the street without hesitation.

Table 3-25 presents the results of the one week Acclimation study. The second Acclimation study was not conducted because the barriers were vandalized (chains removed) and were not repaired in time for data collection. The Post versus Before findings relative to running into the road were not confirmed during the Acclimation study. This lack of verification is attributable to the non-occurrence of this type of behavior in the Before data used for the Acclimation comparison. Furthermore, the Post versus Before results for this behavior are probably spurious, as the Before proportions at the Experimental site were based on only 12 observations.

Pedestrian Motivational Factors

Table 3-26 is a compilation of the frequent responses of those pedestrians who performed the desired action. For the Meter Post Barrier countermeasure the desired action was defined as: walking past the metered location and then crossing at the corner (at right angles to the parked vehicle).

Before the installation of the barriers 22% of the pedestrians stated that they crossed at the corner because of "habit". While 16% said it was safer and 12% said it was illegal to cross elsewhere. After the installation of the countermeasure most of the percentages remained about the same, with the exception of legality. In the Post study 26% indicated that it was illegal to cross elsewhere. Thus, the barriers may have served to remind the pedestrian of the illegality of jay walking.

Table 3-25

Behavioral Changes by Countermeasure Installation
Meter Post Barrier: Washington, D.C.
(Acclimation 1 – Before)*

	Phase:	Acclimation 1
Expected	RUNNING INTO ROADWAY	
	SCANNING TRAFFIC	**
	IN FRONT OF PARKED VEHICLES	
Post Hoc	VEHICLE/PEDESTRIAN SEPARATION	↑
	VEHICLE INDUCED HESITATION (TRAFFIC LANE)	↑
	NUMBER OF OBSERVATIONS	85

*No Acclimation 2 phase data were collected for this countermeasure.
**Based on 75 observations.

Table 3-26

Frequent Survey Responses for Pedestrians
Performing Desired Actions
Meter Post Barriers

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 92)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 92)	REASON FOR DESIRED ACTIONS (N = 54)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 54)
22% Habit	39% Usually not or never (at this location)	26% Illegal to cross elsewhere	44% Did not notice them
16% Safer	33% If lighter traffic	20% Habit	35% Had no effect
13% Convenience	16% If in a hurry	15% Safer	
12% Illegal to cross elsewhere	10% Usually do	11% Convenience	
8% Heavy midblock traffic			
7% Old age			

*Walking past the metered location and then crossing at corner (at a right angle to the parked vehicles).
**Entering the roadway between vehicles parked at the metered location.

When questioned as to the conditions under which they would cross midblock 39% of the pedestrians in the Before survey stated "never at this location". Another 33% said they would consider crossing midblock if the traffic was lighter. In the Post survey the pedestrians performing the desired action were asked what effect the countermeasure had, if any, on their crossing behavior. Forty-four percent (44%) stated they had not noticed them and another 35% stated that they had no effect.

Table 3-27 presents the most frequent responses of those pedestrians who performed the undesired actions, i.e., entering the roadway between vehicles parked at the metered location. The reason given for performing undesired actions and the percentage given those reasons were essentially the same before and after the installation of the Barriers. Sixty percent (60%) noted convenience as the major motivating factor in both study phases. The second most frequently noted factor was that the pedestrian was in a hurry (20%) for the Before and 19% for the Post study).

Table 3-27

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Meter Post Barriers

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 213)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 213)	REASON FOR UNDESIRED ACTION (N = 75)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 75)
60% Convenience	37% If heavier midblock traffic	60% Convenience	63% Had no effect
20% In a hurry	20% Usually not or never (at this location)	19% In a hurry	20% Did not notice them
14% Break in traffic	14% If convenient	8% Store on other side	12% Had to walk around barrier
5% Heavy corner traffic	9% Usually does		
	8% If not in a hurry		

*Entering the roadway between vehicles parked at the metered location.
**Walking past the metered location and then crossing at corner (at a right angle to the parked vehicles).

When asked when they would go to the corner to cross 37% replied "if the traffic was heavier". Another 20% said usually never at this location and 14% indicated they would cross at the corner if it was convenient to do so. Most of these pedestrians (63%) felt that the countermeasure had no effect on their crossing behavior, with 20% saying that they did not even see the barriers. Finally 12% noted that it caused them some inconvenience when crossing, i.e., they had to walk around the barrier to get to the street.

It appears that the barrier was perceived as ineffective by those who crossed midblock and generally not noticed by those pedestrians who walked to the corner to cross.

Merchant/Pedestrian Reaction

All of the study sites were predominately commercial in nature. This section therefore, deals exclusively with the reactions of the merchants to the Meter Post Barriers. Table 3-28 presents the merchants' responses to the survey conducted at the Control and Experimental locations.

Table 3-28

Frequent Survey Responses for Merchants
Meter Post Barrier

CONTROL SITES			EXPERIMENTAL SITES		
Conditions Affecting Business (N = 18)	Conditions Causing Inconvenience (N = 18)	Perceived Effect of the Countermeasure (N = 18)	Conditions Affecting Business (N = 34)	Conditions Causing Inconvenience (N = 34)	Perceived Effect of the Countermeasure (N = 34)
50% None	39% None	56% None	41% Not enough parking	47% Not enough parking	65% None
33% Not enough parking	22% Not enough parking	22% More difficult to cross street	29% None	35% None	18% More difficult for loading/unloading vehicles
17% Too much traffic	6% Not enough time on meters	11% More difficult for loading/unloading vehicles	15% Too much traffic	9% Too much traffic	15% Harder to cross street
11% Street deliveries block traffic	6% Too much traffic	11% Inconvenience	6% Barrier blocks loading/unloading of vehicles.	9% Barriers cause inconvenience for entering/exiting cars	9% Harder to enter/exit car
6% Parking should be free	6% Street too narrow		6% Not enough time on meters		
	6% One-way street		6% Barriers are a nuisance		

At the Control and Experimental locations the merchants' major complaint revolved around the lack of available parking (about 1/3 of the respondents). They indicated that the lack of adequate parking causes an inconvenience to their customers and affects their business. Several merchants at the Experimental site volunteered, in response to the general survey items, that the barriers presented a problem for both customers and merchandise delivery.

When specifically asked about the effects of the countermeasure on their business, 56% at the Control site and 65% at the Experimental site indicated that they perceived no negative effects. The remainder noted that the barriers made it more difficult to cross the street (22% Control and 15% Experimental site) and created a problem for the loading and unloading of goods (11%) Control and 18% Experimental).

It should be mentioned that the merchants who opposed the barriers were quite specific about their complaints. This group of merchants were strongly opposed to the installation. They felt that the money could have been more profitably spent for road maintenance or to develop off-street parking areas.

Stop Line Relocation

Salient Site and Countermeasure Characteristics

The Stop Line Relocation Countermeasure was tested at four locations: Washington, D.C., San Jose, Akron, and Columbus. The Control and Experimental sites in D.C. were located at the intersections of two-way, four-lane streets, with a two-way, two-lane street. The four-lane roadway was a heavily traveled major arterial, while the intersecting roads had light traffic throughout the day. Pedestrian traffic at the intersection was moderate. Both the Control and Experimental intersections were signalized and pedestrian signals were also present. The buildings at the intersections were multi-story apartment houses and small businesses. At the Experimental site, all four 12-inch wide stop lines were moved 12 feet back from their standard 4-foot position, thus leaving a 16-foot gap between the leading edge of the crosswalk and stop line.

In San Jose, the Control site was located at the intersection of a two-way, four-lane street with a two-way, two-lane street. The Experimental site was located at the intersection of the above mentioned four-lane street with another two-way, four-lane street. Vehicle and pedestrian traffic was light to moderate during the entire day. Both intersections were signalized and pedestrian controls were also present. The buildings at both sites were store front businesses. At the Experimental site, all four 12-inch stop lines were moved between 11 and 12 feet back from their 5- or 6-foot positions from the crosswalk.

The Akron sites were located on the same two-way, six-lane street. On one leg of the Control and Experimental intersection parking was permitted thus reducing the street to five travel lanes. At both sites, the intersecting street was a two-way street with three lanes on one side of the intersection and four lanes on the other. Pedestrian and vehicle activity was heavy on the main street and moderate on the intersecting streets. Traffic signals, without pedestrian heads, were present at each intersection. The buildings at the sites were small retail stores and an occasional larger department store. At the Experimental site, the two 18-inch stop lines on the major street were set back 9 feet from their 3-foot position.

In Columbus, the sites were located on a major two-way, four-lane street. At the Control site, the intersecting street was a two-way, three-lane street, with the center lane designated for left turns. At the Experimental site, the intersecting street was a two-way street having three lanes on one side of the intersection and four lanes on the other side. The three-lane leg had the center lane dedicated to left turns. The four-lane leg had three lanes entering the intersection; one was devoted to left turns, one to right turns, and one lane was used for through movements. Pedestrian activity was light at both sites. Vehicle traffic was moderate on both streets at the two sites. Both intersections were signalized and both had no pedestrian signal or crosswalks. The buildings abutting the sites were single and multi-family residences. On the major road, two 12-inch wide stop lines were installed 30 feet from the corner. On the intersecting road, the stop lines were placed 36 feet from the corner. A "Stop Here on Red" sign was placed adjacent to each of the stop lines. Crosswalks were not installed at either site in Columbus.

Behavioral Changes

Table 3-29 presents the results of the Post versus Before behavioral evaluation studies for the Stop Line Relocation countermeasure. A synopsis of the behavioral changes induced by the countermeasure follows:

Expected

1. Distance of stopped vehicles from pedestrians (crosswalk) – significant increase at all locations except Columbus where this item was not applicable (no marked crosswalk existed). (Average increase in separation was 6 feet in D.C., 3 feet in San Jose, and 7 feet in Akron.)
2. Turning conflict (vehicles) – statistically significant decrease in Akron.*
3. Turning conflict (pedestrians) – significant decrease in Akron.

*See Attachment B for the actual percentages.

Table 3-29

Behavioral Changes by Countermeasure Installation
Stop Line Relocation
(Post – Before)

	Countermeasure Location:	D.C.	San Jose	Akron	Columbus
Expected	DISTANCE OF STOPPED VEHICLES FROM CROSSWALK (ft)	↑ *	↑ *	↑ *	N/A *
	TURNING CONFLICT – 1 (VEHICLES)	**	**	↓ **	**
	TURNING CONFLICT – 3 (PEDESTRIANS)			↓	
Post Hoc	SCANNING TRAFFIC	***	↑ ***	↑ ***	***
	LEAVING CROSSWALK	↓			
	OUTSIDE CROSSWALK	↑			
	VEHICLE INDUCED HESITATION (PARKING LANE)	↓			
	VEHICLE STOPLINE VIOLATIONS	↑ *	↑ *	↑ *	N/A *
	PEDESTRIAN ENTRY BETWEEN STOPLINE & CROSSWALK	↑			N/A
	NUMBER OF OBSERVATIONS	597	142	3113	110

*Based on 323 stopped vehicle observations in D.C., 487 in San Jose, and 334 in Akron. The category was not scored in Columbus due to the absence of a crosswalk during both phases. The stopline existed only at the experimental site in the Post phase.

**Based on 581 turning vehicle observations in D.C., 571 in San Jose, 111 in Akron, and 324 in Columbus.

***Based on 60 observations in D.C., 65 in San Jose, 329 in Akron, and 60 in Columbus.

Post Hoc

1. Pedestrian scanning of traffic – significant increase in San Jose and Akron.
2. Leaving crosswalk – statistically significant decrease in D.C.
3. Outside crosswalk – statistically significant increase in D.C.
4. Vehicle induced pedestrian hesitation while standing in the parking lane – statistically significant decrease in D.C.
5. Vehicle stop line violations – significant increase at all locations except Columbus where the stop line existed in the Post phase only.

6. Pedestrian entry between stop line and crosswalk – significant increase in D.C. The absence of a marked crosswalk in Columbus precluded this item being tested at that location.

As expected, setting back the stop line significantly increased the vehicle/crosswalk separation. In D.C. and Akron, the stop line was moved 12 feet and this resulted in a 6- and 7-foot increase in vehicle/crosswalk separation, respectively. In San Jose, the stop line was moved 10 feet and the resulting increase in vehicle/crosswalk separation was 3 feet. Data was not available for Columbus since there was no stop line at the Columbus sites during the Before study. A Post Hoc finding related to vehicle/crosswalk separations was the significant increase in vehicle violations of the stop line after its setback. Thus, the incidence of stopping on or past the stop line increased about twofold after its relocation. However, the net effect was an increase in the distance between the stopped vehicles and the crosswalk.

In Akron, a significant decrease in both the percent of pedestrians involved in turning conflicts and a decrease in the percent of vehicles involved in turning conflicts was detected. A review of the vehicle and pedestrian activity at the Experimental location indicates that these results are probably associated with the 32% decrease in turning vehicles and the 51% decrease in pedestrian volume experienced at the site during the Post study. (The Before data was collected around Christmas time – 18 and 19 December).

For some unexplained reason, there was a significant increase in scanning at the San Jose and Akron locations. One possible explanation is that the pedestrians may have had to make a more discernable head movement in order to observe the vehicles that were stopped further away. Therefore, it might have been more likely that these head movements would be detected by the coders.

In D.C., there was a significant increase in the percent of pedestrians crossing outside the crosswalk and between the crosswalk and the relocated stop line. Some of the pedestrians in D.C. seemed to consider the space between the crosswalk and the relocated stop line as part of the permissible crossing area. D.C. also experienced an unexpected decrease in the percent of pedestrians leaving the crosswalk and hesitating in the parking lane. Both of these changes were caused by an increase of these behaviors at the Control site.

Table 3-30 presents the results of the Acclimation studies in D.C. This data is consistent with the Post versus Before data in the area of vehicle stop line separation, vehicle stop line violations, and leaving the crosswalk. Once again, the decrease in the percent of pedestrians leaving the crosswalk was due to an unexplained increase of the behavior at the Control site. The decrease in parking lane hesitations in the first Acclimation period is likewise attributable to the changes at the Control site. Confirmed by one of the two Acclimation studies was the increase in scanning and entry between the crosswalk and stop line.

Table 3-30

Behavioral Changes by Countermeasure Installation
Stop Line Relocation: Washington, D.C.
(Acclimation – Before)

	Phase:	Acclimation 1	Acclimation 2
Expected	DISTANCE OF STOPPED VEHICLES FROM CROSSWALK (ft)	↑ *	↑ *
	TURNING CONFLICT–1 (VEHICLES)	**	**
	TURNING CONFLICT–3 (PEDESTRIANS)		
Post Hoc	SCANNING TRAFFIC	***	↑ ***
	LEAVING CROSSWALK	↓	↓
	VEHICLE INDUCED HESITATION (PARKING LANE)	↓	
	VEHICLE STOPLINE VIOLATIONS	↑ *	↑ *
	PEDESTRIAN ENTRY BETWEEN STOPLINE & CROSSWALK	↑	
	NUMBER OF OBSERVATIONS	360	356

*Based on 170 stopped vehicle observations in Acclimation 1 and 158 in Acclimation 2.

**Based on 318 turning vehicle observations in Acclimation 1 and 311 in Acclimation 2.

***Based on 40 observations in Acclimation 1 and 40 in Acclimation 2.

In all fairness, it should be noted that the countermeasure was not primarily designed to modify the pedestrian's behavior. These behaviors were studied, however, in order to detect any unforeseen consequences of the countermeasure.

Pedestrian Motivational Factors

Table 3-31 is a compilation of the responses of those pedestrians who crossed in the crosswalk and with the signal. Before the relocation of the stop line 23% of the pedestrians indicated they performed the desired action because it was safer and 22% mentioned habit. After the relocation, 36% said they crossed within the crosswalk and with the signal because it was safer, while only 9% mentioned habit as a motivator. The other responses given to the Before and Post survey were similar in magnitude. With legality, avoidance of an accident, and heavy traffic receiving 11%-18% of the responses.

Table 3-31

Frequent Survey Responses for Pedestrians Performing Desired Actions Stop Line Relocation

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 246)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 246)	REASON FOR DESIRED ACTION (N = 88)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 88)
23% Safer	38% Usually not or never (at this location)	36% Safer	74% Did not notice it
22% Habit	36% If lighter traffic	17% Illegal to cross against signal	17% Had no effect
18% So not to be hit	14% If in a hurry	11% So not to be hit	6% Felt safer due to cars stopping further away
14% Illegal to cross against signal		11% Heavy traffic	
11% Heavy traffic		9% Habit	

*Crossing within the crosswalk with the signal
**Crossing against the signal outside of the crosswalk.

When asked when they would cross outside of the crosswalk or against the signal, 38% of the respondents in the Before study stated never and another 36% said they would cross in the undesired manner if the traffic was lighter.

Most pedestrians (74%) surveyed in the Post study were not aware of the relocation of the stop line and 17% indicated that although they noticed it, it had no effect on their crossing behavior. Six percent (6%) stated that they felt safer because the vehicles stopped further away.

Table 3-32 presents the survey results for those pedestrians who crossed outside of the crosswalk and/or against the signal. The most frequently given responses for performing the undesired action were the same in the Before and Post studies. Twenty percent (20%) of the Before study respondents and 27% of the Post study respondents stated that they were in a hurry. Twenty percent (20%) and 17%, respectively said that the light facing the traffic was still green. In the Before study 17% of the pedestrians felt that the signal was too short. Elderly pedestrians were the people who most frequently mentioned inadequate signal timing. In the After study, 12% of the pedestrians thought that the stop line was part of the crosswalk.

Table 3-32

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Stop Line Relocation

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 60)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 60)	REASON FOR UNDESIRED ACTION (N = 60)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 60)
20% In a hurry	35% If heavier traffic	27% In a hurry	85% Did not notice it
20% Traffic light was still green	15% Usually does	17% Traffic light was still green	10% Had no effect
17% Signal too short	10% If not in a hurry	12% Thought was part of crosswalk	
12% Break in traffic	8% Good weather	5% Convenience	
7% Bad weather	7% If traffic light was red	5% Break in traffic	
5% Others do it	7% At night		

*Crossing against the signal outside of the crosswalk.
**Crossing within the crosswalk with the signal.

When asked to indicate when they would perform the desired action, 35% said "in heavier traffic" and 15% said they usually do cross in the desired manner. Another 10% said they would wait for the signal if they were not in a hurry. Very few of the pedestrians noticed the relocated stop line (15%) and only 5% indicated that it affected their crossing behavior.

Once again we note the importance of convenience and safety as the motivational factors which differentiate those pedestrians who performed the desired actions from those who performed the undesired actions.

Merchant/Resident Reaction

The merchant and resident interviews were designed to reveal the social and economic impact of the countermeasure. Because of the relatively nonreactive nature of the stop line relocation, there appeared to be no reason to survey the merchants and residents.

Vendor Warning Signal

Salient Site and Countermeasure Characteristics

The Vendor Warning Signal was tested at two locations in Northern Virginia. Unlike previous experiments, the Control and Experimental studies were conducted at the same site. One site consisted of a two-way, four-lane road with parallel parking permitted on both sides of the street (hereafter known as the four-lane site). Part of the 817-foot block was included in a school zone. The area predominately consists of single family homes. The vehicle traffic was moderate and pedestrian activity was light. The posted speed limit was 35 mph.

The second site was a two-way, two-lane road with parallel parking permitted on both sides (hereafter known as the two-lane site). The 464-foot street was essentially residential in character, with single family houses in one side of the street and a small office building on the other side. The vehicle and pedestrian activity was light during the entire day. The posted speed limit was 25 mph.

An experimental warning signal was designed by BioTechnology and fabricated by the 3M Company. The signals were basically a modified Model 131 Signal Head. A black stencil was applied to the 12-inch x 12-inch amber face shield. The stencil masked the shield with the exception of the center portion depicting the silhouette of a running child. The signal had a flash rate of 72 pulses per minute. Two signals were placed on top of a van-type ice cream truck.* Both signals were placed on the left side of the roof; one facing front and one facing the rear. In the Experimental condition, both Experimental signals were activated. The Control condition consisted of turning off the experimental signals and activating the truck's four-way flashers. Two additional conditions were also tested at the more heavily traveled four-lane site (vendor not present, and vendor present but no signals on).

Behavioral Changes

Before discussing the behavioral data, we will present the data collection schedule for the four- and two-lane sites.

The Four-lane scenario is listed on the next page.

*BioTechnology would like to express its appreciation to Thomas J. Lipton, Inc. for the permission to use a Good Humor truck for the conduct of these experiments.

Period	Time	Vehicle Status	Data Collection Mode
1.	9:00 – 9:30 AM	Not Present	TES
2.	9:31 – 10:00 AM	Present – No Signal	TES
3.	10:01 – 10:30 AM	Present – Four-way Flashers	TES
4.	10:31 – 11:00 AM	Present – Experimental Signal	TES
5.	11:01 – 11:30 AM	Present – Experimental Signal	Interview
6.	11:31 – 12:00 AM	Present – Four-way Flashers	Interview
7.	12:01 – 12:30 PM	Not Present	No Data
8.	12:31 – 1:00 PM	Not Present	No Data
9.	1:01 – 1:30 PM	Not Present	TES
10.	1:31 – 2:00 PM	Present – No Signal	TES
11.	2:01 – 2:30 PM	Present – Four-way Flashers	Interview
12.	2:31 – 3:00 PM	Present – Experimental Signal	Interview
13.	3:01 – 3:30 PM	Present – Experimental Signal	TES
14.	3:31 – 4:00 PM	Present – Four-way Flashers	TES

The vehicle behavior in Table 3-33 for the four-lane road represents a comparison of periods 3 and 14 versus 4 and 13. These comparisons were based on a total of 258 vehicles approaching from the front and 204 vehicles approaching from the rear. The driver survey data consists of periods 6 and 11 versus 5 and 12.

Table 3-33

Behavioral Changes by Countermeasure Installation
Vendor Warning Signal: Washington, D.C.

	Countermeasure Location:	4-Lane Road	2-Lane Road
Expected	VEHICLE SPEED–APPROACHING FROM FRONT (mph)	↓ *	*
	VEHICLE SPEED–APPROACHING FROM REAR (mph)	**	**
	NUMBER OF DRIVER INTERVIEWS	68	50

*Based on 258 vehicle observations on the 4-lane road and 78 on the 2-lane road.

**Based on 204 vehicle observations on the 4-lane road and 56 on the 2-lane road.

The two-lane scenario was:

Period	Time	Vehicle Status	Data Collection Mode
1.	9:31 – 10:00 AM	Present – Four-way Flashers	TES and Interview
2.	10:01 – 10:30 AM	Present – Experimental Signals	TES and Interview
3.	10:31 – 11:00 AM	Present – Four-way Flashers	TES and Interview
4.	11:01 – 11:30 AM	Present – Experimental Signals	TES and Interview
5.	11:31 – 12:00 AM	Present – Four-way Flashers	TES and Interview
6.	12:01 – 12:30 PM	Not Present	No Data
7.	12:31 – 1:00 PM	Not Present	No Data
8.	1:01 – 1:30 PM	Present – Experimental Signals	TES and Interview
9.	1:31 – 12:00 PM	Present – Four-way Flashers	TES and Interview
10.	2:01 – 2:30 PM	Present – Experimental Signals	TES and Interview
11.	2:31 – 3:00 PM	Present – Four-way Flashers	TES and Interview
12	3:01 – 3:30 PM	Present – Experimental Signals	TES and Interview
13.	3:31 – 4:00 PM	Present – Four-way Flashers	TES and Interview
14.	4:01 – 4:30 PM	Present – Experimental Signals	TES and Interview

The Vehicle behavior reported in Table 3-33 for the two-way road represents a comparison of the odd numbered periods with the even numbered periods (excluding periods 6 and 7). Similarly, the driver survey data represents a comparison of the same periods. The vehicle comparisons were based on a total of 78 vehicles approaching from the front and 56 vehicles approaching from the rear.

The driver response to the Experimental signal versus the four-way flashers is presented in Table 3-33. We hypothesized that the Experimental signal would result in a significant speed decrease over the flashers. A verbal synopsis of the results follows:

Expected

1. Vehicle speed (approaching from the front) – significant decrease in the average approach speed on a four-lane roadway (–2 mph).
2. Vehicle speed (approaching from the rear) – no statistically significant change on either roadway, a decrease was expected.

Post Hoc

1. None

The results indicate that the Experimental signal significantly reduced the speed of front-approaching vehicles at the four-lane site. No significant change was noted at either site for rear approaching traffic. An interesting finding at the four-lane site was uncovered relative to the four-way flashers. The activation of these flashers did not decrease the speed of front approaching traffic from that observed under the "No Signal" condition.

It would appear that a combination of factors might have operated to reduce the effectiveness of the Experimental signals:

1. The signal was mounted approximately eight feet above the road surface.
2. The ice cream truck was situated near the curb in the parking lane during the testing period.
3. The two-lane location presented sight distance problems because of road curvature.

Driver Motivational Factors

A sample of drivers were interviewed after they had passed through the speed measurement area.* One item of the survey asked the drivers whether they saw flashing lights on the ice cream truck. At the four-lane site the Experimental signal was recalled by a significantly larger proportion of the drivers than the flashing signal (increase of .27). It is interesting to note that at both sites only the drivers approaching from the rear were interviewed. Thus although the Experimental signal was recalled by a significantly greater proportion of the drivers at the four-lane site this did not seem to result in any speed change on their part.

In an earlier part of the survey, the drivers were asked whether anything unusual caught their attention as they drove down the street. The response to this item and some later survey items are presented in Table 3-34 which contains the results from both sites. While slightly more (26% versus 17%) of the drivers exposed to the Experimental signal volunteered that it caught their attention, this difference was not statistically significant (at either site or in combination). When questioned as to the purposes of the flashers, 15% stated that they were to warn the driver to slow down and another 13% mentioned that they alerted the driver to look for children. With the Experimental signal, these responses represented 22% and 33% of the driver responses.

Thirty-nine percent (39%) of the drivers exposed to the flashers and 45% of the drivers exposed to the Experimental signal stated that it caused them to slow down. The consequences of this statement were not totally consistent with the speed data discussed in the previous section. Watching for children was the next most frequent way in which the drivers stated that they modified their behavior.

*A copy of the interview can be found in Appendix B, Data Collection and Analysis Procedures.

Table 3-34

Frequent Survey Responses for Drivers
Vendor Warning Signal

CONVENTIONAL SIGNALS			EXPERIMENTAL SIGNAL		
Anything Noticed While Driving (N = 65)	Purpose of Signals on Truck (N = 65)	Effect on Manner of Driving (if seen) (N = 34)	Anything Noticed While Driving (N = 53)	Purpose of Signal on Truck (N = 53)	Effect on Manner of Driving (if seen) (N = 36)
17% Truck or signals	52% Did not notice them	39% Slowed down	33% Watch for children	45% Slowed down	26% Truck or signal
83% Nothing or something else	15% Slow down	33% None	30% Did not notice it	26% None	74% Nothing or something else
	13% Watch for children	17% Watched for children	22% Slow down	23% Watched for children	23% None
	13% Other	17% Looked	15% Use caution	16% Looked	11% Looked
	10% Use caution	9% Other	9% Other	10% Other	8% Were more careful

Bus Stop Relocation

Salient Site and Countermeasure Characteristics

The Bus Stop Relocation countermeasure was tested at two locations: Miami and San Diego. The Miami Control location was at the intersection of a two-way, five-lane arterial with a two-way, two-lane secondary street. The major street also had a left turn channel on both approaches to the intersection. The Experimental site was on a two-way, four-lane arterial with a two-way, two-lane secondary street. The major street also had a left turn channel on both approaches to the intersection. Both intersections were unsignalized and did not have marked crosswalks. Buildings abutting the sites were mostly commercial in nature. Vehicle activity was moderate and pedestrian activity was light to moderate at the intersection. Bus passengers embarking and disembarking on the near side of the intersection was light but steady throughout the day.

In San Diego, the Control site was located on a two-way arterial with four lanes on one side of the intersection and five on the other side. The arterial intersects with a one-way, three-lane street. At the Experimental location a two-way, four-lane arterial intersects with a one-way, three-lane street. Both sites were controlled by traffic and pedestrian signals with right turn on red permitted. The buildings at both intersections were commercial businesses.

At both sites vehicle traffic was moderate and pedestrian activity was heavy during the entire day. The subpopulation of bus passengers embarking and disembarking on the near side of the intersection was moderate throughout the entire day.

Behavioral Changes

Table 3-35 presents the results of the behavior studies. A synopsis of the behavioral changes induced by the countermeasure follow:

Expected

1. Entry in front of a stopped bus – a significant decrease in San Diego in the percent of pedestrians entering the roadway in front of a stopped bus.

Table 3-35

Behavioral Changes by Countermeasure Installation
Bus Stop Relocation
(Post – Before)

	Countermeasure Location:	Miami *	San Diego
Expected	ENTRY IN FRONT OF STOPPED BUS		↓
Post Hoc	VEHICLE/PEDESTRIAN SEPARATION	↓	
	TURNING CONFLICT–3 (PEDESTRIANS)	↓	↓
	VEHICLE OVERTAKING		↓
	VEHICLE INDUCED HESITATION (PARKING LANE)		↑
	NUMBER OF OBSERVATIONS	138	2021

* Note that no traffic control signals exist at Experimental and Control site locations for this countermeasure in Miami.

Post Hoc

1. Vehicle/pedestrian separation – a significant decrease in Miami.
2. Turning conflict (pedestrians) – significant decrease at both locations.

3. Vehicle overtaking percent of pedestrians entering a triffic lane within one car length in front of standing [not parked] vehicle) – significant decrease in San Diego.

4. Vehicle induced pedestrian hesitation (while standing in the parking lane) – significant increase in San Diego.

We hypothesized that moving the bus stop to the far side of the intersection would reduce the percent of pedestrians crossing in front of the bus. In San Diego, the incidence of crossing in front of the bus did, in fact, decrease to zero during the Post study. It should be noted that although over 100 pedestrians crossed in front of the bus at the Experimental site during the Before study, none of them crossed against the traffic or pedestrian signal. Therefore, there was actually very little hazard associated with the crossings at this site. In Miami, no pedestrians were ever observed crossing in front of the bus. Thus, our choice of sites in Miami was unfortunate, in that we could not possibly demonstrate an effect.*

The remainder of the behavioral results are concerned with Post Hoc finds. It appears that none of these findings were associated with the relocation of the bus stop. Rather, they appear to be related to shifting the study area from one side of the intersection to the other side. For instance, the decrease of pedestrian turn/merge conflicts in Miami was related to the large increase in these conflicts at the Control site. In San Diego, this decrease was related to moving the bus stop to the other side of a one-way street. In this case fewer turn/merge conflicts were observed due to the absense of left turns into the crosswalk during the Post Study.

Pedestrian Motivational Factors

Table 3-36 presents the frequent responses of the pedestrians performing the desired behavior, i.e., waiting for the bus to leave and then crossing the street (and with the signal in San Diego). Before the relocation of the bus stop pedestrians noted safety (34%), legality (26%), and to avoid getting hit (19%) as motivating factors. After the relocation, the San Diego pedestrians mentioned legality as the most important reason why they waited for the signal and crossed behind the bus (42%). A large percentage of the pedestrians (37%) also stated that they crossed in the desired manner because they waited until the signal said it was okay to walk.

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*A preliminary study indicated a small percent of crossings in front of the bus at both the Control and Experimental locations. Our failure to observe any such behavior during the actual study was both perplexing and embarrassing.

Table 3-36

Frequent Survey Responses for Pedestrians
Performing Desired Actions
Bus Stop Relocation

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR DESIRED ACTION* (N = 68)	CONDITION UNDER WHICH UNDESIRED ACTION** WOULD BE PERFORMED (N = 68)	REASON FOR DESIRED ACTION (N = 19)	POINT OF CROSSING IF UNRELOCATED BUS STOP (N = 19)
34% Safer	29% If lighter traffic	42% Illegal to cross against signal	47% At corner irregardless of bus presence
26% Illegal to cross against signal	26% If in a hurry	37% "Walk" signal was on	26% In front of bus
19% So not to be hit	26% Usually not or never* (at this location)	16% Safer	11% Behind the bus
10% Heavy traffic	10% Usually does	5% Habit	11% After the bus passed
9% Habit	7% Never – can't see cars because bus blocks view		5% Behind the bus at unsignalized intersection
7% "Walk" signal was on	6% If no police were around		

*Waiting for the bus to pass and crossing in the crosswalk with the pedestrian signal.
**Crossing against the pedestrian signal in front of a bus stopped at a bus stop. (No signal is present in Miami.)

When asked the conditions under which they would cross in front of the bus (and against the signal in San Diego), 29% of the Before sample said if the traffic was lighter, 26% said if they were in a hurry and 26% usually not or never would at this location. In the Post study, pedestrians were asked where they would cross if the bus stop were moved back to the near side of the intersection. Forty-seven percent (47%) said they always cross at the corner, (26%) said they would cross in front of the bus and 11% indicated that they would cross behind the bus. Another 11% stated that they would wait for the bus to leave before crossing. It appears that most of the pedestrians who performed the desired actions were concerned with the safety and legality of their actions.

Table 3-37 presents the responses of those pedestrians in San Diego who crossed in front of the bus and against the signal. The major motivational factor once again appears to be convenience. Half of those pedestrians surveyed in the Before study stated that they performed the undesired behavior because they were in a hurry and 38% said they would not have crossed in that manner had they not been in a hurry. Table 3-38 also reflects the fact that we did not observe any pedestrians performing the undesired action during the Post study survey.

Table 3-37

Frequent Survey Responses for Pedestrians
Performing Undesired Actions
Bus Stop Relocation

BEFORE INSTALLATION		AFTER INSTALLATION	
REASON FOR UNDESIRED ACTION* (N = 8)	CONDITION UNDER WHICH DESIRED ACTION** WOULD BE PERFORMED (N = 8)	REASON FOR UNDESIRED ACTION (N = 0)	PERCEIVED EFFECT OF THE COUNTERMEASURE (N = 0)
50% In a hurry	38% If not in a hurry	No undesired behavior was observed for this countermeasure at the Experimental sites during the Post phase.	
25% Too long a wait for signal	13% Usually not or never (at this location)		
13% Did not see lights changing	13% If heavier traffic		
13% Others do it	13% If light changed when started across		

*Crossing against the pedestrian signal in front of a bus stopped at a bus stop.
**Waiting for the bus to pass and crossing in the crosswalk with the pedestrian signal.

Merchant/Resident Reaction

Table 3-38 represents the responses of merchants to the actual relocation of a bus stop (Experimental sites) or the concept of relocating a bus stop (Control sites). The most frequent traffic problem mentioned at the Control sites was the current lack of adequate parking. When specifically queried as to the consequences of moving the bus stop, most of the merchants at the Control sites felt it would not have any detrimental effect on their business.

At the Experimental sites, the lack of parking was also the most frequently noted pre-existing traffic-related problem. During the preliminary questions, one merchant mentioned that the relocation of the bus stop resulted in the loss of business and another noted that pedestrians were now leaning against his window while waiting for the bus. When specifically queried about the effects of the relocation, the majority of the merchants felt it would have no detrimental effects.

Table 3-38

Frequent Survey Responses for Merchants
Bus Stop Relocation

CONTROL SITES			EXPERIMENTAL SITES		
Conditions Affecting Business (N = 9)	Conditions Causing Inconvenience (N = 9)	Perceived Effect of the Countermeasure (N = 9)	Conditions Affecting Business (N = 10)	Conditions Causing Inconvenience (N = 10)	Perceived Effect of the Countermeasure (N = 10)
67% None	33% None	89% None	60% None	70% Not enough parking	80% None
33% Not enough parking	33% Not enough parking		20% Not enough parking	30% None	10% Has lower volume of business
	22% Too much traffic (esp. rush hour)		10% Relocated bus stop took away business	10% Unsynchorinized traffic lights	10% Trash left at bus stop hurts business
	11% One-way intersecting streets		10% Peds waiting for bus lean on windows		
			10% Not enough parking		

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

This final chapter of Volume I presents the author's conclusions and recommendations as to the effectiveness, design, and deployment of the tested countermeasures. The material in this chapter not only represents a synthesis of the data presented in Chapter 3 but also includes personal observation made by the field teams during the course of the study. These observations have been incorporated in the chapter in order to capture the content and flavor of the reactions of the public and the highway/traffic officials to the countermeasures.

Effectiveness of the Countermeasures

This section attempts to summarize the behavioral effects of the nine countermeasures tested during the current contract effort. During the course of the behavioral evaluation studies, each of the countermeasures was tested at a minimum of two locations. Over 30 types of pedestrian and vehicle behavior were observed at each of these locations. Preparing a terse yet comprehensive summary of this huge data base required considerable human judgment.

Table 4-1 combines the findings presented in Chapter 3 with the author's judgment of the internal and external validity of the behavioral data. In deriving this table, consideration was given to the following features:

1. Consistency of the behavioral changes across the test sites (replication).
2. Occurrence of the behavior at the test site (base rates).
3. Sample size at the test sites.
4. Unique characteristics of each of the test sites.

The entries in each cell of the table represent a conclusion on the part of the author. In effect, these conclusions are based on the author's subjective consideration of the above noted factors. The judgmental process proceeded along the following lines:

1. If statistically significant behavioral changes were detected at two or more of the site pairs and these changes appeared to be attributable to the countermeasure, then the entry denoting a changes was made in the table.
2. If only one statistically significant change was detected and the failure to replicate was due to inadequate sample size at the other sites, unique characteristics of the sites or countermeasures, at the other sites, or low base rates of the behavior then the entry denoting a change was made in the table.

3. If the significant change(s) could, with some confidence, be attributable to factors other than the installation of the countermeasure, then no entry was made in the table.

Table 4-1

Countermeasures and Their Behavioral Impact*

Behavioral Category	Countermeasures								
	Preventive Markings	Median Barrier	Crosswalk Set-Back	Midblock Crosswalk	Diagonal Parking	Meter Post Barriers	Stop Line Relocation	Vendor Warning Signals	Bus Stop Relocation
Pedestrian/Vehicle Separation				↑					
Pedestrian Scanning					↑		↑		
Vehicle Speed			↑	↓	↓				
Abort Crossing						↓			
Entry in Front of Stopped Bus									↓
Pedestrian Hesitation in Traffic Lane				↓					
Pedestrian Backing up in Parking Lane		↓				↓			
Pedestrian in Front of Parked Vehicles		↓		↓		↓			
Running in Roadway		↓	↑	↓	↓				
Sudden Appearance					↓				
Crossing Outside of Crosswalk		↓		↓					
Vehicle Stop Line Violations			↑				↑		
Vehicle Crosswalk Violations			↑						
Vehicle/Crosswalk Separation							↑		
Mid Block Crossings		↓							
Crossings in Crosswalk Area				↑					
Vehicle Speed			↑		↓				
Veh/Ped Turning Conflict(% of Peds Involved)									
Veh/Ped Turning Conflict(% of Peds That Stop)									
Veh/Ped Turning Conflict(% of Vehicles Involved)									
Bus Stop Related									
Crossing Against Light									
Crossing One-Half Against Light									
Running into Roadway									
Running into 2nd Half									
Trapped on Median									
Walking on Median									
Leaving Crosswalk									
Outside Crosswalk									
Vehicle Overtaking									
Pedestrian Hesitation in Parking Lane									
Pedestrian Backing up in Traffic Lane									
Intersection Run(Against Light)-1st Half)									
Intersection Run(Against Light)-2nd Half)									

*An increase in a particular behavior is designated by a "↑" while a decrease is "↓". Shaded boxes indicate those behaviors that were expected to be affected.

The reader may note that while over 30 types of behavior were collected, only 17 behaviors are listed as changed in the table. The remaining behaviors did not appear to be consistently modified by any of the countermeasures. The unaffected behaviors were:

Veh/Ped Turning Conflict (% of Peds Involved) – Type 3 Conflict
Veh/Ped Turning Conflict (% of Peds That Stop) – Type 2 Conflict
Veh/Ped Turning Conflict (% of Vehicles Involved) – Type 1 Conflict
Bus Stop Related
Crossing Against Light
Crossing One-Half Against Light
Running into Roadway
Running into 2nd Half
Trapped on Median
Walking on Median
Leaving Crosswalk
Outside Crosswalk
Vehicle Overtaking
Pedestrian Hesitation in Parking Lane (Induced by Vehicles)
Pedestrian Backing up in Traffic Lane (Induced by Vehicles)
Intersection Run (Against Light) – 1st Half
Intersection Run (Against Light) – 2nd Half

By rotating Table 4-1, we can select one or more countermeasures that may produce a specific behavioral change. For example, if we wished to reduce crossing between parked vehicles, which is a component of the "Dart-Out" accident type, we might consider installing a Median Barrier or a Midblock Crosswalk, or Diagonal Parking. If, additionally, we wanted to increase pedestrian scanning, we could reduce the three countermeasures to a single candidate, Diagonal Parking. We must, of course, first define the geometrics and social constraints existing at the problem location before selecting (or eliminating) candidate countermeasures.

On the basis of the Snyder and Knoblauch (1970) definitions, a list of remedial countermeasures could be proposed. Once again, any such list must be considered tentative in nature. Table 4-2 presents a set of candidate countermeasures that might reduce the incidence of a particular accident type. Within the framework of this Table, three of the accident types are not addressed by any of the countermeasures and three of the countermeasures do not appear to have any accident reduction potential. However, one of these countermeasures, the Crosswalk Set-Back, did not receive an adequate or conclusive test. In retrospect, the two installations of this countermeasure did not meet some of the design characteristics required for an effective control device. In particular, the Columbus installation did not include any barrier to guide the pedestrians to the relocated crosswalk. Although barriers were installed in Akron, their design permitted pedestrians to circumvent them. Therefore, we recommend that the Crosswalk Set-Back be tested in conjunction with a more restrictive barrier.

Table 4-2

Accident Types and Potential Countermeasures

ACCIDENT TYPES	COUNTERMEASURES: Preventive Markings	Median Barrier	Crosswalk Set-Back	Midblock Crosswalk	Diagonal Parking	Meter Post Barriers	Stop Line Relocation	Vendor Warning Signal	Bus Stop Relocation
Dart-Out (First Half)		X			X	X			
Dart-Out (Second Half)		X		X					
Intersection Dash									
Vehicle Turn/Merge With Attention Conflict									
Ped Strikes Vehicle		X							
Multiple Threat							X		
Bus Stop Related									X
Vendor-Ice Cream Truck									

Design of Countermeasures

During the course of this project, a series of specific countermeasures were tested. These countermeasures represented one attempt to design devices to meet the desired objectives, i.e., reduce specific accident-related behaviors. Obviously, the objectives could have been addressed through a variety of countermeasure designs. The current contract effort did not attempt to empirically determine the optimal design of the various countermeasures. Instead, "expert" opinion was used to develop the design specifications of the deployed countermeasures.

On the bases of our experience with the deployed countermeasures, a series of potential installation or operating problems were revealed. Most of the information relating to these potential problems was obtained through conversations with city highway engineers and local merchants. Table 4-3 presents a synopsis of the problems and potential problems associated with the countermeasures as designed and tested.

Table 4-3

Countermeasure and Potential Installation or Operating Problems

COUNTERMEASURES

POTENTIAL PROBLEMS	Preventive Markings	Median Barrier	Crosswalk Set-Back	Midblock Crosswalk	Diagonal Parking	Meter Post Barriers	Stop Line Relocation	Vendor Warning Signal	Bus Stop Relocation
City ordinances				x	x			x	
Reduction in parking capacity			x	x	x		x		
Reduction of traffic flow capacity			x	x	x		x		x
Re-timing of traffic signals			x	x			x		
Relocation of pedestrian signal			x						
Possible relocation of bus stop			x				x		
Countermeasure associated vehicle damage		x				x			
Loading and unloading merchandize		x			x	x			
Pedestrian rerouting		x	x			x			x
Additional maintenance requirements	x	x	x			x		x	
Accumulation of trash and snow removal		x	x		x	x			
Undesirable appearance		x	x			x			

Table 4-3 reveals that those countermeasures that used chains or chain link barriers presented problems of repair, sanitation, customer inconvenience, and esthetics. Other countermeasures such as Diagonal Parking, Midblock Crosswalk, and Vendor Warning Signal can present legal problems in their implementation. Documentation also revealed that vehicles damaged (and were damaged by) the Median Barrier and Meter Post Barriers. Once again, it should be stressed that these problems are indicative of the countermeasures as tested and are not necessarily inevitable consequences of the other devices that might address the same accident-related behaviors.

Deployment of the Countermeasures

Each of the nine countermeasures require a specific type of location and pedestrian/vehicle behavior. Table 4-4 presents a list of the major criteria for site selection. Some of these criteria were identified in the planning stages of the study, e.g., pedestrian/vehicle behaviors; while other criteria were derived from an analysis of the behavioral data, e.g., the desirability of installing Meter Post Barriers on both sides of the street.

Table 4-4

Site Selection Criteria by Countermeasure

Countermeasure	Site Selection Criteria
1. Preventive Markings	1. Intersection 2. Pedestrian crossing against signal, accepting small vehicle gaps or in conflict with turning vehicles
2. Median Barrier	1. Sufficient median to accommodate barrier and vehicle over-hang 2. Uninterrupted median (no turnabouts) 3. Pedestrians running into 1st and/or 2nd half of roadway at nonintersection locations
3. Crosswalk Set-Back	1. Intersection 2. No driveways between corner and relocated crosswalk 3. Sufficient sidewalk width to accommodate pedestrian barriers 4. Good sight-distance at corners 5. Pedestrian in conflict with turning vehicles
4. Midblock Crosswalk	1. Heavy midblock pedestrian volume 2. Moderate to light, slow moving traffic if crosswalk is unsignaled 3. Existence of a "natural path" between two pedestrian generators 4. Pedestrians running into or entering roadway near midblock
5. Diagonal Parking	1. Low traffic volume 2. Sufficient roadway width to accommodate the through traffic lane(s) and provide a safety area behind parked vehicles 3. Pedestrians running out into roadway between parked vehicles
6. Meter Post Barriers	1. Uninterrupted parking meters on both sides of the street 2. Heavy parking utilization without breaks for alleys, driveways, etc. 3. Sufficient curb height to restrict vehicle over-ride 4. Pedestrians entering roadway from between parked vehicles
7. Stop Line Relocation	1. No driveway between corner and relocated stop line 2. At least 2 lanes of traffic approaching from the same direction 3. Pedestrians entering the roadway in front of stopped or standing vehicles into lane of moving traffic
8. Vendor Warning Signal	1. Installed on truck canvassing high accident routes 2. Pedestrian running across road to or from vendor
9. Bus Stop Relocation	1. Adequate geometrics to permit far side bus stop (no alley, etc.) 2. Pedestrians entering the roadway in front of stopped or standing buses into lane of moving traffic

These site characteristics in Table 4-4 are, of course, relative to the countermeasures as tested. Design modifications could negate some of the site requirements and/or create new requirements.

REFERENCES

Bartholomew, W. M. Pedestrian accidents in service areas of selected city recreation facilities. *Traffic Safety*, 1967, *11*(4), 117-123.

Biehl, B. M., Older, S. J., & Griep, D. J. The safety of pedestrians. Road Research Laboratory, Paris, France, October 1969.

Blumenthal, M., & Wuerdemann, H. A state accident investigation program: Phase II. Final Report. FH-11-6926. Prepared by The Travelers Research Corporation, Hartford, Connecticut, with National Highway Safety Bureau, U.S. Department of Transportation, Washington, D.C., July 1969.

Box, P. C. Non-involved vehicle accident elements. *Public Safety Systems*, 1970, *35*(5), 7-15.

Butler, E. L. Denver's new traffic control system includes pedestrian separation period. *Traffic Digest and Review*, April 1953, *1*.

Cameron, M. H. Study of pedestrian (zebra) crossings. Prepared by Australian Road Research Board, Melbourne, Australia, 1970.

Cleveland, D. E. Selected bibliography on traffic control for pedestrian safety. Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan, June 1969.

Cleveland, D. E. Pedestrian crosswalk safety studies. Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan, July 1969.

Cohen, J., Dearnaley, E. J., & Hansel, C. E. M. The risk taken in crossing a road. *Operational Research Quarterly*, 1955, *6*(2), 120-128.

Denver Department of Public Works. School speed limit study, 1965: A test of reduced school speed limits and other school area traffic controls. Prepared for National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C., October 1965.

Duff, J. T. Mutual obligations of turning traffic and pedestrians at signal controlled intersections and appropriate indication thereof. *International Road Safety and Traffic Review*, 1963, *11*(2), 9-10, 12, 14, 17, 48.

Fisher, A. J., & Hall, R. R. The influence of car frontal design on pedestrian accident trauma. *Accident Analysis and Prevention*, 1972, *4*, 47-58.

Fleig, P. H., & Duffy, D. J. A study of pedestrians safety behavior using activity sampling. *Traffic Safety*, 1967, *11*(4), 106-111.

Fruin, J. J. Pedestrian planning and design. Metropolitan Association of Urban Desginers and Environmental Planners, Inc., New York, New York, 1972.

Garwood, R., & Moore, R. L. Pedestrian accidents. *Traffic Engineering and Control*, September 1962.

Harris, J. I., & Perkins, S. R. Traffic conflict characteristics. Research Publication GMR-780. Eelctro-Mechanics Department, Research Laboratories, General Motors Corporation, Warren, Michigan, August 1968.

Hayes, A. T. Pedestrian control. *Institute of Traffic Engineers Proceedings*, 1961.

Hazlett, R. D., & Allen, M. J. The ability to see a pedestrian at night: The effects of clothing, reflectorization and driver intoxication. Division of Optometry, Indiana University, Bloomington, Indiana.

Heimstra, N. W., Nichols, J., & Martin, G. An experimental methodology for analysis of child pedestrian behavior. *Pediatrics,* November 1969, *44* Supplement, 832-838.

Herms, B. F. Pedestrian crosswalk study: Accidents in painted and unpainted crosswalks. Project PS 69-2-001. Police Department, Traffic Bureau, Public Works Department, Traffic Engineering Section, City of San Diego, California, August 1970.

Hollich, G. F. Intersection solution – Center refuge gives pedestrians a better chance. *Street Engineering,* 1968, *3*(5), 20-22.

Jacobs, G. D. The effect of vehicle lighting on pedestrian movement in well-lighted streets. RRL Report LR 214. Road Research Laboratory, Berkshire, England, 1968.

Jacobs, G. D. The effects of zebra crossing installations on pedestrians and vehicles. No. 1: Yiewsley High Street. *Surveyor and Municipla Engineer,* July 1965.

Jacobs, G. D., Older, S. J., & Wilson, D. G. A comparison of X-way and other pedestrian crossings. Road Research Laboratory, Berkshire, England.

Jacobs, G. D., & Wilson, D. G. A study of pedestrian risk in crossing busy roads in four towns. RRL Report LR 106. Road Research Laboratory, Berkshire, England, 1967.

Kainuma, Y. Pedestrian behavior as it is related to the installation of safety facilities. National Police Agency, National Research Institute of Police Science, Japan, 1969.

Kaiser, J. M. The effects of supplementary pedestrian signals. Graduate Thesis submitted to Yale University, May 1959.

Kalinoski, J. R. Evaluation of school crossing warning signs. Portland Traffic Safety Commission, Engineering Committee, 1964.

Katz, A. Methods to reduce pedestrian accidents. Technion Research and Development Foundation, Ltd., Isreal, 1970.

Katz, A., Elgrichi, A., & Guttmann, L. Proposed warrants and standards for pedestrian guardrails. Report No. 1: Pedestrian behavior at locations with guardrails. Publication No. 72/7. Road Safety Centre, Israel, 1970.

Kraay, J. Crossing pedestrians. Road Safety Research Foundation Swov., Transport Ministry, Netherlands, 1970.

Ladd, W. You are an AP. *Public Safety,* 1954, *46*(3), 16-17.

Los Angeles City Unified School District. Accident investigation. Comprehensive Pedestrian Safety Project PS 70-001 (003). Student Auxiliary Services Branch, School Traffic and Safety Education Section, Los Angeles, California, 1973.

Mackie, A. M., & Jacobs, G. D. Comparison of road user behaviour at panda, zebra, and light-controlled crossings. *Traffic Engineering and Control,* 1965, *6*(12), 714-718, 732.

Malo, A. F., & Cleveland, D. C. Improved pedestrian safety at crosswalks. Prepared jointly by Detroit Department of Streets and Traffic, and Highway Safety Research Institute, University of Michigan, for Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1970.

Malo, A. F., et al. An innovative pedestrian crosswalk safety device demonstration. HSRI Report No. TrS-8. Prepared jointly by Detroit Department of Streets and Traffic, and Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan, 1971.

Marvin, W. L. Driver observance of crosswalk and stop lines. *Traffic Engineering*, 1951, *21*(5), 157-159.

McCarroll, J. R., & Haddon, W. Controlled studies on automobile accidents in New York City. *Acta Medecinae Legalis et Socialis*, January 1963.

Miller, F. D., & Michael, H. L. A study of school crossing protection. *Traffic Safety Research Review*, 1964, *8*(2).

Mortimer, R. G., & Nagamachi, M. Effects of roadway markings on vehicle stopping in pedestrian crosswalks. Report HuF-2. Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan, 1969.

Mueller, E. A., & Rankin, W. W. Pedestrians. Traffic control and roadway elements – Their relationship to highway safety. Revised. Chapter 8. Highway User Federation for Safety and Mobility, 1970.

Navin, F. P. D., & Wheeler, R. J. Pedestrian flow characteristics. *Traffic Engineering*, 1969, *19*(7), 30-33, 36.

Older, S. J. Movement of pedestrians on footways in shopping streets. *Traffic Engineering and Control*, 1968, *10*(4), 160-163.

Older, S. J., & Grayson, G. B. Perception and decision in the pedestrian task. Transportation and Road Research Laboratory, Berkshire, England, 1972.

Plummer, D. The need for reporting "non-involved" vehicles and "driver intent" in accident data. *Traffic Digest and Review*, March 1972, 2-9.

Poole, C. J. A study of pedestrian behavior in busy urban streets. Witwatersrand University, South Africa, 1972.

Reading, J. B. Pedestrian protection through behavior modification. *Traffic Engineering*, July 1973.

Road Research Laboratory. Pedestrians. Research on Road Traffic. Chapter 12. Department of Scientific and Industrial Research, London, England, 1965.

Rudden, J. B. Warrants for and experiences with pedestrian intervals at signalized intersections. *Institute of Traffic Engineers Proceedings*, 1959, 181-182.

Ryan, G. A. Children in traffic accidents. *Pediatrics*, 1969, *44*(5), 847-854.

Sandahl, J., & Percivall, M. A pedestrian traffic model for town centers. *Traffic Quarterly*, July 1972, *26*, 359-372.

San Diego, City of. 1968 collision index: A summary of high accident locations. Police Department, Traffic Division, Engineering Department, Traffic Engineering Division, April 1969.

Shapiro, L., & Mortimer, R. G. A literature review and bibliography of research and practice in pedestrian safety. Report HuF-3. Highway Safety Research Institute, University of Michigan, Ann Arbor, Michigan.

Singer, S. Pedestrian regulation enforcement and the incidence of pedestrian accidents. Contract No. FH-11-6968. Prepared by Dunlap and Associates, Inc., Darien, Connecticut, for National Highway Safety Bureau, U.S. Department of Transportation, Washington, D.C., August 1969.

Snyder, M. B., & Knoblauch, R. L. Pedestrian safety: The identification of precipitating factors and possible countermeasures. Volume I and Volume II, Appendices. Report No. FH-11-7312. Prepared by Operations Research, Inc., Silver Spring, Maryland, for National Highway Safety Bureau, U.S. Department of Transportation, Washington, D.C., January 1971.

Terry, D. S., & Thomas, G. J. Farside bus stops are better. *Traffic Engineering*, March 1971.

Traffic Laws Commentary. Pedestrian response to red lights. No. 69-3. National Committee on Uniform Traffic Laws and Ordinances, Washington, D.C., September 1969.

Uruno, F., & Hanawa, K. Pedestrian safety. National Research Institute of Police Science; Traffic Division, Japan, 1969.

Vuchic, V. R. Pedestrian crossing time in determining widths of signalized traffic arterials. *Transportation Science*, 1967, *1*(3), 224-231.

Watanabe, S., & Matsui, H. Theoretical study for pedestrian trafficways and facilities. Transportation Engineering Department, Nagoya Institute of Technology, Japan, April 1969.

Welke, R. C. Improved pedestrian indications aid D.C. drivers. *Traffic Engineering*, January 1968.

Wilson, D. G., & Older, S. J. The effects of installing new zebra crossings in Rugby and Chelmsford. RRL Report LR 358. Road Research Laboratory, Berkshire, England, 1970.

Zeigler, C. D. A study of on-street parking arrangements. Research Report SS 19.1. Texas Highway Department, District Seventeen, Austin, Texas, August 1971.

Attachment A

Inter-rater Reliabilities of PAS Behavioral Categories*

Behavioral Category	Inter-rater Reliability
Abort	.94
Turning Confilct – 1	.95
Turning Conflict – 2	.86
Turning Conflict – 3	.95
Trapped on Median	.91
Walking on Median	.99
Leaving Crosswalk	.89
Outside Crosswalk	.95
Bus Stop Related	.98
Vehicle Overtaking (Intersection)	.99
Vehicle Overtaking (Mid block)	.93
Crossing Against Light	.81
Crossing ½ Way Against Light	.94
Vehicle Induced Hesitation (Traffic lane)	.86
Vehicle Induced Hesitation (Parking lane)	.89
Backup Movement (Traffic lane)	.97
Backup Movement (Parking lane)	.87
In Front of Parked Vehicles	.96
Running into Roadway	.83
Running in Roadway	.79
Sudden Appearances	.83
Running into 2nd Half	.97
Intersection Run – 1st Half	.89
Intersection Run – 2nd Half	.84

*Based on the average Pearson Product-Movement Correlation among 3 raters over 20 PAS periods.

Attachment B

Percent Used to Calculate the Net Change Associated with the Countermeasures*

Table 3-2 (page 3-5) PREVENTIVE MARKINGS (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Scanning of Traffic				
Washington, D.C.	60.0 (84)	52.0 (132)	53.0 (40)	50.0 (36)
San Diego	73.0 (60	62.0 (60)	78.0 (108)	73.0 (124)
Crossing Against Light Signal				
Washington, D.C.	0.0 (153)	0.0 (163)	0.0 (213)	0.4 (223)
San Diego	Not Applicable			
Vehicle/Pedestrian Separation				
Washington, D.C.	98.0 (153)	98.2 (163)	98.6 (213)	96.0 (223)
San Diego	67.9 (28)	85.2 (27)	46.9 (32)	60.7 (28)
Running into Roadway				
Washington, D.C.	6.5 (153)	3.7 (163)	1.9 (213)	1.8 (223)
San Diego	0.0 (28)	3.7 (27)	0.0 (32)	3.6 (28)
Turning Conflict-1 (Vehicles)				
Washington, D.C.	2.8 (389)	2.9 (311)	14.3 (147)	5.8 (155)
San Diego	0.0 (170)	0.0 (164)	4.1 (49)	1.8 (55)
Turning Conflict-3 (Pedestrians)				
Washington, D.C.	8.5 (153)	6.1 (163)	18.3 (213)	8.5 (223)
San Diego	0.0 (28)	0.0 (27)	6.3 (32)	3.6 (28)
Trapped on Median				
Washington, D.C.	10.5 (153)	6.1 (163)	1.9 (213)	2.7 (223)
San Diego	Not Applicable			
Leaving Crosswalk				
Washington, D.C.	22.2 (153)	30.1 (163)	6.1 (213)	9.0 (223)
San Diego	7.1 (28)	0.0 (27)	9.4 (32)	0.0 (28)

Table 3-3 (page 3-7) PREVENTIVE MARKINGS (Acclimation-Before)

	Before-Control	Acclimation-Control	Before-Experimental	Accl.-Experimental
Scanning of Traffic				
Acclimation 1	60.0 (84)	44.0 (96)	53.0 (40)	65.0 (20)
Acclimation 2	60.0 (84)	46.0 (90)	53.0 (40)	27.0 (52)
Crossing Against Light Signal				
Acclimation 1	1.0 (100)	0.0 (78)	0.0 (135)	0.8 (130)
Acclimation 2	0.9 (109)	0.0 (83)	0.0 (150)	0.6 (168)
Vehicle/Pedestrian Separation				
Acclimation 1	97.0 (100)	97.4 (78)	98.5 (135)	100.0 (130)
Acclimation 2	97.2 (109)	97.6 (83)	98.7 (150)	99.4 (168)
Running into Roadway				
Acclimation 1	6.0 (100)	2.6 (78)	3.0 (135)	3.8 (130)
Acclimation 2	6.4 (109)	3.6 (83)	3.3 (150)	3.0 (168)
Turning Conflict-1 (Vehicles)				
Acclimation 1	2.3 (173)	2.0 (149)	10.5 (95)	9.3 (86)
Acclimation 2	1.9 (206)	5.2 (153)	10.8 (120)	10.6 (142)
Turning Conflict-3 (Pedestrians)				
Acclimation 1	10.0 (100)	3.8 (78)	11.9 (135)	10.8 (130)
Acclimation 2	9.2 (109)	12.0 (83)	12.7 (150)	13.1 (168)
Leaving Crosswalk				
Acclimation 1	26.0 (100)	33.3 (78)	10.4 (135)	3.8 (130)
Acclimation 2	27.5 (109)	32.5 (83)	10.7 (150)	9.5 (168)

Table 3-6 (page 3-12) MEDIAN BARRIER (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Running into 2nd Half				
Washington, D.C.	16.4 (55)	8.9 (45)	7.2 (83)	0.0 (10)
NYC	1.0 (96)	12.9 (70)	1.8 (56)	6.4 (78)

*Net Change ≈ (Post Experimental – Before Experimental) – (Post Control – Before Control)
The initial number in each cell is the percent. The value in parentheses is the frequency of occurrence of the item upon which the percent is based.

Attachment B (Continued)

Percent Used to Calculate the Net Change Associated with the Countermeasures

Table 3-6 (page 3-12) MEDIAN BARRIER (Post-Before) (Continued)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Crossing in Midblock				
Washington, D.C.	30.0 (67)	21.0 (56)	43.0 (54)	0.0 (48)
NYC	55.0 (285)	33.0 (541)	48.0 (231)	11.0 (251)
In Front of Parked Vehicles				
Washington, D.C.	100.0 (55)	97.8 (45)	38.6 (83)	70.0 (10)
NYC	46.9 (96)	67.1 (70)	5.4 (56)	11.5 (78)
Running in Roadway				
Washington, D.C.	10.9 (55)	11.1 (45)	7.2 (83)	10.0 (10)
NYC	5.2 (96)	21.4 (70)	5.4 (56)	11.5 (78)
Vehicle/Pedestrian Separation				
Washington, D.C.	78.2 (55)	97.8 (45)	89.2 (83)	100.0 (10)
NYC	100.0 (96)	91.4 (70)	100.0 (56)	98.7 (78)
Trapped on Median				
Washington, D.C.	16.4 (55)	20.0 (45)	25.3 (83)	0.0 (10)
NYC	63.5 (96)	25.7 (70)	23.2 (56)	55.1 (78)
Vehicle Induced Hesitation (Parking Lane)				
Washington, D.C.	5.5 (55)	4.4 (45)	9.6 (83)	0.0 (10)
NYC	20.8 (96)	41.4 (70)	19.6 (56)	15.4 (78)

Table 3-7 (page 3-14) MEDIAN BARRIER (Acclimation-Before)

	Before-Control	Accl.-Control	Before-Experimental	Accl.-Experimental
Running into 2nd Half				
Acclimation 1	24.1 (29)	4.2 (24)	6.7 (60)	0.0 (4)
Acclimation 2	22.6 (31)	2.9 (34)	6.5 (62)	0.0 (7)
Crossing in Midblock				
Acclimation 1	Data not taken during Acclimation phases.			
Acclimation 2				
In Front of Parked Vehicles				
Acclimation 1	100.0 (29)	100.0 (24)	36.7 (60)	25.0 (4)
Acclimation 2	100.0 (31)	97.1 (34)	35.5 (62)	85.7 (7)
Running in Roadway				
Acclimation 1	13.8 (29)	0.0 (24)	6.7 (60)	0.0 (4)
Acclimation 2	12.9 (31)	8.8 (39)	6.5 (62)	0.0 (7)
Trapped on Median				
Acclimation 1	13.8 (29)	29.2 (24)	18.3 (60)	25.0 (4)
Acclimation 2	12.9 (31)	23.5 (34)	21.0 (62)	0.0 (7)

Table 3-12 (page 3-20) CROSSWALK SET-BACK (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Turning Conflict-1 (Vehicles)				
Akron	3.2 (156)	3.1 (258)	0.0 (462)	0.0 (431)
Columbus	5.2 (77)	6.0 (67)	9.2 (87)	1.1 (123)
Turning Conflict-3 (Pedestrians)				
Akron	25.0 (24)	24.2 (33)	0.0 (33)	0.0 (37)
Columbus	5.3 (75)	6.5 (62)	20.0 (55)	1.8 (55)
Outside Crosswalk				
Akron	0.0 (24)	3.0 (33)	33.3 (33)	21.6 (37)
Columbus	2.7 (75)	0.0 (62)	0.0 (55)	97.2 (55)
Vehicle Induced Hesitation (Parking Lane)				
Akron	12.5 (24)	6.1 (33)	3.0 (33)	0.0 (37)
Columbus	4.0 (75)	6.5 (62)	1.8 (55)	0.0 (55)
Running in Roadway				
Akron	16.7 (24)	6.1 (33)	0.0 (33)	8.1 (37)
Columbus	9.3 (75)	9.7 (62)	3.6 (55)	7.3 (55)
Vehicle Stop Line Violations				
Akron	0.0 (85)	4.6 (195)	8.8 (102)	67.5 (120)
Columbus	0.0 (6)	11.1 (9)	9.1 (11)	83.3 (6)

Attachment B (Continued)

Percent Used to Calculate the Net Change Associated with the Countermeasures

Table 3-12 (page 3-20) CROSSWALK SET-BACK (Post-Before) (Continued)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Vehicle Crosswalk Violations				
Akron	0.0 (85)	0.5 (195)	1.0 (102)	36.7 (120)
Columbus	0.0 (6)	0.0 (9)	9.1 (11)	50.0 (6)

Table 3-16 (page 3-26) MIDBLOCK CROSSWALK (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Crossing in Crosswalk Area				
Washington, D.C.	Control Site Data		8.6 (174)	27.8 (263)
Miami	Not Collected for		6.7 (45)	58.5 (41)
Toledo	this Item		35.9 (78)	60.2 (88)
Vehicle/Pedestrian Separation				
Washington, D.C.	89.9 (189)	92.4 (145)	76.4 (174)	93.5 (263)
Miami	73.3 (90)	69.4 (62)	66.7 (45)	82.9 (41)
Toledo	77.9 (86)	90.5 (63)	87.2 (78)	95.5 (88)
In Front of Parked Vehicle				
Washington, D.C.	51.3 (189)	64.1 (145)	77.6 (174)	64.6 (263)
Miami	72.2 (90)	87.1 (62)	77.8 (45)	14.6 (41)
Toledo	46.5 (86)	39.7 (63)	39.7 (78)	15.9 (88)
Running in Roadway				
Washingotn, D.C.	6.3 (189)	6.2 (145)	6.9 (174)	1.9 (263)
Miami	15.6 (90)	12.9 (62)	6.7 (45)	4.9 (41)
Toledo	4.7 (86)	6.3 (63)	3.8 (78)	0.0 (88)
Scanning Traffic				
Washington, D.C.	65.0 (111)	67.0 (120)	67.0 (172)	60.0 (108)
Miami	71.0 (28)	71.0 (78)	80.0 (112)	48.0 (112)
Toledo	89.0 (35)	97.0 (37)	97.0 (38)	76.0 (41)
Vehicle Induced Hesitation (Traffic Lane)				
Washington, D.C.	6.9 (189)	6.2 (145)	3.4 (174)	8.4 (263)
Miami	16.7 (90)	16.1 (62)	37.8 (45)	17.1 (41)
Toledo	0.0 (86)	15.8 (63)	10.3 (78)	3.4 (88)
Running into 2nd Half				
Washington, D.C.	7.9 (189)	6.2 (145)	10.3 (174)	1.1 (263)
Miami	14.4 (90)	12.9 (62)	8.9 (45)	4.9 (41)
Toledo	Not Applicable due to one-way street.			

Table 3-17 (page 3-29) MIDBLOCK CROSSING (Acclimation-Before)

	Before-Control	Accl.-Control	Before-Experimental	Accl.-Experimental
Crossing in Crosswalk Area				
Acclimation 1	Control Data not Taken		11.9 (101)	20.9 (67)
Acclimation 2			14.0 (86)	17.8 (45)
Vehicle/Pedestrian Separation				
Acclimation 1	89.1 (101)	92.4 (79)	81.2 (101)	91.0 (67)
Acclimation 2	89.1 (92)	92.0 (75)	80.2 (86)	93.3 (45)
In Front of Parked Vehicles				
Acclimation 1	52.5 (101)	54.4 (79)	92.1 (101)	62.7 (67)
Acclimation 2	51.0 (92)	52.0 (75)	90.1 (86)	80.0 (45)
Running in Roadway				
Acclimation 1	5.9 (101)	10.1 (79)	5.9 (101)	3.0 (67)
Acclimation 2	6.5 (92)	9.3 (75)	5.8 (86)	8.9 (45)
Scanning Traffic				
Acclimation 1	65.0 (111)	44.0 (68)	67.0 (172)	71.0 (122)
Acclimation 2	65.0 (111)	69.0 (36)	67.0 (172)	67.0 (91)
Vehicle Induced Hesitation (Traffic Lane)				
Acclimation 1	6.9 (101)	1.3 (79)	3.0 (101)	6.0 (67)
Acclimation 2	7.6 (92)	2.7 (75)	3.5 (86)	8.9 (45)

Attachment B (Continued)
Percent Used to Calculate the Net Change Associated with the Countermeasures

Table 3-17 (page 3-29) MIDBLOCK CROSSWALK (Acclimation-Before) (Continued)

	Before-Control	Accl.-Control	Before-Experimental	Accl.-Experimental
Vehicle Induced Hesitation (Parking Lane)				
Acclimation 1	9.9 (101)	6.3 (79)	5.9 (101)	11.9 (67)
Acclimation 2	10.9 (92)	9.3 (75)	7.0 (86)	8.9 (45)
Running into 2nd Half				
Acclimation 1	5.9 (101)	8.9 (79)	7.9 (101)	3.0 (67)
Acclimation 2	6.5 (92)	6.7 (75)	8.1 (86)	6.7 (45)

Table 3-21 (page 3-34) DIAGONAL PARKING (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Running into Roadway				
Miami	1.6 (322)	4.9 (366)	1.8 (164)	6.6 (183)
San Diego	12.5 (8)	0.0 (10)	29.4 (17)	0.0 (10)
Scanning Traffic				
Miami	75.0 (53)	75.0 (52)	68.0 (56)	100.0 (21)
San Diego	60.0 (15)	68.0 (22)	25.0 (16)	100.0 (6)
In Front of Parked Vehicles				
Miami	76.4 (322)	71.6 (366)	59.8 (164)	15.8 (183)
San Diego	37.5 (8)	80.0 (10)	94.1 (17)	100.0 (10)
Sudden Appearance				
Miami	1.6 (322)	4.4 (366)	1.8 (164)	1.1 (183)
San Diego	12.5 (8)	0.0 (10)	29.4 (17)	0.0 (10)
Abort				
Miami	3.1 (322)	0.5 (366)	3.0 (164)	3.3 (183)
San Diego	12.5 (8)	0.0 (10)	0.0 (17)	0.0 (10)
Vehicle Induced Hesitation (Traffic Lane)				
Miami	3.4 (322)	1.9 (366)	1.2 (164)	4.9 (183)
San Diego	0.0 (8)	0.0 (10)	0.0 (17)	0.0 (10)
Backup Movement (Traffic Lane)				
Miami	3.4 (322)	0.5 (366)	1.8 (164)	4.9 (183)
San Diego	12.5 (8)	0.0 (10)	0.0 (17)	0.0 (10)
Running in Roadway				
Miami	0.9 (322)	2.2 (366)	2.4 (164)	1.6 (183)
San Diego	0.0 (8)	0.0 (10)	0.0 (17)	0.0 (10)

Table 3-24 (page 3-39) METER POST BARRIER (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Running into Roadway				
Washington, D.C.	2.0 (50)	3.2 (31)	5.4 (56)	0.0 (45)
NYC	2.3 (87)	0.0 (133)	4.3 (47)	1.5 (67)
Toledo	3.0 (66)	4.5 (89)	7.3 (41)	0.0 (12)
Scanning Traffic				
Washington, D.C.	95.0 (22)	95.0 (40)	87.0 (39)	81.0 (100)
NYC	65.0 (152)	72.0 (123)	65.0 (156)	79.0 (92)
Toledo	63.0 (42)	77.0 (30)	86.0 (50)	81.0 (36)
In Front of Parked Vehicles				
Washington, D.C.	90.0 (50)	90.3 (31)	96.4 (56)	97.8 (45)
NYC	81.6 (87)	93.2 (133)	72.3 (47)	55.2 (67)
Toledo	72.7 (66)	64.0 (89)	68.3 (41)	58.3 (12)
Abort				
Washington, D.C.	0.0 (50)	12.9 (31)	3.6 (56)	4.4 (45)
NYC	1.1 (87)	3.0 (133)	17.0 (47)	1.5 (67)
Toledo	0.0 (66)	0.0 (89)	4.9 (41)	0.0 (12)
Vehicle Induced Hesitation (Parking Lane)				
Washington, D.C.	38.0 (50)	77.4 (31)	39.3 (56)	44.4 (45)
NYC	42.5 (87)	39.8 (133)	14.9 (47)	29.9 (67)
Toledo	18.2 (66)	13.5 (89)	43.9 (41)	0.0 (12)

Attachment B (Continued)

Percent Used to Calculate the Net Change Associated with the Countermeasures

Table 3-24 (page 3-39) METER POST BARRIER (Post-Before) (Continued)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Backup Movement (Traffic Lane)				
Washington, D.C.	0.0 (50)	0.0 (31)	5.4 (56)	4.4 (45)
NYC	4.6 (87)	13.5 (133)	12.8 (47)	4.5 (67)
Toledo	0.0 (66)	2.2 (89)	0.0 (41)	0.0 (12)
Backup Movement (Parking Lane)				
Washington, D.C.	0.0 (50)	16.1 (31)	7.1 (56)	4.4 (45)
NYC	4.6 (87)	19.5 (133)	19.1 (47)	4.5 (67)
Toledo	4.5 (66)	1.1 (89)	2.4 (41)	0.0 (12)

Table 3-25 (page 3-42) METER POST BARRIER (Acclimation 1-Before)†

	Before-Control	Accl.-Control	Before-Experimental	Accl.-Experimental
Running into Roadway				
Acclimation 1	3.8 (26)	5.9 (17)	0.0 (12)	3.3 (30)
Scanning Traffic				
Acclimation 1	95.0 (22)	100.0 (22)	87.0 (39)	86.0 (36)
In Front of Parked Vehicles				
Acclimation 1	92.3 (26)	94.1 (17)	91.7 (12)	96.7 (30)
Vehicle/Pedestrian Separation				
Acclimation 1	92.3 (26)	88.2 (17)	50.0 (12)	96.7 (30)
Vehicle Induced Hesitation (Traffic Lane)				
Acclimation 1	26.9 (26)	5.9 (17)	8.3 (12)	26.7 (30)

Table 3-29 (page 3-47) STOP LINE RELOCATION (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Distance of Stopped Vehicles from Crosswalk (in feet)				
Washington, D.C.	7.80 (44)	9.68 (50)	10.86 (28)	16.80 (50)
San Jose	6.65 (20)	7.41 (22)	8.63 (32)	12.79 (28)
Akron	5.46 (50)	7.38 (50)	10.26 (50)	14.82 (50)
Columbus	Not Applicable			
Turning Conflict-1 (Vehicles)				
Washington, D.C.	6.1 (181)	3.0 (198)	8.5 (318)	3.8 (263)
San Jose	3.9 (102)	2.7 (110)	1.5 (271)	1.0 (300)
Akron	12.7 (368)	15.0 (387)	40.9 (66)	31.1 (45)
Columbus	8.3 (196)	0.6 (172)	1.2 (161)	0.6 (163)
Turning Conflict-3 (Pedestrians)				
Washington, D.C.	13.2 (151)	6.4 (109)	19.0 (189)	7.4 (148)
San Jose	8.3 (48)	12.0 (25)	8.7 (46)	13.0 (23)
Akron	24.8 (436)	18.8 (431)	15.3 (1508)	5.1 (738)
Columbus	16.7 (24)	4.3 (23)	10.7 (28)	5.7 (35)
Scanning Traffic				
Washington, D.C.	50.0 (8)	20.0 (20)	47.0 (32)	32.0 (28)
San Jose	53.0 (49)	57.0 (28)	20.0 (25)	50.0 (40)
Akron	44.0 (96)	37.0 (132)	24.0 (185)	35.0 (144)
Columbus	53.0 (68)	57.0 (68)	55.0 (44)	38.0 (16)
Leaving Crosswalk				
Washington, D.C.	4.6 (151)	27.5 (109)	15.9 (189)	15.5 (148)
San Jose	20.8 (48)	20.0 (25)	2.2 (46)	8.7 (23)
Akron	6.0 (436)	10.0 (431)	11.3 (1508)	15.0 (738)
Columbus	0.0 (24)	0.0 (23)	0.0 (28)	0.0 (35)
Outside Crosswalk				
Washington, D.C.	2.6 (151)	2.8 (109)	10.1 (189)	18.9 (148)
San Jose	0.0 (48)	0.0 (25)	0.0 (46)	0.0 (23)
Akron	5.5 (436)	7.2 (431)	31.9 (1508)	34.3 (738)
Columbus	0.0 (24)	0.0 (23)	0.0 (28)	0.0 (35)
Vehicle Induced Hesitation (Parking Lane)				
Washington, D.C.	6.6 (151)	12.8 (109)	7.4 (189)	6.8 (148)
San Jose	4.2 (48)	8.0 (25)	0.0 (46)	0.0 (23)
Akron	3.4 (436)	7.2 (431)	2.3 (1508)	5.6 (738)
Columbus	12.5 (24)	0.0 (23)	0.0 (28)	11.4 (35)

†No Acclimation 2 phase data were collected for this countermeasure.

Attachment B (Continued)

Percent Used to Calculate the Net Change Associated with the Countermeasures

Table 3-29 (page 3-47) STOP LINE RELOCATION (Post-Before) (Continued)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Vehicle Stop Line Violations				
Washington, D.C.	24.3 (210)	17.3 (284)	11.7 (120)	45.8 (203)
San Jose	33.3 (114)	31.8 (154)	25.4 (224)	63.5 (263)
Akron	28.9 (180)	15.8 (234)	11.0 (172)	22.8 (162)
Columbus	Not Applicable			
Pedestrian Entry Between Stop Line and Crosswalk				
Washington, D.C.	4.6 (151)	4.6 (109)	4.2 (189)	9.5 (148)
San Jose	0.0 (48)	0.0 (25)	0:0 (46)	0.0 (23)
Akron	6.1 (436)	9.0 (431)	15.0 (1508)	15.9 (738)
Columbus	Not Applicable			

Table 3-30 (page 3-49) STOP LINE RELOCATION (Acclimation-Before)

	Before-Control	Accl.-Control	Before-Experimental	Accl.-Experimental
Distance of Stopped Vehicles from Crosswalk (in feet)				
Acclimation 1	7.80 (44)	7.84 (50)	10.86 (28)	16.32 (47)
Acclimation 2	7.80 (44)	7.66 (50)	10.86 (28)	14.79 (48)
Turning Conflict-1 (Vehicles)				
Acclimation 1	6.2 (113)	7.2 (83)	10.4 (183)	5.2 (135)
Acclimation 2	6.2 (113)	5.6 (72)	10.4 (183)	10.9 (128)
Turning Conflict-3 (Pedestrians)				
Acclimation 1	12.2 (98)	8.7 (69)	21.8 (110)	9.6 (83)
Acclimation 2	12.2 (98)	7.7 (65)	21.8 (110)	16.9 (83)
Scanning Traffic				
Acclimation 1	50.0 (8)	25.0 (12)	47.0 (32)	25.0 (8)
Acclimation 2	50.0 (8)	0.0 (0)	47.0 (32)	75.0 (8)
Leaving Crosswalk				
Acclimation 1	3.1 (98)	14.5 (69)	19.1 (110)	18.1 (83)
Acclimation 2	3.1 (98)	20.0 (65)	19.1 (110)	14.5 (83)
Vehicle Induced Hesitation (Parking Lane)				
Acclimation 1	6.1 (98)	14.5 (69)	10.9 (110)	8.4 (83)
Acclimation 2	6.1 (98)	6.2 (65)	10.9 (110)	12.0 (83)
Vehicle Stop Line Violations				
Acclimation 1	27.2 (136)	23.4 (111)	13.2 (76)	46.8 (94)
Acclimation 2	27.2 (136)	22.9 (140)	13.2 (76)	46.3 (82)
Pedestrian Entry Between Stop Line and Crosswalk				
Acclimation 1	7.1 (98)	5.8 (69)	7.3 (110)	16.9 (83)
Acclimation 2	7.1 (98)	4.6 (65)	7.3 (110)	7.2 (83)

Table 3-33 (page 3-53) VENDOR WARNING SIGNAL (Post-Before)☆

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Vehicle Speed-Approach from Front (mph)				
4-lane Road	34.54 (105)	N/A	N/A	32.06 (153)
2-lane Road	18.96 (35)	N/A	N/A	18.37 (43)
Vehicle Speed-Approach from Rear (mph)				
4-lane Road	28.15 (78)	N/A	N/A	29.51 (126)
2-lane Road	21.03 (20)	N/A	N/A	21.13 (36)

Table 3-35 (page 3-57) BUS STOP RELOCATION (Post-Before)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Entry in Front of Stopped Bus				
Miami	0.0 (16)	0.0 (27)	0.0 (54)	0.0 (41)
San Diego	14.3 (516)	9.1 (397)	10.8 (492)	0.0 (616)
Vehicle/Pedestrian Separation				
Miami	62.5 (16)	92.6 (27)	68.5 (54)	73.2 (41)
San Diego	99.6 (516)	99.7 (397)	100.0 (492)	100.0 (616)

☆Before-Control = 4-way conventional flashers; Post-Experimental = symbolic experimental signal.

Attachment B (Continued)

Percent Used to Calculate the Net Change Associated with the Countermeasures

Table 3-35 (page 3-57) BUS STOP RELOCATION (Post-Before) (Continued)

	Before-Control	Post-Control	Before-Experimental	Post-Experimental
Turning Conflict-3 (Pedestrians)				
Miami	6.3 (16)	22.2 (27)	11.1 (54)	2.4 (41)
San Diego	41.0 (516)	36.0 (397)	30.9 (492)	11.9 (616)
Vehicle Overtaking				
Miami	0.0 (16)	0.0 (27)	0.0 (54)	0.0 (4.1)
San Diego	11.6 (516)	21.2 (397)	0.2 (492)	0.0 (616)
Vehicle Induced Hesitation (Parking Lane)				
Miami	25.0 (16)	18.5 (27)	27.8 (54)	22.0 (41)
San Diego	9.7 (516)	5.0 (397)	1.8 (492)	2.4 (616)