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SEVEN EXPERIMENT DESIGNS ADDRESSING PROBLEMS OF SAFETY AND CAPACITY ON TWO-LANE RURAL HIGHWAYS

Volume VII: Experimental Design to Develop and Evaluate Measures for Reducing the Effects of Roadside Friction on Traffic Flow

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16. Abstract The objective of this experiment is to investigate the problems of roadside friction which interfere with the smooth flow of traffic that is caused by external forces. This report is designed to determine the effects of roadside friction on driver behavior and to study various countermeasures at problem locations. This Technical Report consists of seven other volumes. They are:

Vol.	pp.	Title
I	38	Introduction, Description of Experiments and Common Elements
II	70	Develop and Evaluate Dynamic Aids for Narrow Bridges
III	72	Evaluation of MUTCD and Other Traffic Controls for Highway Construction and Maintenance Operations on Two-Lane Highways
IV	58	Develop and Evaluate Remedial Aids to Warn Drivers of Slow Moving Vehicles on a Grade
V	62	Vehicle Equivalency and Capacity Including Effects of Commercial and Recreational Vehicles on Rural Non-Controlled Access Highways
VI	54	Comparative Evaluation of Warning-Advisory and Regulatory Traffic Control Devices
VIII	70	Remedial Aids for Intersections with Inadequate Sight Distance

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1. INTRODUCTION

This report contains the Experimental Design to "Develop and Evaluate Measures for Reducing the Effects of Roadside Friction on Traffic Flow."* This is Volume VII of an eight-volume report. Volume I contains background information and summaries of the seven experiments, as well as a discussion of those elements common to each of the seven experimental designs.

This volume contains the following:

- Background and Objectives,
- A State-of-the-Art Review,
- The Experimental Design,
- A Bibliography.

1.1 Background

Roadside friction, in the form of vehicular, pedestrian or bicycle activity on or adjacent to the roadway shoulder, often interferes with the smooth and safe flow of traffic. With the exception of fixed roadside furniture, relatively little research has been done in this area. There is thus a need to develop and evaluate measures for reducing the effects, on traffic flow and safety, of roadside friction elements. The continuing growth of strip development, and of non-vehicular traffic, on the roadside and shoulders in rural areas demands that this problem be investigated, and that measures be devised for informing motorists of the need for caution in the presence of such friction elements.

1.2 Objective of Experiment

The objective of this experiment is to develop and evaluate the relative merit of warning signs and other devices, used singly or in combination, in improving traffic flow and safety in the presence of a variety of different types of roadside friction elements. The following types of friction elements are considered:

- Vehicles entering the main roadway from driveways;
- Parked or disabled vehicles on the side of the road;

*This experiment is referred to as Experiment F in Volume I.

2. STATE-OF-THE-ART

The literature search for this experiment attempted to obtain information related to elements of roadside friction, including pedestrians, hitchhikers, bicycles, parked vehicles on or adjacent to the roadway shoulder, and slow moving vehicles or school buses on the shoulder or in the traffic stream. Relatively few references were found which are directly concerned with previous research efforts related to the problem of roadside friction as described above. Most of the past research deals with specific types of fixed objects and their relationship to accidents, roadside elements in terms of their design and the resulting impact on safety or studies related to the interaction between pedestrian and bicycle traffic and vehicular traffic. The first two of these are not included in the scope of this experimental design. As defined in the statement of work, the experiment is to focus on stopped or slow-moving vehicles on or off the paved surface of the roadway, pedestrians, bicycles and hitchhikers. Specific items which were recommended for inclusion in the experiment were:

- Commercial establishments off the roadway;
- Transitory roadside incidents--parked or abandoned vehicles, vehicle repairs;
- Roadside maintenance activities--mowing, utility operations, shoulder maintenance;
- Driveways.

2.1 Types of Friction Elements

The Highway Capacity Manual (HCM) (1) defines four types of friction:

- Intersectional friction - caused by potential and actual traffic movement conflicts at an intersection or merge of two traffic streams;
- Stream friction - the retarding effect caused by mutual interferences between traffic units traveling in the same direction;
- Medial friction - caused by the interference between opposing traffic streams. The above friction types will not be examined in this experiment;

driveways, residential units, residential driveways and lane width were relatively unimportant predictors of accident rates.

Brangan (4), in a study of rural arterials in Ireland, found that while a large investment has been made in these arterials for moving long and medium distance traffic, roadside development interferes with this function. He states that all forms of development on arterial roads have adverse effects on traffic safety and flow. He suggests that development be strictly monitored along arterials. New development should be sited adjacent to, but not on, arterials.

Box (6), in an extensive study of driveways found that there is a strong relation between increased number of commercial establishments and increased accidents expressed either on a million-vehicle-mile or route-mile basis. Similarities have been found in driveway accident characteristics on urban and rural routes with left turn entry movements the most critical factor.

2.3 Shoulders

The AASHTO Blue Book (7) defines a shoulder as "the portion of roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use and for lateral support of base and surface courses." The width of a shoulder may vary from two feet (.6 m) on minor rural roads to 10 to 12 feet (3 to 3.6 m) on major roads.

Shoulders of sufficient width are essential if a roadway is to maintain a smooth traffic flow and reduce marginal friction. A disabled vehicle parked off the traveled lanes on a shoulder will produce much less friction than a disabled vehicle in the traffic lane. This is critical on two-lane roads where traffic in both directions will be severely affected.

It is necessary to differentiate between the travel lane and the shoulder. Taragin (8) investigated road sections where the shoulder was not marked and was uniform in appearance with the rest of the road. He found that vehicles, particularly commercial vehicles, encroached on the shoulder in the presence of opposing vehicles. The addition of solid is present, there is little detrimental effect on traffic flow. Jilla suggests placing bicycle lanes on streets without parking and with adequate width. Loop and Layton (13) in a similar study found similar results.

The increase in pedal cycle deaths recently has led to the incorporation of bicycle safety provisions mandated by the Highway Safety Act of 1973. Kaplan (14) has developed a standard for highway safety for bicycles including bicycle lanes, signing, bicycle paths, etc. The development and utilization of these standards is necessary to reduce the number of accidents. Most of the fatalities and injuries to bicyclists occur in the under 15-year age group. Brezina (15) investigated accidents of young cyclists. He found that the majority of accidents occur during the rush hour traffic flows. The primary causes were the inability of the cyclist to evaluate the risk of a road environment, prediction of traffic movement and control of the bicycle. Marginal friction of this type could be reduced by the use of exclusive bike lanes.

In March 1977, the Federal Highway Administration released for distribution a new section of the MUTCD (16). This new edition is entitled "Part IX - Traffic Controls for Bicycle Facilities" (17) and covers bicycle use related signs, pavement markings and signals which may be used on highways or bikeways. The intent of Part IX is to define the standards for traffic control devices, but it will not be a legal requirement for their installation.

During the period from 1937 to 1961, there was a marked decrease in the absolute number of pedestrian deaths in the United States. Since 1961, however, there has been a slight upward trend in pedestrian fatalities (18). The majority of these deaths are urban. Pedestrians account for only 9 percent of all traffic fatalities on rural roads. Most urban areas have sidewalks or a parking lane that can be used by pedestrians as walkways. As such, they are off the traveled lane. On a two-lane rural road with narrow or no shoulders, the pedestrian is at times forced to walk on the road. This hazardous situation is sometimes compounded by poor lighting, bad weather and poor visibility conditions.

in the driveway will be required for actuation. The legend for the final treatment will be "Driveways Ahead" for the first sign and "Vehicles Entering When Flashing" with the beacons for the second sign.

In the second and third treatments, the warning signs will be located 750 feet (230 m) upstream of the driveway.

For the fourth treatment, the first sign will be located 750 feet (230 m) upstream and the actuated beacon sign at 375 feet (115 m) upstream. Signing treatments are presented in Figure 1.

Approach Speed Limit

At the first site, the approach speed should be 55 MPH (88 km/h) and at the second, 40 MPH (64 km/h). Data will be collected from about 1000 feet (305 m) upstream of the driveway to a point 600 feet (183 m) downstream of the driveway. The Maine Facility in-road detectors (see Volume I) will be supplemented at intermediate points with the Transportation Data Corporation traffic recorder detectors. Lateral placement data will be measured at five points: 500 feet (152 m), 200 feet (61 m), and 100 feet (30 m) upstream of the driveway, at the driveway, and 100 feet (30 m) downstream of the driveway.

Friction Elements

There will be five levels of this independent variable. They are:

a. Base condition (no vehicle on driveways);

b. Passenger vehicle on driveway waiting to merge onto roadway;

c. Passenger vehicle on driveway waiting to cross to opposite lane of roadway;

d. Truck on driveway waiting to merge;

e. Truck on driveway waiting to cross to opposite lane.

These conditions will be staged with cooperative vehicles in the driveway. An observer stationed upstream on U.S. 2 will alert the staged vehicle of the approach of a main street vehicle. The staged vehicle driver will position the front of the vehicle three feet from the right side of the edge line. Figure 2 shows the vehicle orientations for merge and cross traffic maneuvers. The vehicle should use the proper turn signal indication (right or left), as appropriate.

Ambient Lighting

There will be two levels of ambient lighting: day and night. Day data will be collected from one hour after sunrise to one hour before sunset. Night data will be collected from one hour after sunset to one hour before sunrise. Data should not be collected during the dusk or twilight due to the extreme variability of lighting conditions and short duration.

Entry Vehicle Type

Two types of main street vehicles will be examined: passenger type vehicles and trucks. The passenger type vehicles include cars, pickup trucks and vans. Trucks should include dual rear axle and larger trucks and large self-contained recreational vehicles. No data will be collected on vehicles towing trailers.

Entry Speed

The independent variable, entry speed of the main street vehicle into the test section will not be stratified into speed classes, but instead will be treated as a covariate in analysis. This speed will be measured at the furthest up-stream detector.

3.1.3 Dependent Variables

The dependent variables in this experiment are lateral placement and speed related MOEs. Lateral placement will be measured using the TDC detectors at five points in the test section. The speed related MOEs are mean speed, speed variance and 85th percentile speeds at each detector and speed profiles over the entire test section.

The design for this experiment will be a complete block design with a $4 \times 2 \times 5 \times 2 \times 2 = 160$ cells. A summary of this design is presented in Table 1.

TABLE 1. - Summary of Driveway Design

Independent Variables:	Levels
1. Sites	2
2. Signing Treatments	4
3. Friction Element	5
4. Ambient Lighting	2
5. Entry Vehicle Type	2
6. Entry Speed	Covariate
	160 cells

Dependent Variables:

1. Mean Speed
2. Speed Variance
3. 85 Percentile Speeds
4. Speed Profiles
5. Lateral Placement

Dry pavement and good visibility only

The use of this vehicle should be in conjunction with some visible activity. The second vehicle type is an apparently disabled car that will be parked on the shoulder. To reduce the possibility of passing motorists' stopping to offer help, there should be no one in or around the PDV vehicles. The car can be jacked up on one side to simulate a flat tire.

Lateral Offset of PDV

Two levels of this independent variable will be investigated. Measurements will be made from the right side of the edge line to the left side of the PDV. The first offset will be two feet (.6 m)*. The second will be five feet (1.5 m) from the roadway edge.

In the HCM, lateral clearance is considered one of the factors affecting the capacity of the road. The purpose of the lateral offset variable is to verify the HCM values of capacity reduction. In addition, the changes in offset will allow different levels of driver behavior to be examined. The HCM tables of capacity reduction due to lateral clearance have values for offsets of 0, 2, 4 and 6 feet (0, .6, 1.2, 1.8 m). The zero-foot offset was eliminated in the previous report as being unsafe. The two-foot (.6-m) offset is included as the lowest value that the HCM has in the capacity reduction tables. The second offset, five feet (1.5 m), was chosen as the mean of the four- and six-foot (1.2- and 1.8-m) positions. This was done to reduce the size of the experiment design.

Ambient Lighting

Two levels of ambient lighting will be used--day and night. Collection of data during the day should be between one hour after sunrise to one hour after sunset. Night data collection should be between one hour after sunset to one hour before sunrise. Data should not be collected during dusk hours.

---

*Although the reaction of motorists and the efficiency of remedial aids for zero of small negative PDV offsets would represent valuable data, this condition is considered too dangerous to include in the experimental design.

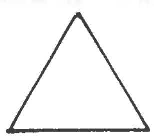
	Parked Car Aids	Maintenance Vehicle Aids
I Base	No lights or aids - day Taillights - night	No lights or aids - day Taillights - night
II	4-Way Flashers	4-Way Flashers
III		Rotating Beacon
IV	4-Way Flashers + 	Rotating Beacon + 4-Way Flashers

FIGURE 3: Warning Aid Treatments

TABLE 2. - Summary of PDV Design

INDEPENDENT VARIABLES

		Levels
1.	Shoulder width	2
2.	Lateral offset from edge of roadway	2
3.	Ambient Lighting	2
4.	PDV type	2
5.	Entry Vehicle type	2
6.	Warning Aids	4
7.	Entry Vehicle Speed	Covariate
		128 cells

DEPENDENT VARIABLES

1. Mean speed
2. Speed Variance
3. 85%ile Speed
4. Speed Profiles
5. Lateral Placement

Dry pavement and good visibility only

Baseline data will be collected without PDV at both sites, day and night.

TABLE 3. - Location of Parked Vehicles and L.P. Detectors

Level No.	Location of Parked Vehicle* (ft)	Offset (ft)	Location of L.P. Detectors* (ft)
1	+500	2	+700, +600, +500, +400, +200, +100, 0, -100
2	+250	2	+600, +300, +200, +100, 0, -100
3	-250	2	+500, +200, +100, 0, -100, -400, -500, -600
4	-500	2	+500, +200, +100, 0, -100, -400, -500, -600
5	+500	5	+700, +600, +500, +400, +200, +100, 0, -100
6	+250	5	+600, +300, +200, +100, 0, -100
7	-250	5	+500, +200, +100, 0, -100, -400, -500, -600
8	-500	5	+500, +200, +100, 0, -100, -400, -500, -600
9	None	-	+500, +200, +100, 0, -100, -400, -500, -600

* "+" denotes upstream of driveway
"-" denotes downstream of driveway

1 ft. = .3048 m

3.3.3 Dependent Variables

The dependent variables in this experiment are lateral placement and speed related MOEs. Lateral placement will be measured using the TDC detectors at five points in the test section. The speed related MOEs are mean speed, speed variance and 85th percentile speeds at each detector and speed profiles over the entire test section.

A summary of the design is presented in Table 5. One of the treatments of the location of the PV, the no-vehicle condition data, will use the data collected in the driveway experiment. This will reduce the number of cells from 180 to 171.

3.4 Experiment No. 4

The primary objective of Experiment No. 4 is to study the effects of bicycles on traffic flow. As part of this experiment, the signing of the new Section IX of the MUTCD, "Traffic Controls for Bicycle Facilities,"* will be tested. Due to the nature of this experiment, it will not be possible to use the Maine Facility for testing.

3.4.1 Site Criteria

The sites for this experiment will have to be chosen in an area where there exists or may exist a relatively heavy flow of bicycle traffic. An example of a good site might be a section of roadway in close proximity to a large college or university. In an area such as this, many students and faculty take advantage of the economical bicycle for short commuting trips.

At least two sites should be chosen. Sites should have moderate vehicular traffic, speed limits in the 25- to 35-MPH (40- to 56-km/h) range, two lanes, and have no existing bike lane. A street in a residential area near a college would be adequate. At one of the sites, curb parking should be allowed, but not necessarily utilized, and at the other, curb parking prohibited. Street width at both sides should be sufficient to allow for the installation of bike lanes on one side of the street. When the bike lanes are installed, they should be started at least 1/4 mile (.4 km) or more preceding the test

*Promulgated by FHWA on March 25, 1977.

locations at the first upstream signalized intersection, and should continue at least 1/4 mile (.4 km) beyond the test section.

Data collection for this experiment will be accomplished solely with 16-mm time-lapse movie filming of a 100-foot (30 m) test section. Filming at five frames/second and assuming vehicle speeds of 35 MPH (56 km/h), vehicle speeds and lateral placement can be computed every ten feet (3 m). To produce these many data points, ten TDC traps would be required for speed measurement and an additional ten for lateral placement.

The choice of test section will depend on finding a suitable location for the camera that is elevated and easily accessible (see Data Collection Section).

3.4.2 Independent Variables

Entry Vehicle Type

Two types of vehicles are anticipated for study--passenger vehicles and trucks. Passenger vehicles will include cars, pickup trucks and vans. The second category is trucks. If the sites are chosen in a residential area, the truck traffic may be very low or nonexistent. If, after site selection, this is found to be true, the variable should be dropped from the design and data collected on passenger cars only.

Remedial Aids

The base condition will be the two sites without bike lane markings. In the case of the site with parking allowed, the cyclist will ride three feet (1 m) from the edge of the parking lane. At the no-parking site, the bike should be ridden three feet (1 m) from the curb or pavement edge. To assist the rider in maintaining this distance, the roadways should be marked lightly with a line at the correct location.

The second treatment should be a six-foot (2 m) bike lane with pavement markings, but no signing as shown in Part IX MUTCD (see Figures 4 and 5 for parking and no parking sites). The diamond shaped marking is the Preferential Lane Symbol Pavement Marking. It is intended for use on highway facilities where lanes are reserved for exclusive use by a particular type

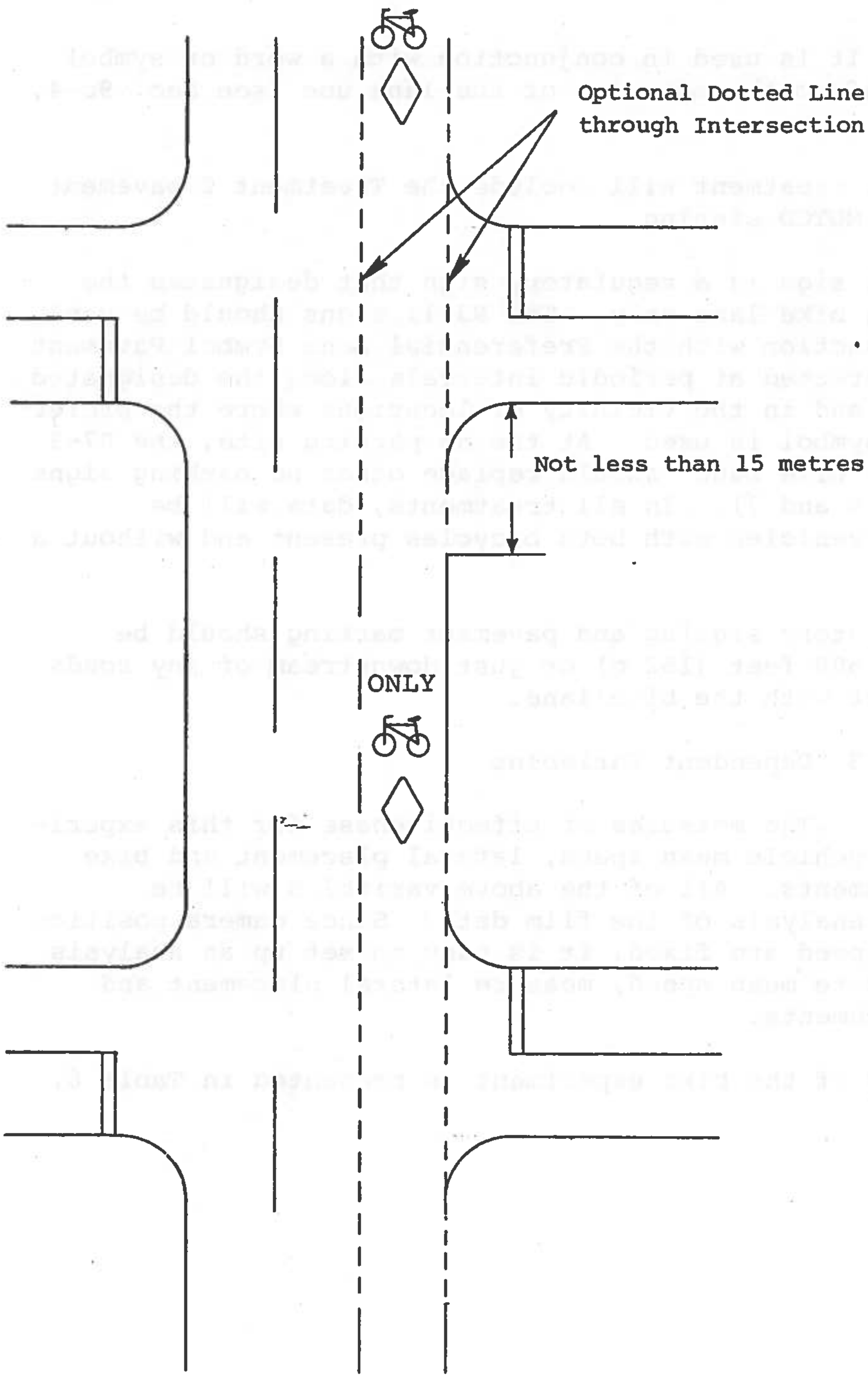


FIGURE 5 : Designated Bicycle Lane - Two-Way Traffic
without Parking
Low Rt. Turn Volume
Pavement Markings

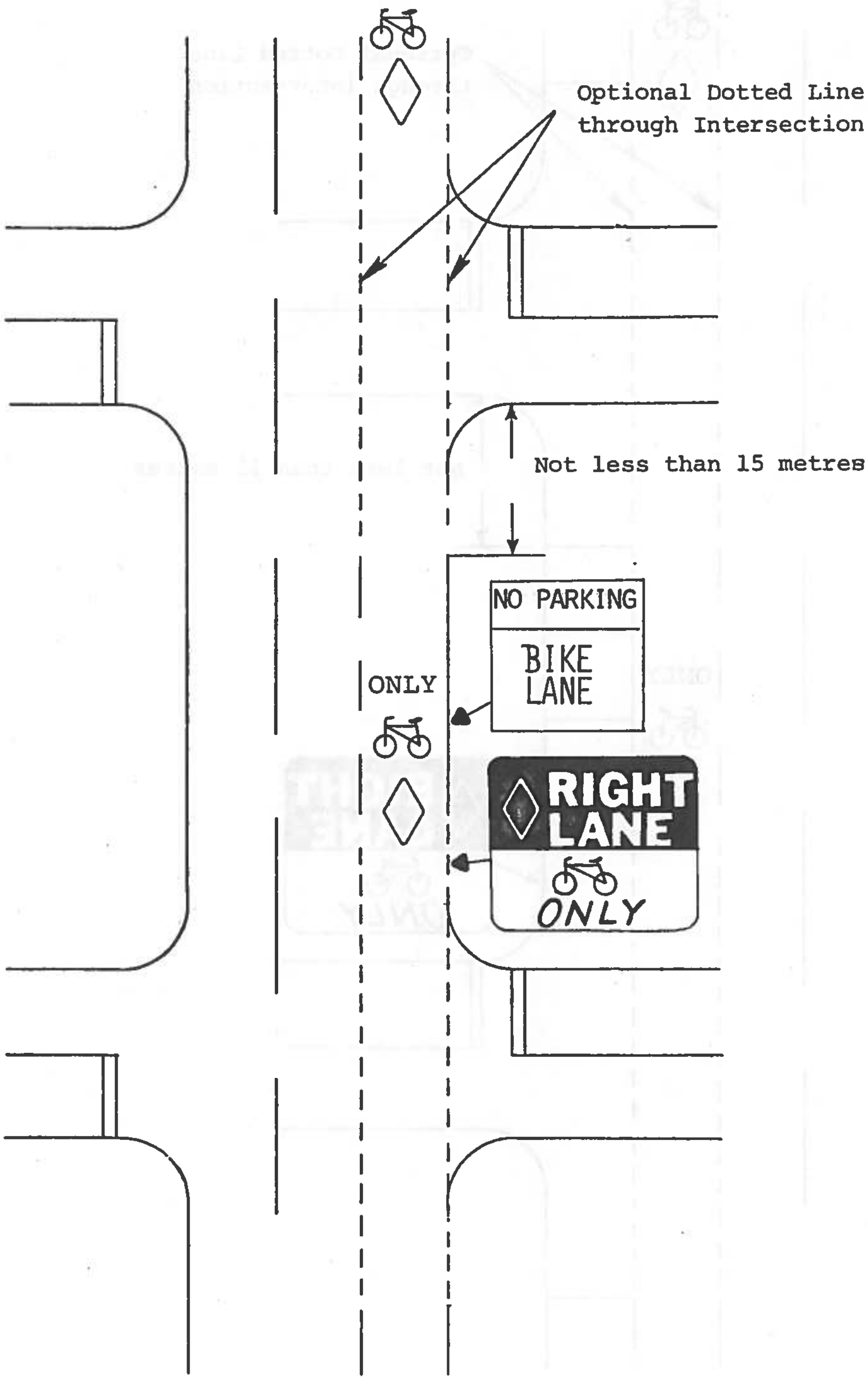


FIGURE 6: Designated Bicycle Lane - Two-Way Traffic
without Parking
Low Rt. Turn Volume
Signing and Pavement Markings

TABLE 6. - Summary of Bicycle Experiment

INDEPENDENT VARIABLES	Level
1. Parking Allowed	2
2. Remedial Aids	3
3. Presence of Bicycle	2
4. Entry Vehicle Type	2
	24 cells

DEPENDENT VARIABLES

1. Mean Speed
2. Lateral Placement
3. Proportion of Encroachments

Day only, good visibility, dry pavement

3.6 Data Collection

Data to be collected for the four experiments will include speed related parameters as well as lateral placement data. For experiments that will be conducted on the Maine Facility, existing instrumentation will be used to the maximum possible extent. However, the prevailing 200-foot (61 m) spacing of the permanent detector stations may yield too few points for the construction of meaningful speed profiles. It is recommended that the TDC traffic data recorder be deployed at intermediate locations in the portion of the test section immediately preceding the driveway, PD vehicle, etc. In addition to allowing a finer definition of speed profiles, the TDC equipment will permit the determination of time mean speeds.

If the test sites are located off the Maine Facility, the TDC equipment will have to be deployed at all positions where data is desired, except in the bicycle experiment.

It will be necessary to deploy the TDC sensors in a configuration from which the tire-to-tire width of the vehicle can be deduced. This is accomplished by utilizing two lateral placement sensors to measure the position of the front wheels. It will be necessary to make the above modification for the first detector at which lateral placement measurements are made.

Location of sensors has been discussed in the individual experiment variable sections.

In the bicycle experiment, the use of 16-mm time-lapse photography will be necessary for data collection. The camera should be a 16-mm movie camera with film capacity of 400 feet (120 m). It should also be capable of using interchangeable lens by use of a "C" mount. This will allow the use of the large selection of lens available for 16-mm and 35-mm cameras. With this capability, it will be possible to use a wide range of camera positions.

The setup should be on the near side of the street so that the lateral placement of the vehicle can be measured. Although parking is allowed at one site, it will be necessary to restrict parking in the test section so the bike is continuously visible. On the site where parking is not allowed, camera location will also be on the near side of the street. Camera location should be elevated to make data reduction easier.

Speed Related Parameters (on Maine Facility)	250 vehicles per cell
Speed Related Parameters (off Maine Facility) (assuming μ = 25-30 MPH (30-48 km/h) and σ = 5 MPH (8 km/h))	100 vehicles per cell
Lateral Placement Related Parameters (Exp. 1, 2 & 3)	250 vehicles per cell
Lateral Placement Related Parameters (Exp. 4)	100 vehicles per cell

3.8 Summary of Design

Experiment 1 involves signing treatments to warn motorists of vehicles entering from driveways. Four levels of signing will be studied.

Experiment 2 will investigate remedial aids to reduce friction due to parked or disabled vehicles on the side of the road. Four levels of warning aids will be tested. These are:

- The base condition (no aids - day, taillights - night);
- Four-way flashers;
- Warning triangle (parked cars) or rotating beacon (maintenance vehicles);
- Four-way flashers plus warning triangle (parked cars) or rotating beacon plus four-way flashers (maintenance vehicles).

Experiment 3 involves combining two friction elements, a driveway entry and a parked passenger car. The remedial aids consist of five combinations of warning signs and PV rear lighting.

Experiment 4 studies the effects of bicycles on traffic flow. The signing and pavement marking of the new Section IX of the MUTCD will be tested. This experiment cannot be implemented on the Maine Facility and special site criteria must be met to obtain an appropriate test location.

The lateral placement data will be analyzed in terms of three parameters (see Figure 8):

- Distance from outside of right front wheels to the edge line - D_1;
- Distance from outside of left wheels to the centerline of the roadway - D_2;
- Width of the vehicle - D_3.

The parameter, D_3, is equal to the distance from outer edge to outer edge of the front tires plus the overhang of the fender. The wheel spacing will be deduced from lateral placement data at the traps where both left and right wheel placements are measured. The overhang of the average car is approximately 6 inches. Lateral placement data will be categorized into $D_2 > 0$ and $D_2 < 0$ and analyzed separately.

For $D_2 > 0$, i.e., the left edge of the vehicle is not encroaching the centerline, the parameter of interest will be D_1. The desired effect is to maximize D_1 with $D_2 > 0$. This means that the vehicle moves to the left side of the lane without crossing the centerline. The distributions of D_1 will be compared for changes in scale and location parameters.

For $D_2 < 0$, i.e., centerline encroachments, the parameter of interest will be D_2, the distance that the left wheel has encroached on the centerline. The distribution of encroachments for each warning or remedial aid will be tested for a reduction in mean distance over the centerline. Parametric tests, such as the "t" and "F" tests, will be used to test for mean and variance changes. In addition, the proportion of encroachments should be tested for changes in all cases.

Measures such as the 15 percentile lateral placement will not be considered. Centerline encroachments are accident producing situations. The ideal device would move traffic to the left in the lane but not across the centerline. A relative measure is not appropriate for safety reasons.

In the bicycle experiment, the "t" test will be employed to test for changes in mean speed and lateral placement. The binomial proportion test will be used to test for changes in encroachment rates.

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APPENDIX

Source: (23)

MOTOR VEHICLE SAFETY STANDARD NO. 125

Warning Devices

S1. Scope. This standard establishes requirements for devices, without self-contained energy sources, that are designed to be carried in motor vehicles and used to warn approaching traffic of the presence of a stopped vehicle, except for devices designed to be permanently affixed to the vehicle.

S2. Purpose. The purpose of this standard is to reduce deaths and injuries due to rear end collisions between moving traffic and disabled vehicles.

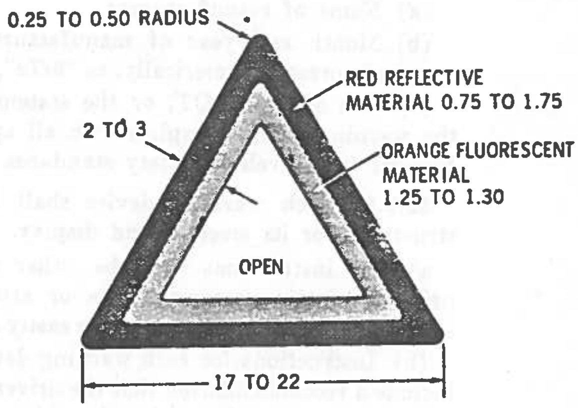
S3. Application. This standard applies to devices without self-contained energy sources, that are designed to be carried in motor vehicles and used to warn approaching traffic of the presence of a stopped vehicle, except for devices designed to be permanently affixed to the vehicle.

S.4. Definitions. "Entrance angle" means the angle having as its sides the line through the center, and normal to the face, of the object to be tested, and the line from the center of the object to the center of the source of illumination (Figure 2).

"Fluorescent" means the property of emitting visible light due to the absorption of radiation of a shorter wave-length which may be outside the visible spectrum.

"Observation angle" means the angle having as its sides the line from the observation point to the center of the object to be tested and the line from the center of that object to the center of the source of illumination (Figure 2).

"Reflex reflective" means reflective of light in directions close to the direction of incident light, over a wide range of variations in the direction of incident light.



DIMENSIONS OF WARNING DEVICE (Inches)

Figure 1

S5. Requirements.

S5.1 Equipment.

S5.1.1 Reflex reflective material and fluorescent material that meet the requirements of this standard shall be affixed to both faces of the warning device. Alternatively, a dual purpose orange fluorescent and red reflective material that meets the requirements of this standard (hereafter referred to as "dual purpose material") may be affixed to both faces in place of the reflective and fluorescent materials.

S5.1.2 Each warning device shall be protected from damage and deterioration—

(a) By enclosure in an opaque protective reusable container, except that two or three warn-

S5.2.6 The device shall consist entirely of the triangular portion and attachments necessary for its support and enclosure, without additional visible shapes of attachments.

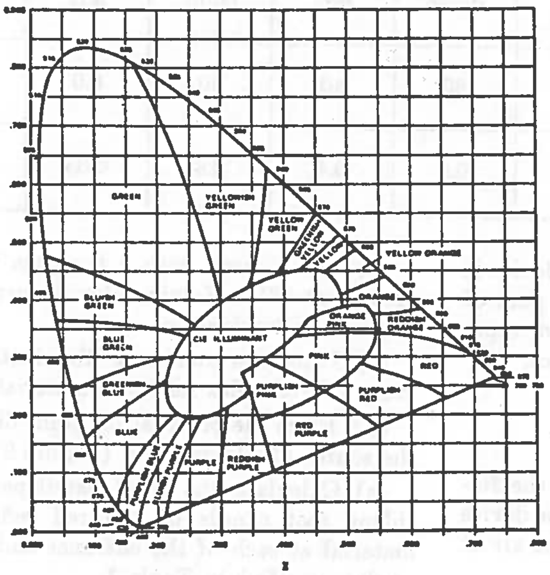


Figure 4. - CIE Chromaticity Diagram.

S5.3 Color.

S5.3.1 The color of the red reflex reflective material on the warning device shall have the following characteristics, both before and after the warning device has been conditioned in accordance with S6.1, when the source of illumination is a lamp with a tungsten filament operating at 2856° Kelvin color temperature. Expressed in terms of the International Commission on Illumination (CIE) 1931 standard colorimetric observer system (CIE chromaticity diagram, Figure 4), the chromaticity coordinates of the red reflex reflective material shall lie within the region bounded by the spectrum locus and the lines on the diagram defined by the following equations:

Boundary	*Equations*
Yellow	$y=0.33$
White	$x+y=0.98$

S5.3.2 The color of the orange fluorescent material on the warning device shall have the following characteristics, both before and after the warning device has been conditioned in accordance with S6.1, when the source of illumination is a 150-watt high pressure xenon compact arc lamp. Expressed in terms of the International Commission on Illumination (CIE) 1931 standard colorimetric observer system, the chromaticity coordinates of the orange fluorescent material shall lie within the region bounded by the spectrum locus and the lines on the diagram defined by the following equations:

Boundary	*Equation*
Yellow	$y=0.49\,x+0.17$
White	$x+y=0.93$
Red	$y=0.35$

The 150-watt high pressure xenon compact arc lamp shall illuminate the sample using the unmodified spectrum at an angle of incidence of 45° and an angle of observation of 90°. If dual purpose material is being tested, it shall be illuminated by a 150-watt high pressure xenon compact arc lamp, whose light is diffused by an integrating sphere.

S5.4 Reflectivity. When the red reflex reflective material on the warning device is tested in accordance with S6.2, both before and after the warning device has been conditioned in accordance with S6.1, its total candlepower per incident foot candle shall be not less than the values specified in Table I for each of the listed entrance angles.

S5.5 Luminance. When the orange fluorescent material on the warning device is tested in accordance with S6.3, both before and after the warning device has been conditioned in accordance with S6.1, it shall have a minimum relative luminance of 25 percent of a flat magnesium oxide surface and a minimum product of that relative luminance and width in inches of 44.

S5.6 Stability. When the warning device is erected on a horizontal brushed concrete surface both with and against the brush marks and subjected to a horizontal wind of 40 miles per hour in any direction for 3 minutes—

(a) No part of it shall slide more than 3 inches from its initial position;

(b) Its triangular portion shall not tilt to a position that is more than 10° from the vertical; and

(c) Its triangular position shall not turn through a horizontal angle of more than 10° in either direction from the initial position.