NO-PASSING ZONE TREATMENTS
FOR SPECIAL GEOMETRIC
AND TRAFFIC OPERATIONAL SITUATIONS

(Summary Report)

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16. Abstract  
The MUTCD states that where center lines are installed, no passing zones shall be established at vertical and horizontal curves and elsewhere on two and three-lane highways where an engineering study indicates passing must be prohibited because of inadequate sight distances or other special conditions. The MUTCD states further that the no-passing marking may also be used on approaches to railroad grade crossings and other locations where passing should be prohibited.  

Accepted practice has been to designate no-passing zones where insufficient safe sight distance to an opposing vehicle exists (horizontal and vertical alignment). There exist many sections of two-lane rural highway where adequate opposing vehicle sight distance is provided; however, the normal passing maneuver expectancy condition is interrupted by a geometric feature or by the unexpected introduction of a vehicle into the passing lane. Guidelines for application of no-passing zones at these special situations are less clearly specified; hence, no-passing zones are being applied by traffic engineers using varied criteria.  

This report presents suggested guidelines for uniform application of no-passing zone treatments on rural two-lane highways at uncontrolled and controlled intersections, railroad grade crossings, narrow two-lane bridges, one-way bridges, school zones, roadside development, and transition sections between two-lane and divided highways.  

Two sets of guidelines are presented: (1) utilizing MUTCD standard signs and markings, and (2) utilizing an experimental advance treatment consisting of a short dotted line marking adjacent to the approach centerline and the NO-PASSING ZONE pennant sign. The guidelines include suggested lengths of no-passing zones to provide sufficient driver expectancy conditioning for the situations and suggested guidelines for installation. Minimum distances between successive no-passing zones for operational safety are also presented.  

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Conceptual conflict distance models were developed by Donald L. Woods and Graeme D. Weaver. Carlton Allen, Nancy Matlock, and Donald R. Hatcher contributed significantly to the concurrent field testing phase of the experimental no-passing zone treatments on which suggested guidelines for use presented herein are based. The manuscript was prepared by Joyce Heldreth.

The research staff is particularly appreciative of the assistance given by Mr. H. Douglas Robertson and Mr. Howard H. Bissell, FHWA contract managers, in arranging the review workshop with representatives from State Transportation Departments and for their cooperation and advice throughout the research project.

The suggested guidelines for marking no-passing zones at the special situations were evaluated by traffic engineers from nine States. Comments and suggestions received at this evaluation workshop were extremely valuable toward developing a research product that would be more responsive and beneficial to the needs of the profession. Special acknowledgment is expressed to the agencies listed below for participating in the workshop.

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I. INTRODUCTION

This summary report contains a brief discussion of the research approach and presents pertinent findings and suggested guidelines for installing no-passing zone treatments at special situations. The final research report, "No-Passing Zone Treatments For Special Geometric and Traffic Operational Situations," contains detailed documentation of the study.

The MUTCD states that where center lines are installed, no passing zones shall be established at vertical and horizontal curves and elsewhere on two and three-lane highways where an engineering study indicates passing must be prohibited because of inadequate sight distances or other special conditions. The MUTCD states further that the no-passing marking may also be used on approaches to railroad grade crossings and other locations where passing should be prohibited.

Accepted practice has been to designate no-passing zones where insufficient safe sight distance to an opposing vehicle exists (horizontal and vertical alignment). There exist many sections of two-lane rural highways where adequate opposing vehicle sight distance is provided; however, the normal passing maneuver expectancy condition is interrupted by a geometric feature or by the unexpected introduction of a vehicle into the passing lane. Guidelines for application of no-passing zones at these special situations are less clearly specified; hence, no-passing zones are being applied by traffic engineers using varied criteria.

This report presents suggested guidelines for uniform application of no-passing zone treatments on rural two-lane highways at uncontrolled and controlled intersections, railroad grade crossings, narrow two-lane bridges, one-way bridges, school zones, roadside development, and transition sections between two-lane and divided highways.

Two sets of guidelines are presented: (1) utilizing MUTCD standard signs and markings, and (2) utilizing an experimental advance treatment consisting of a short dotted line marking adjacent to the approach centerline and the NO-PASSING ZONE pennant sign. The guidelines include suggested lengths of no-passing zones to provide sufficient driver expectancy conditioning for the situations and suggested guidelines for installation. Minimum distances between successive no-passing zones for operational safety are also presented.

RESEARCH OBJECTIVES

The research was conducted to be responsive to three objectives (1):

1. Define the length of no-passing zone needed to provide sufficient driver expectancy conditioning for the special situations.

2. Develop two sets of guidelines for the uniform application of no-passing zone treatments for the special situations. The first set shall utilize MUTCD standard signs and markings. The second set shall utilize the best new advance treatment that was field tested in another phase of this research study. The guidelines shall specify the conditions under which no-passing zone treatments should be applied.

3. Determine the minimum distances between successive no-passing zones. All types of no-passing zones shall be included, i.e., both regular zones and special situation zones.
The initial phase of the research effort was directed toward determining the extent and seriousness of the passing problem at the special situations. The approach adopted to investigate this, the results of which were documented in two other reports (1, 3), involved a combination of the following:

1. Review of literature dealing with past and current research in the subject area, current State practice, and legal requirements for the special situations.

2. Definition of the traffic maneuvers that could occur if passing on the two-lane highway were permitted where sight distance is adequate for each of the special situations.

3. Development of analytical models describing the traffic maneuvers and potential hazard at the special situations.

4. Detailed accident and roadway information file investigation to identify passing-related accidents associated with the special situations. Files from three States (North Carolina, Texas, and Utah) for the year 1977 were used to evaluate the accident problem.

5. Observation of traffic operations at a limited number of special situations including measurement of passing maneuver characteristics.

6. Discussion with traffic engineers in each of the FHWA Regions to ascertain opinions from practicing traffic engineers concerning their assessment of problems associated with passing at the special situations and to identify innovative treatments attempted.

7. Determination of the minimum distance in which passenger cars can pass a truck traveling at 20 mph (32 km/h). Federally published passing data were used.

8. Analytical determination of the minimum distance in which a typical automobile can pass a truck traveling at only 10 mph (16 km/h).

9. Development of guidelines to establish the length of no-passing zone that would be needed to prohibit passing so that the operational maneuver dictated by the particular special situation can be executed and allow the passing vehicle to avoid the potential conflict situation.

10. Develop guidelines by which the traffic engineer may determine if a passing-related problem exists at a special situation and establish a no-passing zone if this course of action is selected.
One of the specific objectives of the research was to define the length of no-passing zone needed to provide sufficient driver expectancy conditioning for the special situations. To accomplish this, vehicle maneuvers that could be expected to occur at the special situations were identified, and operations were described analytically for passing maneuvers that created potentially hazardous conflict situations at the special situation. The maneuvers were modeled to determine "critical conflict distances" (function of speed, critical exposure time, driver operating characteristics, and vehicle operating characteristics) for the critical maneuvers.

The selection of no-passing zone length in advance of a particular special situation is dependent on the desired operational requirements downstream from the point of pass commitment. For example, in a "classical" rural highway passing maneuver, the passing vehicle may safely continue at highway operating speed after returning to the right lane. Therefore, pass completion rather than abort would be a safe situation. If, though, the vehicle must slow down to travel through a reduced speed zone or come to a stop shortly downstream, and the driver of the passing vehicle is made aware of this downstream constraint, the no-passing zone may be predicated on the operational distance necessary to execute this type of maneuver. If the passing vehicle completes the pass and then is forced to decelerate rapidly from the high passing speed to respond to the downstream operating environment, the no-passing zone would be predicated on the distance necessary to execute this maneuver.

**CRITICAL CONFLICT DISTANCE**

A conflict situation can be defined in several ways. To be consistent, a definition has been adopted based on known operational characteristics of the passing maneuver and the definition of the point within the maneuver commonly referred to as the "critical position" or "point of no return." The "critical position" occurs within the passing maneuver when the passing vehicle in the left lane is abreast of the vehicle in the right lane that is being passed. When the passing vehicle reaches this point, the commitment to complete the pass is reached; it is safer to complete the maneuver than to abort and attempt to pull back in behind the vehicle being passed if the downstream roadway is clear and the passing vehicle may continue at highway operating speed after returning to the right lane. The left-lane occupancy time and distance are less at normal passing speeds for the pass completion maneuver. Throughout the pass initiation distance and left-lane occupancy distance traveled until reaching the critical position, the passing driver may abort and pull back in behind the vehicle being passed.

A conflict situation is assumed to exist during the time interval that the passing vehicle occupies the left lane after reaching the critical position until returning to the right lane in a controlled operational mode that is compatible with the operational constraints imposed by the special situation. The conflict distance is the roadway distance beyond the critical position in which conflicting vehicles are traveling and in which at least one of the conflicting vehicles clears the left lane or in which the passing vehicle returns to the right lane in a controlled operational mode that is compatible with the impending conflict.

**CRITICAL CONFLICT DISTANCE CONCEPTUAL MODELS FOR SPECIAL SITUATIONS**

**Railroad Grade Crossings**

The hazard associated with passing at a...
railroad grade crossing is collision with the train or with adjacent roadside features during the attempt to avoid the train if it is perceived. Two maneuvers can occur. The passing driver recognizing the potential hazard at the "critical position" may abort the maneuver, return to the right lane behind the vehicle being passed, and both vehicles will decelerate to a stop at the crossing. This combination of maneuvers requires a certain length of roadway beyond the "critical position." Another maneuver may occur. The passing driver may not recognize the potential hazard at the "critical position," complete the pass, then recognizing the potential hazard, decelerate rapidly to a stop at the crossing. The length of roadway in which to execute this combination of maneuvers is the pass completion distance plus the stopping distance at high speed from the point of pass completion. This total distance would be longer than the aborted maneuver distance because deceleration is initiated in the first maneuver back at the "critical position;" in the second maneuver it is initiated downstream where the passing vehicle returned to the right lane after completing the pass beyond the critical position.

Figures 1 and 2 illustrate the critical conflict distance conceptual models for the aborted and completed pass maneuver respectively.

School Zones

The passing model for the school zone passing situation is similar to the railroad grade crossing model except that the terminal speed is considered to be the posted school zone speed rather than a stop condition. Two conceptual models were developed as illustrated in Figures 3 and 4 for the aborted and completed pass maneuver respectively. Critical conflict distances were determined from these models for posted school zone speeds of 30 mph (48 km/h) and 40 mph (64 km/h).

Bridges and Underpasses

Bridge structures that are narrower than the approach roadway create adverse driver behavior.

Passing prohibition requirements differ between the "narrow" bridge and the "one-way" bridge. In the former, the vehicles can continue across the structure without creating a potential head-on collision provided the bridge is at least wide enough to carry opposing vehicles. In the latter, one of the vehicles approaching the structure from opposite directions must stop to allow the other to cross the bridge.

Two no-passing situations are presented. One is applicable to the narrow bridge; the other is applicable to the one-way bridge.

Narrow Bridge Structures

Typically, a vehicle approaching a narrow bridge will move laterally to the left (frequently across the centerline in the absence of opposing traffic), and this maneuver could conflict with a passing vehicle. The conceptual models are similar to those presented for the school zone except that the terminal speed is the 85th percentile operating speed. Figures 5 and 6 illustrate the critical conflict distance conceptual model for the aborted and completed pass maneuver respectively.

One-Way Bridge Structures

When the bridge width is too narrow to allow two-way operation, operation differs considerably. If a vehicle encountering in the opposite travel direction does not yield the right-of-way, a passing vehicle must stop before reaching the bridge. Thus, the conceptual model for the situation is similar to the railroad crossing model. Figures 7 and 8 illustrate the critical conflict distance conceptual model for the aborted and completed pass maneuver respectively.
Critical Conflict Distance, $D_C$

**Model Assumptions:**

1. Passing vehicle aborts maneuver at critical position, returns to the right lane behind vehicle being passed, and both vehicles decelerate to a stop with the lead vehicle stopping 15 ft (5 m) before reaching the crossing.
2. Slower vehicle is traveling at 85th percentile speed at critical position.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position ($v_1$, $v_2$).
4. Passing vehicle decelerates at a rate of 5 mph/s (8 km/h/sec) ($a_1$).
5. Slower vehicle decelerates at a rate of 3 mph/s (5 km/h/sec) ($a_2$).

**Figure 1. Railroad-Highway Grade Crossing Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver)**

Critical Conflict Distance, $D_C$

**Model Assumptions:**

1. Passing vehicle completes pass beyond critical position. Pass completion distance is 2/3 total left lane occupancy distance ($d_1$, $d_2$).
2. Passing vehicle decelerates from the right lane re-entry point to a stop 15 ft (5 m) before reaching the crossing.
3. Slower vehicle is traveling at 85th percentile speed at critical position.
4. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position ($v_1$, $v_2$) with constant speed throughout pass completion maneuver.
5. Stopping distance: desirable safe braking distance ($d$) (perception-reaction occurs in latter portion of pass completion maneuver).

**Figure 2. Railroad-Highway Grade Crossing Critical Conflict Distance Conceptual Model (Completed Pass Maneuver)**
Model Assumptions:

1. Passing vehicle aborts maneuver at critical position, returns to right lane behind vehicle being passed, and trails lead vehicle through school zone at posted speed.
2. Slower vehicle is traveling at 85th percentile speed at critical position.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9).
4. Passing vehicle decelerates at a rate of 5 mph/s (8 km/h/sec) (6).
5. Slower vehicle decelerates at a rate of 3 mph/s (5 km/h/sec) (6).

Figure 3. School Zone Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver)

Model Assumptions:

1. Passing vehicle completes pass beyond critical position. Pass completion distance is 2/3 total left lane occupancy distance (4, 8, 9).
2. Passing vehicle begins to decelerate from passing speed to posted school zone speed at right lane re-entry point.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9).
4. Passing vehicle decelerates at a rate of 5 mph/s (8 km/h/sec) (6).
5. Linear deceleration is assumed throughout deceleration distance.

Figure 4. School Zone Critical Conflict Distance Conceptual Model (Completed Pass Maneuver)
Model Assumptions:

1. Passing vehicle aborts maneuver at critical position, returns to right lane behind vehicle being passed, and trails lead vehicle across bridge at 85th percentile operating speed.
2. Slower vehicle is traveling at 85th percentile speed at critical position.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9).
4. Passing vehicle decelerates at a rate of 5 mph/s (8 km/h/sec) (6).

Figure 5. Narrow Bridge and Underpass (Two-Lane, Two-Way) Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver)

Model Assumptions:

1. Passing vehicle completes pass beyond critical position. Pass completion distance is 2/3 total left lane occupancy distance (4, 8, 9).
2. Passing vehicle re-enters right lane a minimum of 200 ft (61 m) in advance of the pavement width transition section.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9) with constant speed throughout pass completion.
4. Slower vehicle is traveling at 85th percentile speed at critical position.

Figure 6. Narrow Bridge and Underpass (Two-Lane, Two-Way) Critical Conflict Distance Conceptual Model (Completed Pass Maneuver)
Model Assumptions:

1. Passing vehicle aborts maneuver at critical position, returns to right lane behind vehicle being passed, and both vehicles decelerate to a stop with the lead vehicle stopping 15 ft (5 m) before reaching the pavement narrowing transition point.
2. Slower vehicle is traveling at 85th percentile speed at critical position.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9).
4. Passing vehicle decelerates at a rate of 5 mph/s (8 km/h/sec) (6).
5. Slower vehicle decelerates at a rate of 3 mph/s (5 km/h/sec) (6).

Figure 7. One-Way Bridge Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver)

Model Assumptions:

1. Passing vehicle completes pass beyond critical position. Pass completion distance is 2/3 total left lane occupancy distance (4, 8, 9).
2. Passing vehicle decelerates from the right lane re-entry point to a stop 15 ft (5 m) before reaching the pavement width transition section.
3. Slower vehicle is traveling at 85th percentile speed at critical position.
4. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9) with constant speed throughout pass completion maneuver.
5. Stopping distance: desirable safe braking distance (8) (perception-reaction occurs in latter portion of pass completion maneuver).

Figure 8. One-Way Bridge Critical Conflict Distance Conceptual Model (Completed Pass Maneuver)
Intersections

Uncontrolled Approaches

Safety problems can be created when passing maneuvers are being executed on uncontrolled approaches to an intersection. Vehicle conflict situations can develop when a third vehicle enters the primary roadway from an intersecting roadway (either controlled or uncontrolled). Also a conflict situation occurs when a vehicle turns to the face of a vehicle passing on the uncontrolled approach leg.

Evaluation of exposure time and distances for the traffic maneuvers that could occur at four-leg intersections (or Tee-intersections) revealed that the most critical situation occurs when a vehicle turns left from the right-intersecting approach into the face of a vehicle passing on the uncontrolled approach leg.

Therefore, the conceptual model is developed for this situation. The left lane occupancy distance to abort or complete the maneuver is equal in this situation (4) because it is similar to a classical rural opposing-vehicle passing situation. The slower vehicle maintains constant speed throughout the maneuver as would be the situation in a normal rural passing maneuver. The conflict is resolved when the passing vehicle re-enters the right lane either ahead of or behind the vehicle being passed. No other speed alteration is required downstream.

Figure 9 illustrates the critical conflict distance conceptual model for this special situation.

Controlled Intersection Approaches

Passing in the vicinity of an intersection on an approach that is STOP-controlled or at which traffic must yield right-of-way to the intersecting roadway traffic may create unsafe operations.

The situation for a STOP-controlled intersection approach is similar to the railroad grade crossing situation. Figure 10 and 11 illustrate the critical conflict distance conceptual model for the aborted and completed pass maneuver respectively.

Roadway Cross Section Transitions

Two-Lane Highway To Divided Highway

Passing in the vicinity of a pavement transition from two-lane cross section to a multi-lane facility can create undesirable vehicle conflicts in the transition area. If the pass is being completed in the throat area, two undesirable maneuvers can occur. The passing vehicle and the vehicle being passed can be "squeezed" in the transition section. This can necessitate speed and/or positional adjustment which further complicates an already increased driving task imposed by negotiation of the geometric situation. Even worse, the passing driver may not correctly perceive the transition section and continue in the left lane beyond the gore to end up traveling in the opposing lane(s).

Figure 12 illustrates the conceptual model in which the pass is aborted at the critical position and the passing vehicle returns to the right lane behind the vehicle being passed. The two vehicles enter the transition at the highway operating speed. This situation is similar to the narrow bridge situation. Figure 13 illustrates the conceptual model in which the passing driver completes the pass beyond the critical position and returns to the right lane 200 ft (62 m) before reaching the transition section. The 200-ft (62-m) distance is included to provide the driver distance in which to regain stable lane position and vehicle control to negotiate the transition maneuver.

Divided Highway To Two-Lane Highway

A period of driving attitude adjustment is required when a driver, after traveling on a divided highway, enters a two-lane highway. Moving to the left lane on the divided high-
Model Assumptions:

1. Passing vehicle completes passing maneuver from "critical position."
2. Slower vehicle is traveling at 85th percentile speed.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle.
4. Left-turn speed is 15 mph (24 km/h) (B).
5. Turning vehicle accelerates at a rate of 2 mph/s (3 km/h/sec) (6).
6. Turning radius is 75 ft (23 m) (B).
7. Clearance distance, \( d_c \) is based on 3-second travel time (B).
8. Pass completion distance from critical position is approximately two thirds of the total left-lane occupancy distance, \( d_2 \) (A, B, 9).

Figure 9. Uncontrolled Intersection Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver and Completed Pass Maneuver)
Model Assumptions:

1. Passing vehicle aborts maneuver at critical position, returns to the right lane behind vehicle being passed, and both vehicles decelerate to a stop with the lead vehicle stopping 15 ft (5 m) before reaching the intersection.
2. Slower vehicle is traveling at 85th percentile speed at the critical position.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9).
4. Passing vehicle decelerates at a rate of 5 m/s² (8 km/h/sec) (6).
5. Slower vehicle decelerates at a rate of 3 m/s² (5 km/h/sec) (6).

Figure 10. Controlled Intersection Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver)

Model Assumptions:

1. Passing vehicle completes pass beyond critical position. Pass completion distance is 2/3 total left lane occupancy distance (4, 8, 9).
2. Passing vehicle decelerates from the right lane re-entry point to a stop 15 ft (5 m) before reaching the intersection.
3. Slower vehicle is traveling at 85th percentile speed at critical position.
4. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9) with constant speed throughout pass completion maneuver.
5. Stopping distance: desirable safe braking distance (8) (perception-reaction occurs in latter portion of pass completion maneuver).

Figure 11. Controlled Intersection Critical Conflict Distance Conceptual Model (Completed Pass Maneuver)
Critical Conflict Distance, $D_C$

Model Assumptions:

1. Passing vehicle aborts maneuver at critical position, returns to the right lane behind vehicle being passed, and trails lead vehicle into the pavement transition area at 85th percentile speed.
2. Slower vehicle is traveling at 85th percentile speed at the critical position.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9).
4. Passing vehicle decelerates at a rate of 5 m/s^2 (8 km/h/sec) (5).
5. Slower Vehicles maintains 85th percentile speed throughout maneuver.

Figure 12. Transition From Two-Lane Highway to Divided Highway Critical Conflict Distance Conceptual Model (Aborted Pass Maneuver)

Model Assumptions:

1. Passing vehicle completes pass beyond critical position. Pass completion distance is 2/3 total left lane occupancy distance (4, 8, 9).
2. Passing vehicle re-enters right lane a minimum of 200 ft (61 m) in advance of the pavement width transition section.
3. Passing vehicle is traveling 10 mph (16 km/h) faster than slower vehicle at critical position (4, 8, 9) with constant speed throughout pass completion.
4. Slower vehicle is traveling at 85th percentile speed at critical position

Figure 13. Transition From Two-Lane Highway to Divided Highway Critical Conflict Distance (Completed Pass Maneuver)
way was not a critical maneuver because no opposing traffic is expected to be encountered. This attitude can carry over beyond the transition until the driver recognizes that he (she) is now travelling on a two-lane highway and left-lane occupancy can now be hazardous. Hence, it may be desired to prohibit passing for a short distance beyond the transition section while the driver is acclimating to the new driving environment.

The length of roadway marked for no-passing in this situation is not dependent on passing operational distance or critical conflict distance in the sense of vehicle interaction as was the case for the other special situations described. Instead, it is a length of roadway in which the driver perceives that the roadway cross section has changed and, therefore, the driving task with respect to left-lane occupancy, has changed. Thus, the length of no-passing zone is related to the distance traveled during this perception time. The perception time differs for various drivers; however, at least 5 seconds would probably be required to negotiate the transition and adjust driving expectancy. Assuming a 10-second perception time would result in a travel distance of about 900 ft (274 m) at 60 mph (97 km/h). A compromise perception time of 7.5 seconds produces no-passing zones of length approximately equal to those at the transition from the two-lane highway to the divided facility. It would be practical to begin and end the two directional no-passing zones at the transition section at the same point. Thus, using the same length before and after the transition would produce a double yellow no-passing marking both approaching and leaving a transition section.

Figure 14 illustrates the critical distance conceptual model for no-passing zone length of need for the transition from a divided highway to a two-lane highway using a 7.5-second driver expectancy adjustment time.

Strip Development

Prohibition of passing throughout lengths of two-lane roadway bordered by commercial businesses or a roadside environment that produces considerable exit/egress maneuvers may be desired for legal enforcement reasons. The normally attentive driver would be expected to recognize that passing throughout this section would be hazardous because the opportunity for vehicle conflict would be increased. However, if positive control is desired or necessary for legal enforcement authority, the double yellow centerline marking is available for use. Vehicles can legally turn left across this marking in entering or exiting from a driveway opening; however, driving to the left of the marking is prohibited. The double yellow marking would extend throughout the entire length of the strip development.

CRITICAL CONFLICT DISTANCES FOR SPECIAL SITUATIONS

Table 1 presents the critical conflict distances for each of the special situations based on the conceptual models discussed above.
Model Assumptions:

1. Distance is based on a 7.5-second driver expectancy adjustment time while traveling at 85th percentile speed.

Figure 14. Transition From Divided Highway to Two-Lane Highway Critical Conflict Distance Conceptual Model.
<table>
<thead>
<tr>
<th>mph</th>
<th>Railroad Grade Crossing</th>
<th>School Zone (30 mph)</th>
<th>School Zone (40 mph)</th>
<th>Narrow Bridge</th>
<th>One-Way Bridge</th>
<th>Uncontrolled Intersection</th>
<th>Controlled Intersection</th>
<th>Transition 2-Lane To Multi-Lane</th>
<th>Transition Multi-Lane To 2-Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>422 382</td>
<td>350 303</td>
<td>- 347</td>
<td>350 400</td>
<td>422 382</td>
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<td>- 502</td>
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<td>718 897</td>
<td>640 868</td>
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<td>976</td>
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<td>867 1052</td>
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<td>1017 1199</td>
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<td>660</td>
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<td>993 1162</td>
<td>670 875</td>
<td>1143 1360</td>
<td>1279</td>
<td>1143 1360</td>
<td>670 875</td>
<td>715</td>
</tr>
</tbody>
</table>

**Notes:**
1. Critical conflict distances are expressed in feet.
2. Operating speed is expressed in mph.

**Metric Conversion:**
1 mph = 1.604 km/h
1 ft = 0.305 m
3. MINIMUM DISTANCE BETWEEN NO-PASSING ZONES

One of the primary objectives of the research involved determination of minimum distance between successive no-passing zones for safe passing operations.

The argument for not closing up relatively short gaps between successive no-passing zones traditionally has been that provision of even short "passing" zones will permit a driver to pass a slow-moving vehicle, whereas closure with a no-passing barrier marking might result in an impatient driver passing in flagrant disobedience of the no-passing marking. Conversely, leaving the roadway unmarked can lead a driver to expect that sufficient distance is available to permit a safe passing maneuver at reasonable speed. Criteria to determine minimum passing zone lengths logically should be based on acceleration characteristics and passing distances of passenger vehicles. Obviously, to avoid forcing a passing driver to complete the maneuver beyond the beginning of the next no-passing zone, minimum allowable passing zone length should not be less than the distance in which a representative vehicle can physically pass even a slow-moving vehicle.

Acceleration data and passing distances published by vehicle manufacturers under Federal requirement were used to establish minimum allowable passing zone lengths. Minimum passing distances were determined for model year 1977 vehicles performing "low-speed" and "high-speed" maneuvers. Low-speed passes, by Federal definition, involve a passenger vehicle passing a 20-mph (32 km/h) truck (35 ft (17 m) length); high-speed passes involve passing a 50-mph (80 km/h) truck. The passing situation under which the tests must be conducted are specified federally (5).

The data revealed that at least 500 ft (152 m) are needed to physically pass a truck traveling only 20 mph (32 km/h)—not including exit and return distance from and to the right lane. These passing distance requirements for even such low speeds as 20 mph (32 km/h) indicate that the current 400 ft (122 m) minimum distance specified in the MUTCD is grossly inadequate in which to execute a passing maneuver. Adding a minimum pass initiation distance of 100 ft (30 m) and a return distance of 150 ft (46 m) to the 500 ft (152 m) low-speed passing distance, it is apparent that 750 ft (229 m) represents the minimum distance that should be allowed between no-passing zones where vehicles can be expected to maintain minimum speeds of at least 20-mph (32-km/h). This length of roadway will permit passing of 20-mph (32-km/h) vehicles if the pass is initiated at the beginning of the "passing zone;" however, a number of maneuvers can be expected to result in clipping, particularly those involving the smaller vehicles with reduced acceleration capability.

It is recognized that in mountainous terrain, it is difficult to provide passing opportunities because of restricted sight distance. Providing even the 400-ft (122-m) "passing" zone is difficult. In fact, distances as short as 350 ft (107-m) between no-passing zones have occasionally not been closed up in severe terrain because to do so would produce several miles of roadway marked for no-passing. Whereas, this might be sufficient distance to pass a lead vehicle at absolutely crawl speeds of 5 to 10 mph (8 to 16 km/h), it must be recognized that "passing" zones as short as this represent a trade-off between safety and the need to provide at least some passing opportunity. Passing attempts for vehicles traveling at the relatively slow speed of 20 mph (32 km/h) will result in unavoidable clips.

Measured passing data for 10-mph (16-km/h) are not available; however, a simplistic model defining the distance required
to pass a 55-ft (17-m) truck at maximum acceleration was developed to estimate minimum passing distances under the following operational assumptions:

1. Maximum acceleration rate ($\ddot{a}$) for the composite passenger car (typical) is 5 mphps (8 kphps) or 7.35 fpsps (2.24 mpsps).

2. The passing vehicle initiates the pass from a position 20 ft (6 m) behind the truck at trailing vehicle speed and returns to the right lane with 100 ft (30 m) separation, accelerating at maximum rate throughout the maneuver.

The minimum passing distance under these assumptions was 302 ft (92 m); the maneuver occurred in 7.28 seconds. The maximum acceleration rate ($\ddot{a}$) is representative of the composite passenger vehicle in peak performance condition on level terrain. It would be expected to be less on the steep inclines than would be encountered in mountainous terrain. The maximum acceleration rate for small cars is only 4 mphs (6 kphps) ($\ddot{a}$) on level terrain. Also, the simplistic model assumed that the passing driver initiated the pass immediately at the beginning of the "passing" zone. The cumulative effect of these adverse performance characteristics suggests that 400-ft (122-m) "passing" zones provide borderline safe passing opportunity for vehicles passing trucks traveling not more than about 10 mph (16 km/h).
4. SUGGESTED GUIDELINES FOR INSTALLING NO-PASSING ZONES AT SPECIAL SITUATIONS

The analysis of passing accident occurrence at the special situations indicated that the probability of a passing-related accident at any individual special situation is very low. No individual situation indicated a significant accident pattern on a national scale. Thus, based solely on estimated nationwide accident experience, universally applied no-passing zone treatment at all special situations is not justified. This should not be construed that there is not a need to install no-passing zone treatment at any special situation. Conversely, where a passing-related problem is identified through engineering evaluation of a particular special situation, installation of a no-passing zone represents a treatment that should be considered to improve the operational safety. The concept of installing traffic control devices to respond to identified operational problems is consistent with traditional practice. The problem with respect to no-passing zone treatment at the special situations has been two-fold:

1. Specific criteria have not been uniformly used to evaluate the need for treatment, and

2. Once a need has been determined by whatever criteria used, specific guidelines for appropriate length of treatment have not been universally applied.

The suggested guidelines herein are presented to assist the transportation engineer in objectively evaluating the need for no-passing treatment at a particular situation and, based on that identified need, select a length of treatment that is predicated on operational requirements for safety.

ENGINEERING EVALUATION OF SPECIAL SITUATIONS

Several conditions are suggested that should be considered in the decision process regarding installation of no-passing treatments at a particular special situation:

1. An abnormally high passing-related accident experience is observed.

2. State statutes specify that specific traffic control devices be installed for legal enforcement of passing operations.

3. Traffic operational, geometric, or environmental conditions of the site singly or cumulatively indicate that prohibiting passing in the vicinity would produce safer traffic operations throughout an already complicated driving environment.

Accident Experience

On an average basis, the probability of a passing-related accident occurring at any given special situation is very low. Even the estimated nationwide probability of an expected intersection passing-related accident is only 0.15 or about one passing-related accident per seven years. Considering the magnitude of the accident rates identified in this study, even a combination of all the special situations at a common point would produce an expected accident rate of less than 0.3 passing-related accidents per year -- about one per three years. Thus, no-passing zone treatment can be suggested on the criterion of accident occurrence only for situations where the occurrence is substantial in comparison to the expected average.

Using these average accident rates as a criterion, the occurrence of two or more passing-related accidents at a given special situation in any single year, or of one passing-related accident in each of two successive years should be considered as indicating an abnormally high accident rate.
The occurrence of only one passing-related accident does not in itself exceed reasonable expectations (since at least one accident must occur at some time if there exists an estimated probability greater than zero); however, the occurrence of two in one year greatly exceeds the expected random possibility. Similarly the occurrence of one in each successive year represents a rate considerably higher than even "twice the average expected number" which is a rule of thumb generally applied to determining the significance of randomly occurring events.

If local average passing-related accident rates are preferred, it is suggested that average rates be determined using local accident data. High accident frequency locations may then be determined using the above guidelines or by other criteria used by the agency to define "high accident frequency."

**State Statutes**

If the State statutes specifically require installation of traffic control devices at a given situation for legal enforcement purposes, no-passing zone treatment is not only warranted, but legally mandated. Where general statewide application of no-passing zone demarcation is not representative, treatment at situations exhibiting passing-related operational problems would be justified and would be expected to increase a driver's awareness of the increased hazard.

**Unique Site Characteristics**

If the engineering evaluation of a given special situation site reveals that site characteristics affect driving performance, prohibiting passing, as part of an overall safety improvement treatment, should be considered. For example, if an abnormally high rate of accidents of various types (not necessarily just passing-related accidents) is observed at a roadway location, all traffic movements in the vicinity should be identified to determine if the cumulative effect of closely-spaced decision points is creating an unduly complex driving task. If the cause of the accident types can be attributed to inability to respond to a downstream operational constraint after or during a passing maneuver, no-passing zone treatment would be justified. Prohibiting this maneuver will reduce the occurrence of one more complex driving task within the vicinity which will allow the driver more time to attend to other driving tasks.

**NO-PASSING ZONE DEMARCATION**

If the engineering evaluation indicates a need for installation of no-passing zone treatment, the length of zone should satisfy operational requirements if the criteria are to be expected to be responsive to the driving needs and be defensible in a court of law.

The suggested lengths of no-passing zones presented herein provide an objective basis for establishing no-passing zones at the special situations. The no-passing zone system should extend a distance at least equal to the critical conflict distance upstream from the situation as defined previously for the appropriate maneuver -- either the aborted pass maneuver or the pass completion maneuver.

Guidelines for marking no-passing zones are presented for two types of traffic control devices. The first uses currently approved MUTCD traffic control devices; the second involves the use of an experimental no-passing zone treatment that was pilot field tested in another phase of this research effort.

**MUTCD Traffic Control Devices**

The standard traffic control devices to denote no-passing zones and to warn drivers of potential hazard consist of the solid yellow barrier stripe, certain regulatory signs, and numerous warning signs.
This section presents suggested usage of conventional MUTCD traffic control devices to designate more positively the reason for a marked no-passing zone. The suggestions include supplementing the conventional solid yellow no-passing zone marking with appropriate warning and/or regulatory signs placed at locations where the combination would be expected.

**Length of No-Passing Zone**

The solid yellow line currently represents the device to denote a section of roadway through which a driver should not operate to the left of the roadway centerline. Under the short zone marking and enforcement concept, the driver, therefore, should return to the right lane at or before reaching the start of the solid yellow line.

The no-passing solid yellow line should, therefore, extend throughout the critical conflict distance for the aborted pass maneuver condition in each of the special situations as illustrated schematically in Figure 15.

Desirably, the passing vehicle should be returning to the right lane at the upstream end of the solid yellow line. Recognizing that visibility of the solid line is limited to about 400 ft (122 m) on level terrain (4) in daylight and about 250 ft (76 m) at night, it is highly probable that the passing vehicle will "clip" into the no-passing zone during the latter portion of the abort and return maneuver. Since the critical conflict distance is predicated on necessary safe distance beyond the "critical position" (where the abort is initiated), extending the solid yellow line throughout the critical conflict distance provides a safety buffer for the return maneuver.

Table 2 presents suggested lengths of solid yellow no-passing zone marking for each special situation. The values in Table 2 are rounded for design.

**Supplementary Signing**

Use of supplementary warning signs to identify the potential hazard is strongly encouraged to add credence to the no-passing zone marking—the proximity of the sign(s) to the beginning of the no-passing zone being considered important to the development of a total information system. Placement of most warning signs on rural highways is suggested to be approximately 750 ft (229 m) or more in advance of the hazard. It is apparent from Table 2 that the appropriate warning sign could be placed at the beginning of the no-passing zone for many of the special situations for expected rural highway speed conditions and still be located within the current MUTCD sign location guidelines. Placement of the warning sign adjacent to the beginning of the no-passing zone where possible rather than merely adhering to the minimum 750-ft (229 m) location would provide better association between the no-passing marking and the unique downstream hazard.

The NO PASSING ZONE pennant sign, although not used statewide by all States, is used by many States at locations where additional identification of the no-passing zone marking is considered necessary. Since the safety problems associated with the special situations are created by vehicle operations that are considerably different from normal rural passing expectancy, use of the pennant would be expected to further enhance driver recognition of the no-passing zone.

**Experimental Traffic Control Devices**

An experimental advance treatment for no-passing zones was developed in a previous research study (4) and field tested in three States as another phase of this research. The experimental treatment consisted of a dotted longitudinal marking adjacent to the roadway centerline marking extending upstream from the beginning of the solid yellow no-passing zone and a NO PASSING ZONE pennant located at the start of the solid
Figure 15. Suggested Application of No-Passing Zone Treatment For Special Geometric and Traffic Operational Situations Using MUTCD Traffic Control Devices
Table 2. Suggested Lengths of No-Passing Zones for Special Geometric and Traffic Operational Situations Using MUTCD Traffic Control Devices (Aborted Pass Maneuver)

<table>
<thead>
<tr>
<th>Operating Speed</th>
<th>Railroad Grade Crossings (3)</th>
<th>School Zones</th>
<th>Bridges and Underpasses</th>
<th>Intersections</th>
<th>Pavement Transitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mph) (km/h)</td>
<td>(ft) (m)</td>
<td>(ft) (m)</td>
<td>(ft) (m)</td>
<td>(ft) (m)</td>
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<td>350  110</td>
<td>400  125</td>
<td>550  170</td>
<td>350  110</td>
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<td>500  155</td>
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<td>400  125</td>
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<td>600  185</td>
<td>750  230</td>
<td>450  140</td>
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<td>700  215</td>
<td>850  260</td>
<td>500  155</td>
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<td>1300  400</td>
<td>700  215</td>
</tr>
</tbody>
</table>

Notes:
1. Lengths in table are rounded values for design purposes.
2. Lengths are based on critical conflict distances presented for the aborted pass maneuver.
3. No-passing zone marking extends upstream from a point 15 ft (5 m) in advance of railroad crossing.
4. No-passing zone marking extends upstream from the beginning of the pavement width transition section.
5. No-passing zone marking extends upstream from a point 15 ft (5 m) in advance of the pavement width transition section.
6. No-passing zone marking extends upstream from the centerline of the far side intersecting approach leg.
7. No-passing zone marking extends upstream from a point 15 ft (5 m) in advance of the intersection.
8. No-passing zone extends upstream from gore point.
9. No-passing zone extends downstream from gore point.
The length of roadway containing the dotted line marking (2-ft stripe, 6-ft gap) represents a safe pass completion distance from the critical position for a given speed condition. It is a "transition" zone to convey that a no-passing zone is being approached. It is not a no-passing zone; hence, the use of a broken line pattern rather than a solid line. The no-passing zone begins at the start of the solid yellow line; therefore, the concept is not radically different from conventional no-passing zone demarcation.

This section presents suggested guidelines for use of this experimental no-passing zone treatment for the special situations.

Length of Experimental Treatment

One of the basic meanings of the advance dotted line treatment is, "there is sufficient distance beyond the start of the dotted marking system in which to complete the pass before reaching the upcoming no-passing zone." If passing drivers interpret correctly this meaning, they are, in effect, being encouraged to complete the maneuver if they have already committed to the pass by the time they have reached the start of the dotted treatment. Also, they are being advised that they will enter a no-passing zone at the downstream end of the dotted treatment.

To be consistent with the meaning of the dotted treatment, the pass completion maneuver represents the appropriate critical conflict distance to be used for designating a no-passing zone system for the special situations with this experimental treatment. The experimental treatment extends back upstream from the special situation for the pass completion maneuver critical conflict distance; however, the system is composed of two markings. The length of the upstream dotted line is equal to the necessary pass completion distance for a selected speed condition. The downstream portion is marked with a solid yellow no-passing zone for a length equal to the distance needed to execute the maneuver that will be required to accommodate the operational constraints imposed by the special situation downstream. The suggested application of the experimental no-passing zone system is illustrated in Figure 16. For example, the length of solid no-passing zone marking for the railroad grade crossing is equal to the safe stopping distance in advance of the crossing. In the school zone situation, it is equal to the distance necessary to decelerate from the passing speed to the posted school zone speed after returning to the right lane at pass completion. Where speed adjustment is not necessary after pass completion (such as at the transition section), a minimum length of 200 ft (61 m) of solid yellow no-passing zone marking is suggested. This distance allows the driver to regain steering control after completing the pass before negotiating the downstream special situation. Also, at least the minimum length of solid line should always be installed after the dotted treatment because the driver expects to enter a no-passing zone after the dotted treatment.

Table 3 presents suggested lengths of dotted and solid marking comprising the experimental no-passing zone treatment for each special situation. The values in Table 3, rounded for design, are based on the pass completion maneuver critical conflict distances discussed previously.

It should be noted that the total length of treatment (dotted plus solid marking) for each situation in Table 3 is generally greater than the corresponding length of solid line treatment alone for the aborted pass maneuver condition in Table 2. However, the lengths of solid line in Table 3 using the experimental treatment generally are less than the no-passing zone lengths suggested in Table 2. Therefore, the experimental treatment exhibits several desirable features compared to using only the solid yellow line:
Figure 16. Suggested Application of No-Passing Zone Treatment For Special Geometric and Traffic Operational Situations Using Experimental Traffic Control Devices
Table 3. Suggested Lengths of No-Pass-Ling Zones For Special Geometric and Traffic Operational Situations Using Experimental Traffic Control Devices (Completed Pass Maneuver)

<table>
<thead>
<tr>
<th>School Zones</th>
<th>40-mph Postured</th>
<th>Two-Lane Grade</th>
<th>Dotted Solid</th>
<th>Dotted Solid</th>
<th>Dotted Solid</th>
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<td>(ft)</td>
<td>(ft)</td>
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<td>875</td>
<td>875</td>
</tr>
</tbody>
</table>

Notes:
1. Minimum length of solid yellow no-passing zone marking used (200 ft) (60 m).
2. Lengths in table are rounded values for design purposes.
3. Length of dotted line is measured downstream from gore point. No advance dotted marking is used.
4. No-passing zone system extends upstream from the beginning of the pavement width transition section in advance of the railroad crossing.
5. No-passing zone system extends upstream from the centerline of the far side intersecting approach leg. Line extends upstream from gore point.
6. No-passing zone system extends upstream from a point 15 ft (5 m) in advance of the pavement width transition section.
7. Minimum length of 200 ft (60 m) of solid no-passing zone stripe is used for all speeds. Line extends upstream from gore point.
8. Length of solid line is measured downstream from gore point. No advance dotted marking is used.

Metric Conversion: 1 mph = 1.609 km/h, 1 ft = 0.305 m
1. The length of no-passing zone (solid yellow line) is less for the experimental treatment than for the conventional treatment; therefore, less total length of roadway is marked for no-passing.

2. The driver is provided advance warning information that a no-passing zone is being approached.

3. If the passing driver decides to complete the pass beyond the critical position, the probability of "clipping" (completing the pass beyond the start of the solid yellow no-passing zone line) would be expected to be less under the experimental treatment than under the conventional marking (because the length of dotted treatment is based on pass completion distance and it is greater than normal visibility distance to the solid line which is the visual cue used by the driver to pass or abort).

4. The additional length of dotted advance marking does not represent a significant increase in pavement paint because it is composed of a 2-ft (0.6-m) stripe, 6-ft (2-m) gap pattern. This represents a 75 percent reduction in the amount of paint for a comparable length of solid line marking.

5. Since the special situations present expectancy problems for the passing driver, the innovative experimental advance treatment coupled with the supplementary advance warning signing would be expected to exert a positive influence on alerting the driver to the downstream operational constraints.

Supplementary Signing

In addition to the dotted marking, the NO-PASSING ZONE pennant sign would be installed at the beginning of the solid yellow no-passing zone marking. The appropriate advance warning sign would be placed at the beginning of the dotted line marking system in situations where this location conforms to the advance warning sign location guidelines specified in the MUTCD.
REFERENCES


