Comparison of International Practices in the Use of No-Passing Controls

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Minimization of no-passing control has assumed greater importance since the publication of the latest Highway Capacity Manual in 1985, so it is important that correct standards be used when making policy for design of alignment or examining the performance of two-way highways. Comparison of some international standards on geometric passing distance requirements revealed widely differing values in published figures. North American and Australian performance in truth differed only slightly, despite different values in their design manuals. Britain, however, used much shorter no-passing distances than the other countries. Differences between countries in their use of no-passing controls were also observed, but the absence of coordination between geometric standards and those for control of passing where those standards were not met was almost universal. The abandonment of current no-passing controls and their replacement by new warrants and application methodology, on the basis of revised geometric standards, is recommended. The resulting effect on lengths and positions of no-passing control zones is expected to be small, but level of service values could be changed. An extension of the present form of no-passing-zone pavement marking is also recommended. Such an extension would include special marking of the approach to the barrier line, in particular to mark the last safe point to begin a passing maneuver, to make the beginning of the barrier line more conspicuous from the point of no return for higher-design-speed roads.

In 1988, the Indonesian government introduced laws supporting the introduction of the double-line, no-passing form of pavement marking controls. Driver behavior in Indonesia was undisciplined; many severe accidents were caused by drivers, particularly of trucks and intercity buses, passing on blind curves. Pavement markings outside cities were almost nonexistent, except on the toll road system being developed.

However, the Indonesian legislation did not contain information that would enable field engineers to determine where double lining should begin and end. Neither were there warrants for the placement of double lines. In researching these matters to prepare advice for the Directorate General of Highways of the Indonesian Department of Public Works, the widely differing practice among English-speaking countries quickly becomes evident, together with the inadequacy and lack of logic of much of that practice. Indonesian practice in geometric design borrowed from AASHTO; Indonesian road signs were an amalgam of the European and Australian standard models. But to simply adopt any other country's warrants without fully understanding the consequences can be dangerous.

The result ot the research was to recommend the adoption of a practice that was closest to that used in Australia, but also using and extending an additional British pavement marking technique. The two essential features of the recommendation were that the start of the double line should be related to the point where minimum passing sight distance is lost (rather than to some arbitrary warrant) and that road users should be advised of the last safe points for starting and aborting a passing maneuver, by the introduction of a new form of pavement marking and perhaps new road signs. This recommendation might be considered for adoption by the United States as a step towards rationalizing current disparate practices. The Indonesian research also revealed an inconsistency in the derivation of the American figures for minimum geometric passing sight distance requirement, suggesting that a term appeared to be missing from the computation.

Correct use of passing sight distance controls is a matter that should be of increased concern to highway and traffic engineers. Introduced several decades ago in North America and Europe, the use of a barrier line prohibiting passing was initially a valuable traffic control device to increase safety on existing two-way roads. As traffic densities increased, the effect of passing restrictions on levels of service became evident, and the proportion of a highway's length without passing opportunity had a major impact on the level of service that could be attained, much more so than other geometric considerations.

Now a third area of significance has emerged in Britain, as part of a coordinated approach to the geometric design of two-way roads that recognized the effects of geometrics on service performance. After several decades in which highway design was dominated by divided highway and particularly limited-access highway design, the need to improve nondivided but high-volume roads came into new prominence, particularly as high design flows became accepted as attainable on this type of road. Central to the new philosophy of design was the minimization of the length of highway with passing restrictions in accord with the principles contained in the 1985 *Highway Capacity Manual* (*1*). These restrictions included those involving either the absence of safe passing visibility or the presence of other prohibitions on passing, such as left-turning protection zones or islands. Three techniques were used to maximize the length of highway with safe passing visibility: minimizing the length of each sight-restricting element by the use of minimum acceptable standards of curvature, combining the horizontal and vertical sight-restricting elements of alignment, and combining the location of alignment and intersection restrictions on passing. These objectives would be supported by the correct sizing and siting of passing restrictions in relation to traffic speeds.

Australia and Britain refer to the maneuver as "overtaking"; the United States and Canada call it "passing." In this

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paper, no distinction has been made between the use of the two terms. Because each country uses two sets of passing standards, one for geometric design and the other for traffic control, the standards will be referred to as either "geometric requirements" or "warrant sight distances," to distinguish one from the other.

CURRENT PRACTICE IN SOME ENGLISH-SPEAKING COUNTRIES

The geometric design manuals (*2–5*) and the traffic control codes (*6–9*) of Australia, Britain, Canada, and the United States revealed differences in values recommended for both geometric passing sight distance minima and sight distance warrants for the use of control devices. In addition, Australia positioned the start of its barrier line differently from the other countries, not at the point where the warrant sight distance is lost. Australia and Britain used a more explicit definition of design speed for geometric design than did either the United States or Canada, although the latter countries shared with the former the 85th-percentile speed definition used for traffic control purposes. In addition, Australia and Britain recognized that overtaking performance followed a statistical distribution; thus, they included consideration of the fraction of the driver population accommodated in their derivation of geometric overtaking sight distance standards.

Meaningful comparisons of standards for minimum safe geometric passing sight distance were difficult to make. For example, values for a 100-km/hr design speed were 1,010 m (Australia), 680 m (Canada and the United States), and 580 m (Britain). Likewise, the warrant distances for use of barrier lines ranged from 185 to 400 m. Each country published its control-warrant standards for determining the need for double-line pavement markings separately from its geometric design standards dealing with the engineering of plan and profile in relation to minimum sight distances. This separation obscured the lack of compatibility between the two sources of advice and may have perpetuated some fundamental errors in the deviation of the recommended values. The differences between countries in the values published, both in warrants for the use of double lines and in the specification of a safe passing sight distance for geometric design, are shown in Figure 1. The reasons for the differences included fundamentals, such as definitions of eye height, object height, and maximum safe rates of deceleration. Britain used a single value ($0.25g$) for the coefficient of deceleration f, independent of speed, in contrast to the other countries. Australia used the widest range, with f values between $0.33g$ and $0.65g$ for design speeds between 130 and 50 km/hr, respectively, and an eye height of 1.15 m compared with Britain's 1.05 m. More esoteric differences were also involved, such as the meaning of design speed or the definition of minimum safe passing sight distance, or Britain's desirable and absolute minimum standards, and departures below those standards. Britain requires sight distances of 820, 580, and 410 m to allow safe overtaking for 99, 85, and 50 percent of the driver and vehicle population, respectively, for a 100-km/hr design speed. AASHTO (*5*) was unclear about its definition of design speed, discussing "the maximum safe speed that can be maintained" without defining it specifically, such as the 99th-percentile free-running speed.

Australia and Britain both equated design speed to the 85th-percentile speed of highway users. A design speed was individually assigned to each geometric element of alignment as the coordinating value of horizontal and vertical alignment for that particular element. These assignments were placed within an overall speed environment for the highway link that was related to the link length and cross section, physical environment, and highway function. Within this field of disparate definitions and parameter values, double-line warrants also differed considerably.

Table 1 presents sample values of the warrants from the four countries' manuals on traffic control devices. The second half of the table presents corresponding values of minimum passing sight distance requirements from the geometric design manuals of the four countries.

Relationships between the two sets of figures were not obvious although some arbitrary basis had been chosen for the warrants determining the need for double-line markings. The justification for a separate method to determine the need for and positioning of the barrier line, rather than using the position where geometric passing sight distance is lost at the design speed, was not made clear in either the geometric design policies (*2–5*) or the uniform devices manuals (*6–9*) of the different countries, although several made apologetic explanations about the avoidance of unduly restrictive controls on overtaking.

MINIMUM REQUIREMENTS FOR PASSING SIGHT DISTANCE

To be able to understand the different values quoted in the design manuals for the minimum passing sight distance

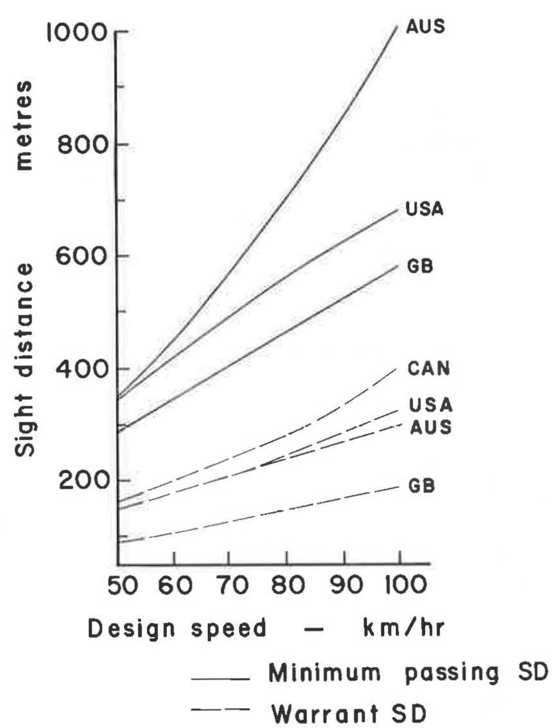

FIGURE 1 Variations in values for minimum passing sight distance, warrants for the use of double-line markings, and stopping sight distance (*1–5*).

requirement, the components of the minimum overtaking maneuver must be analyzed. In diagrams such as Figure III–2 of AASHTO's policy manual (*5*), shown here in a modified form as Figure 2, the complete maneuver was broken into two parts: the perception, analysis, and reaction (*AB*), and the overtake and return to right lane (*BC*). The decision point (*B*), the last point for aborting the maneuver, is at the boundary between the first and second phases.

The minimum passing sight distance requirement could be expressed in two ways, corresponding either to the length of the complete maneuver (*AE*), starting from the trailing position (*A*), or to the distance (*BD*) required to complete the maneuver from the point of no return (*B*). The former was called the establishment sight distance (ESD) in Australia (*2*), and the full overtaking sight distance (FOSD) in Britain (*3*), although the ESD included d_1 from Figure 2. These terms defined the minimum sight distance that should be available when the decision to attempt an overtaking maneuver is made, and therefore the sight distance needed before an overtaking restriction should be terminated. Most authorities seemed to require a minimum passing sight distance based on this version, the minimum length of clear road required to begin an overtaking maneuver as the geometric requirement. In Australia (*2*), the shorter sight distance required for safe completion of the maneuver beyond the point of no return was called the continuation sight distance (CSD), with computed values less than half those for the ESD; in Britain it was the abort sight distance (ASD), taken as half the FOSD. These terms represent the distance that should be the basis of barrier line installation. Figure 3 shows these different definitions.

The different dimensional standards for these minimum overtaking sight distance geometric requirements may have been the result of the different values assigned to variables such as relative speeds of overtaking, overtaken, and oncoming vehicles; clearance interval; and reaction plus perception time. Britain, for example, assessed the overtaking sight distance requirement for 50, 85, and 99 percent of the car and driver population. Troutbeck (*10*) discussed this topic on the basis of experimental work carried out in Australia.

TABLE 1 PUBLISHED SIGHT DISTANCE WARRANTS FOR THE USE OF DOUBLE LINES AND STANDARDS FOR MINIMUM PASSING SIGHT DISTANCES USED IN GEOMETRIC DESIGN

	Design Speed (km/hr)		
	50	70	100
Double-Line Warrants (m)			
Australia	150	210	300
Britain	90	125	185
Canada	160	240	400
United States	150	210	320
Minimum Passing Sight Distance Requirements (m)			
Australia[a]	350	570	1,010
Britain[b]	290	410	580
Canada[c]	340	480	680
United States[d]	360	490	680

[a]Defined as establishment sight distance.
[b]FOSD for 85 percent of the car and driver population.
[c]Minimum passing sight distance.
[d]Derived from AASHTO (*5*).

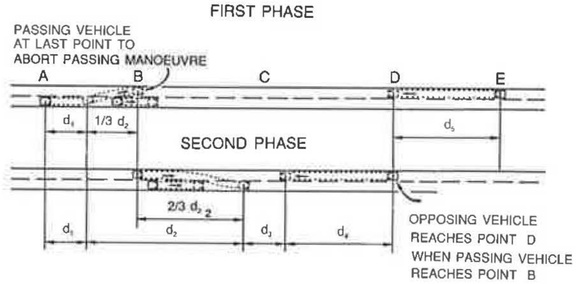

FIGURE 2 Movements of the three vehicles involved in the passing maneuver during the first and second phases (before and after, the point of no return), based on AASHTO (*5*), Figure III–2, modified to include movement *ED* of the opposing vehicle during the first phase.

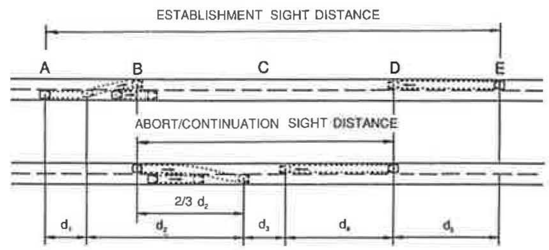

FIGURE 3 The two forms of passing sight distance requirement: the ESD, needed for the complete passing maneuver, the clear distance required before terminating a barrier line; and the ASD or CSD, needed at the point of no return, loss of which should be the warrant for the use of a barrier line.

The AASHTO policy handbook (*5*) was ambiguous about the derivation of its figures for minimum safe passing sight distance; its definition was between the long and the short versions. Figure III–2 showed the minimum passing sight distance requirement as *AD* in Figure 2, equal to $d_1 + d_2 + d_3 + d_4$, but this sum represented the addition of distances between vehicles in noncontemporaneous positions. Consider passing on a long, straight road. A decision to overtake, at point *A*, would be based on the road being clear through to *E*. If, when at *B* alongside the vehicle to be overtaken, an opposing vehicle appeared, the maneuver would be aborted if the vehicle was closer than *D* but continue if the vehicle was beyond *D*.

The length *BD* was the same as the Australian CSD. The equivalent of the Australian ESD was measured from the point when the overtaking vehicle was in the trailing position at *A*, at which time the opposing vehicle would be at *E*, still some 7 or 8 sec from point *D*. To be consistent, AASHTO should quote either $d_2 + d_3 + d_4$ for continuation conditions or $d_1 + d_2 + d_3 + d_4 + d_5$ for establishment conditions, both of which represent contemporaneous positions of the overtaking and oncoming vehicles.

Australian and American values for these two versions of minimum safe passing sight distance are presented in Table 2. The American figures are based on metrication of values given by AASHTO (*5*) in its Figure III–2. Figure 4 shows that, after making allowances for the point raised above and plotting distances against speed of the passing vehicle rather than against the nominal design speed, the two sets of figures were similar. The Canadian figures (*4*) were apparently based on AASHTO (*5*) so they may need to be amended in the

TABLE 2 COMPARISON OF AUSTRALIAN, BRITISH, AND EQUIVALENT AMERICAN VALUES FOR PASSING SIGHT DISTANCES

	85th-percentile speed (km/hr)						
	50	60	70	80	85[a]	90	100
Australia							
CSD (m), 75 percent	165	205	245	332	-	-	-
CSD (m), 85 percent	200	240	285	345	-	410	490
ESD (m)	350	450	570	700	-	840	1,010
Britain							
ASD (m), 85 percent	145	170	205	-	245	-	290
FOSD (m), 85 percent	290	345	410	-	490	-	580
United States							
Equivalent CSD (m)	185	250	315	380	-	445	515
Equivalent OSD (m)	260	350	445	-	580	-	725
Equivalent ESD (m)	345	470	590	715	-	840	965

[a]Britain uses 85 km/hr as a standard design speed.

same way. Table 2 and Figure 4 also show British overtaking sight distance minimum geometric requirements (*3*) for occupation of the passing lane and abort distance. These values were derived from rounded observed values of passing duration, taken as the occupancy of the passing lane (d_2). Unlike those used by the other countries, the British passing lane occupancy figures were found to be relatively unaffected by vehicle speed, and 50 percent of the overtaking maneuvers were completed in under 7 sec, 85 percent in under 10 sec, and 99 percent in under 14 sec. AASHTO (*5*) used a 9- to 11-sec range; Australia quoted 8 to 14 sec over the 50- to 100-km/hr speed range.

If each country had found the same passing lane occupation time, their passing sight distances might also have been the same, except for small differences in details such as clearance (d_3). The uniform passing time with speed of the British findings produced a linear relationship between passing sight distance and speed; the wide range of the Australian passing times, with speed, led to the curved relationship shown in Figures 1 and 4.

In the British computations, the FOSD required at the beginning of the passing lane occupation equated to 2.05 times the 85th-percentile speed multiplied by the time to complete the overtaking maneuver (i.e., the time the passing lane is occupied). In this way, the FOSD could be calculated for different overtaking populations at each design speed. This variable was another that led to differences between the national figures and made comparison difficult. The Americans and Canadians did not state, for example, whether their safe passing sight distance requirements would allow for all passings or for only the more adventurous to be accommodated, but AASHTO (*5*) gave the time of the passing lane occupation as close to 10 sec for d_2 across the 50- to 100-km/hr range. This figure corresponded to the British value for the 85th percentile; the Australian figures generally provided for 85 percent of their driving population.

The British Department of Transport's equivalent of the Australian CSD, called the ASD, was taken as half the FOSD, a proportion that was reasonably consistent with Australian and AASHTO (*5*) findings. However, the values were considerably different, perhaps as a result of different assumptions on relative overtaking and overtaken speeds. More field research is needed to establish whether these differences are the result of fundamentally different driver behavior in the various countries or of the different assumptions made in the computations.

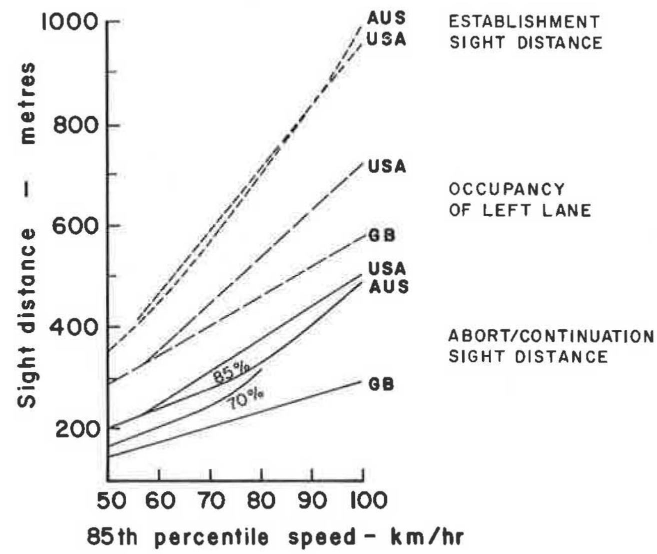

FIGURE 4 Different passing sight distance definitions: full requirement, occupancy of left lane, and minimum at point of no return.

Table 3 presents British, Australian, and American values for CSD and the minimum stopping distance values used in each country. The Australian CSD was almost identical to twice the stopping distance plus 5 sec at the 85th-percentile speed, and this was the basis for evaluating Australia's intermediate sight distance, now replaced by the CSD definition. American figures were even closer, but the British values did not conform to the pattern at all, despite similar stopping distance values. The reason that British values for ASD should be so different to those of the other countries was not clear.

TABLE 3 RELATIONSHIP BETWEEN STOPPING DISTANCES AND CSD OR ASD VALUES

	85th-percentile speed (km/hr)						
	50	60	70	80	85[a]	90	100
Australia							
Stopping distance (m)	45	60	75	95	–	120	155
2 × SD + 5 sec (m)	160	200	250	300	–	365	450
CSD (m)	165	205	245	320	–	410	490
Britain							
Stopping distance (m)	50	70	90	–	120	–	160
2 × SD + 3.6 sec (m)	150	200	250	–	325	–	420
ASD (m)	145	170	205	–	245	–	290
United States							
Stopping distance (m)	65	90	120	150	–	180	210
2 × SD + 3.6 sec (m)	180	240	310	380	–	450	520
Equivalent CSD (m)	185	250	315	380	–	445	515

[a]Britain uses 85 km/hr as a standard design speed.

SITING OF DOUBLE LINES IN RELATION TO POINT WHERE SAFE PASSING VISIBILITY IS LOST

Table 4 presents warrants for the use of double-line overtaking controls with the minimum CSD geometric requirements in the three countries. Most important to this investigation was the relationship, or absence of any explicit relationship, between minimum geometric sight distances and warrant distances. The differences between the two sets of sight distance standards shown in Table 4 introduced further inconsistencies, giving rise to the problem of reconciling the differences between geometric requirements for minimum passing sight distance, and those given in the warrants for the use of barrier lines. The similarities between the American and Australian figures are apparent in Figure 5, yet the positioning of the beginning of the barrier line was quite different.

British and American warrants both required the barrier line to start at the point where sight distance is lost, as specified in the warrant for the 85th-percentile speed at that point. The Australian warrant, with speed and sight distance figures almost identical to those of Americans, required the line to start at a given distance beyond this point of visibility loss. The Australian method immediately commended itself for its rationality. The significance of the distance an overtaking driver could see when he had completed the overtaking maneuver—for this was the requirement of the American and British method—was unclear. The American and British method started the barrier line, that is, the point where overtaking is complete at the point where the warrant sight distance is lost (point *C* in the figures). This distance may have been used as a proxy for some other. The significant sight distances that must be available to the passing driver are point *A*, when he decides to begin a passing maneuver, and point *B*, when he must decide whether to complete or abort the maneuver at the point of no return. The British and American approach suggested that they were using a different definition of no-passing barrier-like markings than the Australians.

America and Britain, in fact, both used a short-zone definition of barrier-line meaning (defined in following paragraphs), yet started the barrier line at the point the warrant sight distance is lost, a practice that fits the long-zone use of

TABLE 4 RELATIONSHIP BETWEEN ASD OR CSD VALUES AND WARRANTS FOR THE APPLICATION OF DOUBLE-LINE CONTROLS

	85th-percentile speed (km/hr)						
	50	60	70	80	85[a]	90	100
Australia							
CSD (m)	165	205	245	320	–	410	490
Warrant (m)	150	180	210	240	–	270	300
Britain							
ASD (m)	145	170	205	–	245	–	290
Warrant (m)	90	105	125	–	155	–	185
United States							
Equivalent CSD (m)	185	250	315	380	–	445	515
Warrant (m)	155	175	210	240	–	280	315

[a]Britain uses 85 km/hr as a standard design speed.

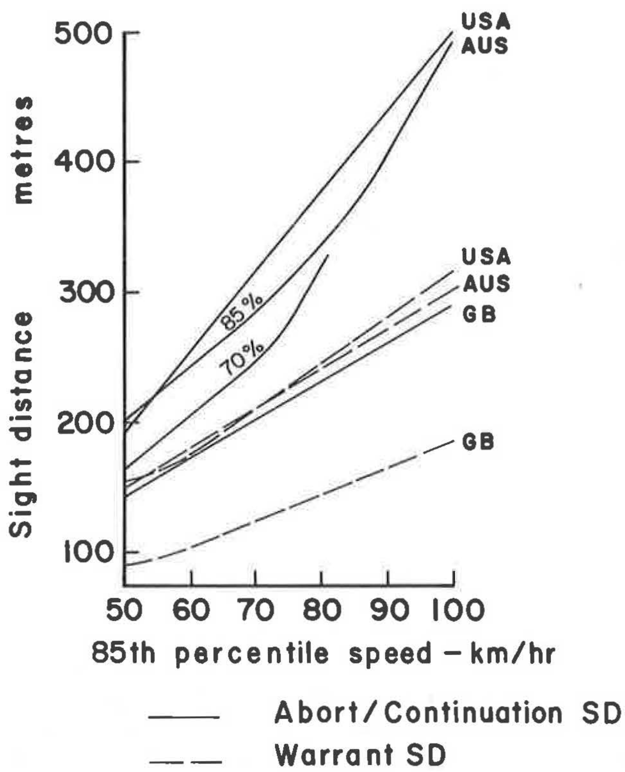

FIGURE 5 Comparison of traffic control warrants with minimum geometric passing sight distance requirements.

barrier lines. Australian practice started the barrier line at a distance about half the ASD beyond the point of loss of the ASD. American practice did not recognize the ASD as significant, although the calculation of passing sight distance is half-based on this concept. But because the ASD was a geometric design concept, with values much higher than those of the warrant sight distance, installing the barrier line in accordance with the warrants produced results similar to what would result from installing it by the previously outlined geometric principles.

No simple relationship between the two approaches could be foreseen, because of the effect of alignment at specific sites. In some locations, both ASD and warrant sight distance might be on the same horizontal or vertical arc, whereas at others the latter may be on the arc but the ASD may include both arc and tangent lengths.

These warrants may have been found to be satisfactory through custom and practice, but some more rational method would be preferable. Only the geometric design approach has the rationality of being based on behavioral research. A single basis for determining passing requirements, and for installing barrier lines where those requirements were not met, would be an improvement.

The assumption will be made that the present warrants should be replaced by the more rational approach of beginning the barrier line at some point related to the loss of CSD or ASD. Troutbeck's treatise (*10*) is the only known example in which the beginning of the barrier line was recommended to be positioned explicitly with respect to the point of loss of geometric overtaking visibility.

Before examining the detail of an alternative to the conventional approach of using independent warrants, the legal meaning attached to the barrier line should be understood. Troutbeck (*10*) identified two legal forms of barrier-line control. In the first, legislation required that the overtaking maneuver must not be begun, that is, the vehicle must not move from right to left lane, after the beginning of the barrier line (Point *B* in Figure 6). Returning to the right lane by crossing the barrier line to complete an overtaking maneuver was permitted. Troutbeck called this method the long-zone definition, when the barrier line started at the point where overtaking sight distance is lost. Few states use this definition in their legal codes. Troutbeck's short-zone definition fixed the beginning of the barrier line at the point by which the vehicle must have completed the overtaking maneuver and returned to the right lane (Point *C*), so that no crossing of the barrier line would be permitted in any circumstance.

In the long-zone form, the barrier line could be unduly restrictive, especially if based on loss of an FOSD that would permit a large percentage of the overtaking-performance spectrum to take place safely in shorter distances than the geometric design minimum, on the basis of the overtaking requirements of 99 or 85 percent of the driver population. Also, the long-zone form gave no guidance to overtaking drivers about the point by which the maneuver must be completed and was unsatisfactory for enforcement purposes.

In the short-zone form, the beginning of the barrier line advised drivers of when the passing maneuver must be completed. This form also avoided ambiguity in the meaning of the marking; a barrier line, as the right-hand member of a pair of lines, must never be crossed. However, this definition gave the driver no advice about the last safe point to begin an overtaking maneuver or about the point of no return. A further disadvantage was that the beginning of the double lining was some distance ahead of the last safe point for beginning a maneuver at the higher design speeds, probably beyond the distance at which a double line could be distinguished by most drivers, so they might be unaware of its presence when starting to pass. To a certain extent, the pennant road sign used in the United States served this purpose by providing a more visible marker, but the sign gave no indication of the point of no return and would be difficult to apply where, as on many older two-way roads, there was considerable roadside activity. Troutbeck suggested that this limit of conspicuity of a pavement marking was around 80 to 100 m, so for design speeds above 50 km/hr the presence of an upcoming double-line marking would be inconspicuous at the point of no return.

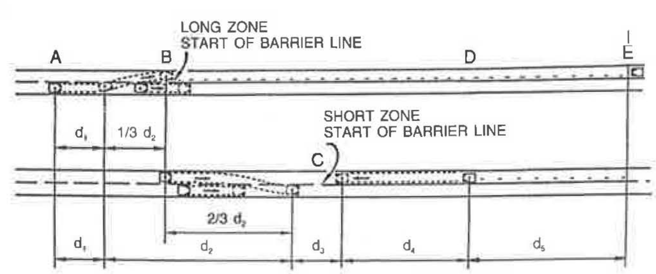

FIGURE 6 Alternative long- and short-zone definitions of the no-passing zone in relation to the minimum passing distance requirement.

This situation would be unrealistic, and some advanced warning of approach to a barrier line should be provided. Whether this should be given at the last point for beginning a maneuver or at the point of no return is debatable.

No provision for this kind of advance-warning road sign or pavement marking was included in the uniform codes of Australia (*6*), Canada (*8*), or the United States (*9*), or in the Vienna Convention and Protocol on international standardization of road signs and pavement markings. The British code (*7*), which follows the European Agreement with certain reservations and additions, contained a pavement marking for use in this situation. However, its use was not carried through in the rational way that would come from following the recommendations of Troutbeck.

In Britain, three types of directional-driving pavement-marking lines are used: advisory center lines; mandatory double lines; and a warning line for use where crossing the center line was hazardous but not forbidden. The warning line, as intermediate between the advisory center line of short marks and long gaps (or sometimes equal marks and gaps) and the continuous line of the interdictory double-line marking, consisted of long marks and short gaps, in a 2:1 ratio. Unfortunately, the British code required the warning line to be used in a rather arbitrary way at the approaches to a double-line zone, instead of using it to indicate the zone between the loss of either FOSD or CSD and the start of the barrier line (i.e., for the length of either *AC* or *BC*).

Adoption of this pavement marking system, with or without pennant signs, would allow points of loss of both FOSD and CSD to be advised to the driver in a way that would not penalize those drivers requiring a shorter passing time, while continuing the use of the unambiguous mandatory message of the continuous barrier line as the required point for completion of all passing maneuvers.

Figure 7 shows how the pavement marking system that is being recommended here would work. For each direction of travel, after the 85th-percentile speed has been measured and an appropriate design speed for the sight-restricting element of alignment has been determined, four salient points on the road's center line must be located:

1. The point at which FOSD for the design speed is lost (having first decided whether this distance is to accommodate 99 percent or a smaller percentage of the driving population),

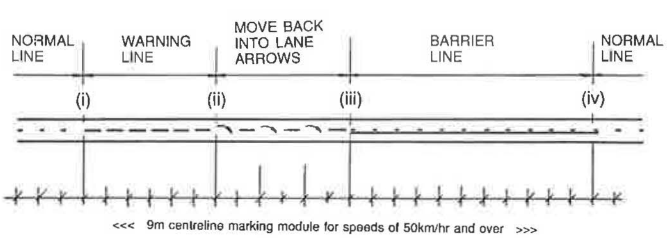

FIGURE 7 The recommended pavement marking system resulting from the short-zone definition and European and Australian pavement marking practice, which bases warrants and the start of the barrier line on loss of CSD, and uses a new marking system to indicate the approach to a no-passing zone.

2. The point at which ASD or CSD is lost,
3. The point by which overtaking maneuvers must be completed, which is half the ASD or CSD ahead of Point 2, and
4. The point at which sight distance again exceeds the FOSD.

The pavement markings will be warning lines between Points 1 and 3 and barrier lines between Points 3 and 4 or until certain checks on the alignment beyond Point 4 are satisfied. Between Points 2 and 3, every second mark of the warning line, counting back from the start of the barrier line, is replaced by a move back into lane arrow, to indicate the imminence of the start of the barrier-line marking. The warning line consists of a 6-m line followed by a 3-m gap where the design speed is 50 km/hr or faster; otherwise, a 4-m line followed by a 2-m gap. Over those lengths where the available visibility, in either direction, is less than that required for FOSD but never falls to as little as the ASD or CSD, the center line is to be marked with the warning line, to indicate the more hazardous situation for overtaking.

At present, many sites in the United States appear to be too restrictively marked for no passing, perhaps as a result of following the misleading tabulation of passing sight distances against design speed in the AASHTO policy manual (*5*). A rectification of this situation might lead more road users to recognize the validity of the passing prohibitions.

CONCLUSION

The investigation of four countries' methods for the application of controls to sites where sight distances were inadequate for safe passing revealed that the apparent differences in published geometric standards between Australia and the United States could be reconciled when like situations were compared, and that the AASHTO (*5*) analysis appeared to be in need of review. British values were found to be signif-

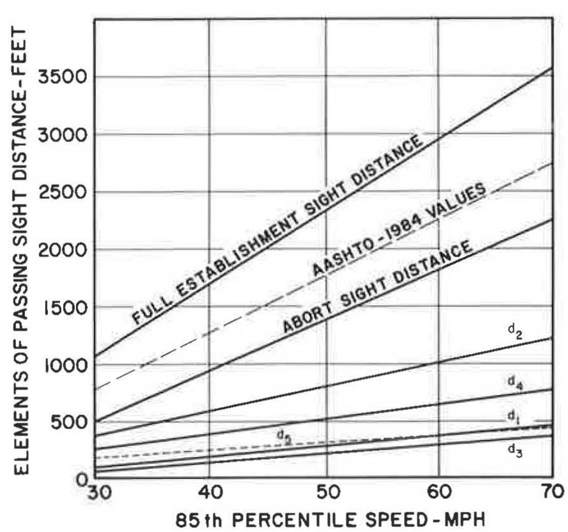

FIGURE 8 Amended Figure III–2 (*5*) to show U.S. equivalent of ESDs and CSDs with the average speed of passing vehicle taken to be the 85th-percentile speed of the highway.

icantly smaller than those of the other countries, although some of the differences were caused by different assumptions about the components of the passing maneuver or the population that is accommodated. AASHTO (*5*) might be recommended to revise its Figure III–2 and dependent Table III–5 to use the average passing speed as the design speed and to recompute FOSD and ASD requirements as described, as an interim measure until further field work verifies the various increments of time in the passing maneuver. An interim revised AASHTO (*5*), Figure III–2, might look like Figure 8, indicating both FOSD and ASD requirements. When a sight distance in one direction was between that required for the FOSD and the ASD value, a warning center line should be used; when less than the latter, a barrier line should begin half the ASD beyond the point where the ASD distance is lost.

The study's central objective was to seek a standard method for installation of double-line pavement markings, but no consensus was found. Australia, using much the same warrants to establish locations requiring the double-line markings as does America, located the beginning of the double lining quite differently. Britain shared the American and Canadian method to find the start of the barrier line but used smaller warrant lengths. Only Australia positioned the start of the double lines at a point explicitly related to the loss of a geometric requirement for passing sight distance.

Most current methods of determining the position of double-line pavement markings to indicate overtaking prohibitions had some of the following deficiencies:

- Incompatibility with actual geometric overtaking sight distance requirements,
- Possible ambiguities of interpretation by highway engineers, and
- Inadequacy in conveying advance warning of the overtaking prohibition and the point of no return to road users.

Present methods separating traffic control techniques and their warrants from geometric design requirements for passing sight distance are unsatisfactory. The present warrant approach is recommended to be discarded in favor of one based on geometric principles, with an additional form of pavement marking to indicate the approach to a passing-restricted zone.

The recommended method of determining the positions of double-line pavement markings has the advantage of rationality over methods apparently in use in some states of Australia, Britain, Canada, and the United States. The method is independent of each country's differences in values for minimum geometric overtaking sight distance standards, which could still be used in the manner of application described, and would replace the warrants currently in use. To be able to carry out the suggested rationalization of their double-lining system, Australia, Canada, and the United States would have to adopt some new style of pavement-marking warning line, but that warning line would be an entirely consistent extension of current practice and one that, in a slightly different form, has already been recommended for adoption in Australia.

The conclusion that the present method of identifying and marking sections of two-way highway where no overtaking should take place should be replaced does not claim that present methods are, in general, unsatisfactory or unsafe. Rather, they could be improved and made more logical, particularly to relate them more closely to the geometric design of highways. This may be a good time for a new study on passing behavior that would show whether AASHTO's long-standing values for duration of the passing maneuver are still representative of contemporary vehicle performance and today's drivers.

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