The Effects of Sight Distance and Controlled Impedance on Passing Behavior

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The purpose of this research was to determine the singular and combined effects of impedance distance, impedance speed, passing sight distance, and traffic volume on driver acceptance of passing opportunities as they occur on rural two-lane highways. A further aim was to describe empirically the effects of these variables on the nature of the passing maneuver.

The report presents a detailed discussion of the methodology, test sites, instrumentation, experimental procedures, and major results. Controlled road tests were designed such that the subject driver was unaware that he was involved in an experiment. An experimenter-controlled, instrumented van produced and regulated the impedance conditions. Passing sight distance was controlled through test site selection, and traffic volume at the test sites was treated as a sampling variable.

The major results indicate that passing sight distance is the predominant variable that influences the decision to pass. An analysis of covariance, in which the effects of traffic volume were controlled, yielded statistically significant effects for impedance speed and the impedance-distance/sight-distance interaction.

•THE RESEARCH presented here is part of an overall program of the Bureau of Public Roads that is aimed at better definition of driver overtaking and passing behavior. The results reported are from the first experiment of a study sponsored by the Bureau under Contract No. CPR-11-4092 and designed to quantify several of the determinants of driver passing behavior on rural two-lane highways. An additional aim of the research was to empirically describe the effects of selected variables on the nature of the passing maneuver.

A specific goal was to examine the influence of the singular and combined effects of impedance speed, impedance distance, and traffic volume on the acceptance or rejection of a passing opportunity where passing sight distance is restricted by the horizontal and/or vertical curvature of the highway. A further purpose was to determine the effects of sight distance on various elements of the passing maneuver.

Because additional analyses of the data are currently in process and because the remainder of the overall program will involve the study of independent variables that can be expected to interact with those studied in this first experiment (e.g., lead vehicle speed), no attempt will be made to draw firm conclusions from the data presented here. Similarly, comparisons between the results obtained in this study and the findings available in the literature will be presented in a more comprehensive final report.

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METHODOLOGY

The general methodology used to implement the research involved the use of an experimenter-controlled, van-type vehicle that was instrumented to facilitate the observation and recording of appropriate measures. The van was driven over selected test sites that were characterized by a specified passing sight distance in the passing zone and that had, prior and adjacent to the passing zone, a sufficiently long area of inadequate passing sight distance within which to impede subject drivers. Figure 1 is a schematic representation of a test site that illustrates the interaction between subject and experimenter vehicles. The impedance areas were striped and officially signed as no-passing zones in order to discourage the subject driver from prematurely passing the experimenter vehicle. In other words, a test site was created on which a subject driver was impeded for a specified distance at whatever speed the experimenter vehicle was driving, and was subsequently faced with a geometrically restricted passing opportunity. This, in effect, simulated the situation in which the driver is the fourth or fifth vehicle in a queue and must follow slower moving traffic for some period of time before being able to pass.

Experimental Procedure and Instrumentation

An operator equipped with speed measurement and communications equipment was located at a point upstream of the impedance zone. Depending on the experimental condition, the instrumented van was positioned a short distance from the beginning of the 1-, 3-, or 5-mile impedance zone. On reception of a "ready" signal from the van, the spot-speed measurement was taken at the first opportunity, i.e., on arrival of the next appropriate vehicle. The following types of vehicles were accepted as subject vehicles: American and foreign sedans, convertibles, and station wagons; sports cars; and pickup and panel trucks. A trial began when one of these vehicles approached the

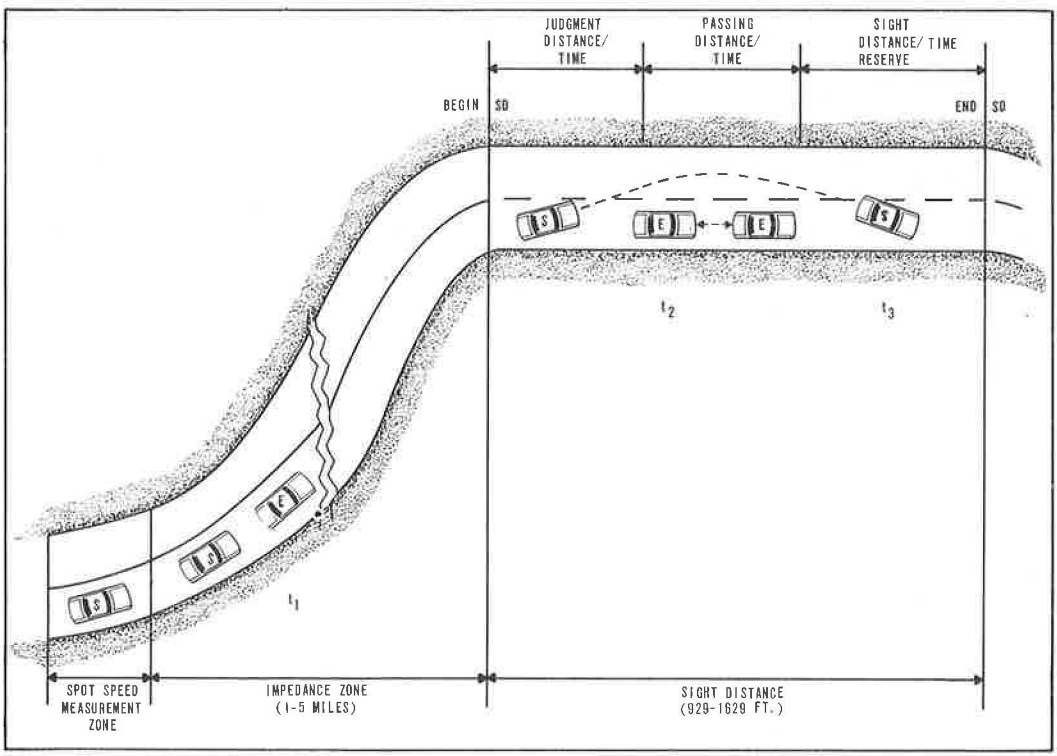

Figure 1. Test site (schematic).

Figure 2. Interior of van (rear view).

beginning of the impedance zone. The spot-speed and a description of the subject vehicle was radioed to the van, which then pulled out onto the highway ahead of the subject vehicle, gradually accelerated to the predetermined speed, and subsequently established impedance. The van continued at this speed until reaching a point approximately ¼ mile before the beginning of sight distance, at which point the speed was gradually adjusted to 35 mph. A constant speed through the passing zone for all subject vehicles was necessary so that the results would not be confounded by the effects of the lead vehicle's speed during the passing maneuver itself. In this way risk varied only as a function of the sight distance. On reaching the location ¼ mile before the beginning of sight distance, the driver of the van made radio contact with a flagman positioned at the end of the passing zone (and out of sight of the subject driver) to indicate that opposing traffic should be stopped. The van then continued through the passing zone collecting the necessary data.

Figure 2 shows the interior of the experimenter van, which was equipped with a one-way mirror system installed in the rear of the van to prevent the subject driver from seeing into the rear window. Through the use of another mirror system, the rear of the van was made to appear to be loaded with boxes.

An operations recorder was used to record impedance time, judgment time, and passing time. Mounted in the front and rear of the experimenter van, 16-mm cameras recorded the passing distance and judgment distance data. The film data were subsequently reduced to numerical form by measuring the position of the subject vehicle relative to reference markings put on the centerline of the highway and recorded on the film. A distance catalog of these references relative to the beginning and end of sight distance permitted the distance involved to be accurately determined from the photographs.

Test Sites

Because certain characteristics of the test sites chosen for the research are critical to the interpretation of results obtained, some of the problems of test site selection deserve mention at this point. The site selection criteria used were as follows:

1. The impedance zones adjacent to the passing zones in which the measurements were being taken had to be a minimum of 5 miles in length, have no signed speed zones, and have no major intersections or other characteristics such as commercial or industrial complexes that could influence vehicle speeds or queue buildup. In order to provide a 5-mile impedance zone, it was necessary to eliminate all passing zones in the impedance area. Appropriate striping and signing procedures consonant with practices of the Pennsylvania Department of Highways were used.
2. The passing zone of test sites had to have a specified distance within the 900- to 1,700-ft range, with a gradient restriction of 5 percent or less. Further, as the subject driver entered the site, the entire sight distance had to be available at a well-defined point and the decrease in sight distance had to approximate a linear function as the subject driver traversed the passing zone to a point near the end of the initially available sight distance.

The characteristic of monotonically decreasing sight distance was necessary because there was no control of the subject population to eliminate local drivers. If the decrease in sight distance is not monotonic (e.g., if it decreases to a point and then increases again), the local driver, who knows that particular section of highway, may begin the pass knowing that he will be getting more sight distance information before he has to finally commit himself to the pass. The nonlocal driver, on the other hand, will make the decision to pass on the basis of the initial sight-distance information. Selecting sites on which there is a monotonic (and in fact, nearly linear) decrease throughout the site requires both the local and nonlocal drivers to utilize the same sight-distance information in making the decision to pass.

Independent Variables

Sight Distance—The study was conducted over a total of five test sites, each representing one of four different levels of passing sight distances: 929, 1,086, 1,363, and 1,629 ft. Several studies in the passing-behavior literature indicate that the 929-ft site was sufficient as a minimum. The use of the 1,629-ft maximum was based in part on the literature and in part on pilot observations made early in the study. It is felt that an adequate range of "restrictive" sight distances was sampled.

Impedance Distance—Impedance distance is defined as the distance over which a subject driver is forced to follow the experimenter vehicle until there is a passing opportunity. Distances of 1, 3, and 5 miles were used in the study.

Impedance Speed—Impedance speed is defined as the speed at which the subject driver was forced to drive over the impedance distance. Three levels of impedance speed, corresponding to a 10, 20, or 30 percent reduction in the speed desired by the subject driver, were used. To ensure a high degree of experimental control over the impedance speed variable required that an estimate be made of the desired speed of each subject driver as he traversed the test site. The reason is that if the experimenter van were traveling at a speed faster than that desired by the subject driver, there obviously would be no impedance condition imposed. To establish the desired speed of the subject, an observer made a spot-speed measure at a point near the beginning of the appropriate impedance zone. This speed was communicated by radio link to the experimenter in the data collection van, who subsequently established a lead vehicle speed (impedance speed) that was 10, 20, or 30 percent less than the spot speed.

Traffic Volume—Because traffic volume on the test sites could not be controlled, it was treated as a sampling variable. Volume was measured continuously during data collection, and the ½-hour volume immediately preceding each trial was noted.

Dependent Variables

The dependent variables in the study were of two types: discrete and continuous. The discrete data collected were passing frequency and abort frequency under each of the experimental conditions. In order to determine the extent to which the independent variables affected the nature of the passing maneuver, judgment time and distance, passing time and distance, and sight distance reserve were measured.

Judgment time (or distance) is the interval between the arrival of the subject driver at the beginning of sight distance and the initiation of the passing maneuver. Passing distance is self-explanatory. However, it should be noted that the initiation of a pass was defined as that point at which the right front tire of the subject vehicle crossed the centerline of the highway. A situation in which this occurred but was not followed by a completed pass was defined as an abort. The end of a pass was defined as that point at which the right rear tire of the subject vehicle crossed the centerline, having passed the experimenter van. Sight distance reserve was the interval in units of time and distance from the end of the pass to the end of sight distance.

Factors such as sex of driver, number in vehicle, vehicle type, state of registration, number of children, and sex of other occupants were also noted for each subject vehicle.

Experimental Design and Analysis

The sight distance, impedance distance, and impedance speed variables were arranged factorially in a 5 by 3 by 3 matrix; i.e., a 3 by 3 matrix for each of five test sites. The complete factorial design permits all interactions to be tested.

The desire to test all interactions of the independent variables dictated that analysis of variance techniques be employed. However, the dependent variable of primary interest is the acceptance or rejection of a passing opportunity, a dichotomous variable for which the underlying probability model is the binomial distribution. Thus the assumptions of normality and homogeneity of variances, necessary to the use of analysis of variance, were violated. For this reason an arcsin transformation was applied to the dichotomous data. Given the arcsin transformation

$$y = 2 \arcsin \frac{x}{n}$$

it can be shown by appealing to the central limit theorem that y is approximately normally distributed with a mean $2 \sin^{-1}(p)^{1/2}$ and variance $1/n$. In this experiment, n is the number of subject drivers under any given condition, and x/n is the proportion of drivers that passed (it is also the probability that a driver will pass).

In other words, the arcsin transformation is such that within each cell the transformed variable y is nearly normal with an approximate homogeneous variance of $1/n$, where n is the number of observations in each cell. Within each cell the n observations give rise to one transformed observation y. For each level of impedance speed, the total number of transformed observations is obtained by collapsing across the impedance distance and sight distance variables. Thus, the total number of observations for each level of impedance speed was $3 \times 5 = 15$. The same is true for each level of impedance distance. Similarly, the total number of transformed observations for each level of the sight distance variable was $3 \times 3 = 9$.

It may be noted that a total of 1,462 observations were made, a minimum of 30 per cell. It can be shown that 30 observations per cell provide a guaranteed power of 0.90 for a given Type I error of 0.05. This power guarantee is based on an assumed overall treatment effect of approximately 0.10 for impedance conditions and approximately 0.15 for sight distance. For all significant F-ratios in the analysis of variance, Scheffé's (1) method of multiple comparison was used to identify the specific source of significant treatment effects.

Because traffic volume had to be treated as a sampling variable, it was handled as a covariate in order to provide a more refined and accurate analysis of treatment effects. Although the covariate was well defined, the analysis of covariance had to be modified to handle the dichotomous aspect of the dependent variable. As in the analysis

of variance situation, the arcsin transformation was used. However, because the result of this transformation combines the "pass, no-pass" observations in each cell into a single observation on the transformed scale, a problem arises because the covariate assumes a number of different values for each observation. If there were replication within each cell, the problem could be solved by using the average of these values as a covariate. However, the lack of replication dictates that another solution be used. The best approach appeared to be to obtain two transformed observations from each original cell by dividing the total observations in the cell on the basis of the magnitude of the corresponding traffic volumes; that is, one of the two observations corresponding to the higher traffic volume and the other to the lower. Because it was desirable to keep the number of subjects per cell as large as possible, more than two transformed observations per cell did not seem feasible. Even though this method results in only half as many observations per cell as compared with the analysis of variance situation, it is felt that the number of observations per cell is sufficiently large to permit the assumption of normality in the transformed observations.

RESULTS AND DISCUSSION

Before proceeding into a discussion of the results obtained, a potentially important point about the sample deserves mention. It will be recalled that the section of highway over which subject drivers were impeded was striped as a "no-pass" zone so that control could be maintained over the impedance distance. In order to produce a sufficiently long impedance area, it was necessary to restripe some sections that were previously passing zones—for example, sections with sight distances in excess of 800 ft. Although this was undesirable, it was believed better to accept this flaw than to compromise on other, more important criteria for site selection.

It was assumed that the double striping and no-passing signs would prevent much of the passing occurring before the test site passing zone. However, the number of "premature" passes, i.e., passes made before the test site passing zone, was sufficiently large that it may have affected the nature of the sample from which the statistical inferences are drawn. That is, the premature passers may well be more aggressive, or less frustration tolerant, than those drivers who were willing to follow the experimenter van throughout the entire impedance zone. In this case, it is probable that a larger proportion would have passed in the passing zone had they reached it. The fact that these drivers are not included in the sample on which these results are based may, in effect, have resulted in a sampling bias favoring the more conservative drivers. The importance of the foregoing discussion of premature passers will become apparent as the discussion of results progresses. The formal analysis of premature passes will be presented in a future research report.

Another limitation that deserves mention is the temporary exclusion of an analysis of the effects of impedance on the continuously distributed dependent variables. The rationale for the exclusion was the analysis of the discrete data showing that the impedance variables contributed a very small portion of the total variance. Given acceptance of the assumption that impedance-produced frustration provides the driver with a "set" and that final acceptance or rejection of the passing opportunity is based on information presented at the beginning of the passing zone (i.e., sight distance and lead vehicle speed information), then it would be expected that impedance effects would contribute even less variance to those variables descriptive of the passing maneuver. However, in the interest of completeness these analyses will be performed and will also be included in future reports.

Discrete Data

The observed increase in passing frequency as a function of sight distance is shown in Figure 3. Although the trend is as expected, the absolute frequencies may be low because of the exclusion of premature passers from the sample. Even though there are no baseline data in the literature as to passing frequency as a function of geometrically limited sight distance, it is interesting to relate our findings to those of Farber and Silver (2) who performed an observational study on a two-lane highway in which the

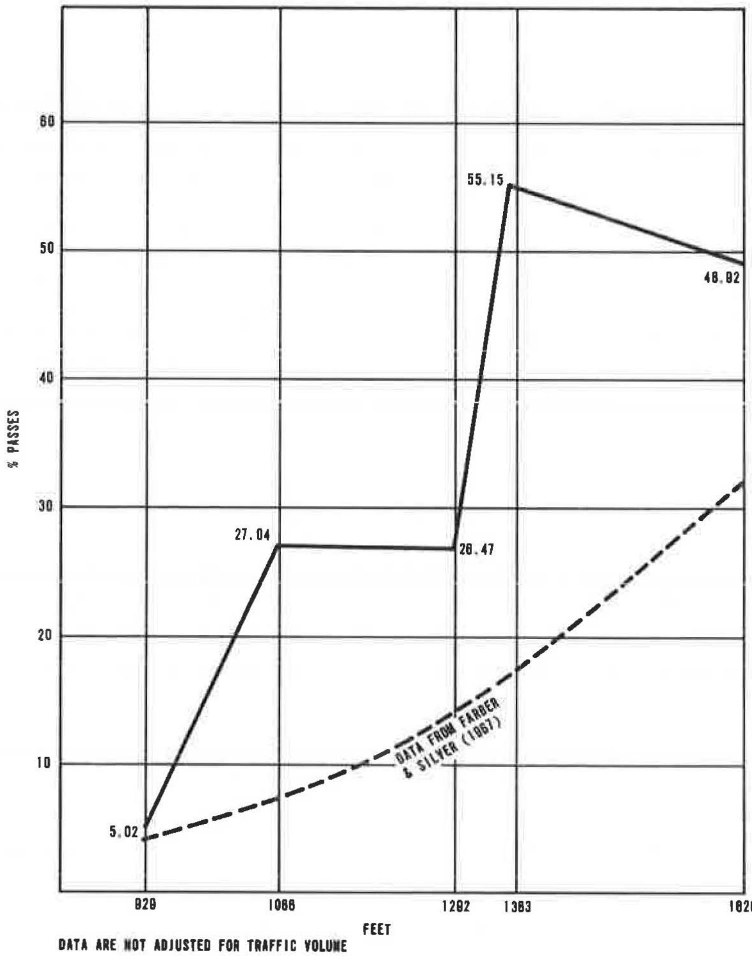

Figure 3. Sight distance.

passing opportunity was restricted by an oncoming vehicle. Although the restricted passing opportunities differ in definition (i.e., geometrics vs the presence of an oncoming vehicle), there is in general corroborative evidence showing that as the sight distance opportunity increases, so does the probability of a pass. Again the studies are not directly comparable, but there is in both cases a requirement for the potential passer to evaluate the risk involved in accepting a passing opportunity. Although the trends are similar, it is likely that the differences in magnitude between the two sets of data reflect a differential perception of risk; i.e., in the Farber and Silver situation the probability of an oncoming vehicle was unity in all cases (2), whereas in our study the potential passer had to estimate the probability of an oncoming vehicle. The risk factor and the conservative performance in the Farber and Silver study were undoubtedly compounded by the fact that the drivers dealt with a closing rate consisting of two vectors, one of which was, of course, not subject to their control, whereas in our study the closing rate in the absence of opposing traffic was determined by the speed of the potential passer.

The analysis of variance performed on the major independent variables indicated that when the effect of traffic volume is not statistically controlled, sight distance produces the only statistically significant (P = 0.01) treatment effect. In Table 1 the statistic omega-square shows sight distance accounting for 79 percent of the total variance (3). Comparisons of individual pairs of test sites (sight distance) by the Scheffé method indicate that the differences between sites 2 and 3 and between sites 4 and 5

TABLE 1

ANALYSIS OF VARIANCE

Source		Degree of Freedom	Sum Squares	Mean Squares	F-Ratio	Required F-Ratio P < 0.01	Required F-Ratio P < 0.05	Omega-Square
Sight distance	(A)	4	8.555293	2.138823	61.029[a]	4.77	3.01	0.79
Impedance distance	(B)	2	0.180139	0.090070	2.570	6.23	3.63	0.01
	(AB)	8	0.571020	0.071378	2.037	3.89	2.59	0.03
Impedance speed	(C)	2	0.245389	0.122695	3.501	6.23	3.63	0.02
	(AC)	8	0.364740	0.045593	1.301	3.89	2.59	0.01
	(BC)	4	0.109017	0.027254	0.777	4.77	3.01	0.00
Error		16	0.560742	0.035046				
TOTAL		44	10.586340					

[a]P = 0.01

are not significant, but that all other comparisons are significant. As shown in Figure 3, there are reversals in passing frequency between these two sets of sites.

The regression analysis performed to obtain adjusted means for the analysis of covariance indicated that traffic volume was significantly correlated ($P = 0.01$) with passing frequency. The results of the covariance analysis (Table 2) indicated that removal of the effects of traffic volume yields, in addition, a significant impedance speed treatment ($P < 0.05$) and a significant impedance distance/sight distance interaction ($P < 0.05$). Apparently traffic volume masked the effects of impedance speed and the impedance distance/sight distance interaction, and the increased degrees of freedom in the covariance analysis made the design more sensitive to departures from the null hypothesis.

Although traffic volume would be expected to affect the probability of a pass, the actual volumes of the high and low categories in our sample are not, from a traffic engineer's point of view, strikingly different; e.g., a range from 16 to 86 vph (vehicles per hour) is fairly typical. From a human performance point of view, however, such differences apparently have operational significance. Because a large portion of the drivers in this experiment may have been local drivers, they would be expected to have experienced extended exposure to the volume conditions existing on the roads where the

TABLE 2

ANALYSIS OF COVARIANCE

Source		Degree of Freedom	Sum Squares	Mean Squares	F-Ratio	Required F-Ratio P < 0.01	Required F-Ratio P < 0.05	Omega-Square
Sight distance	(A)	4	17.518461	4.379615	73.628[a]	3.65	2.52	0.72
Impedance distance	(B)	2	0.345440	0.172720	2.904	4.98	3.15	0.01
	(AB)	8	1.211504	0.151438	2.546[b]	2.82	2.10	0.03
Impedance speed	(C)	2	0.461492	0.230746	3.879[b]	4.98	3.15	0.01
	(AC)	8	0.697486	0.087186	1.465	2.82	2.10	0.01
	(BC)	4	0.184877	0.046219	0.777	3.65	2.52	0.00
Error		60	3.568967	0.059483				
TOTAL		88	23.988227					

[a]P = 0.01 [b]P = 0.05

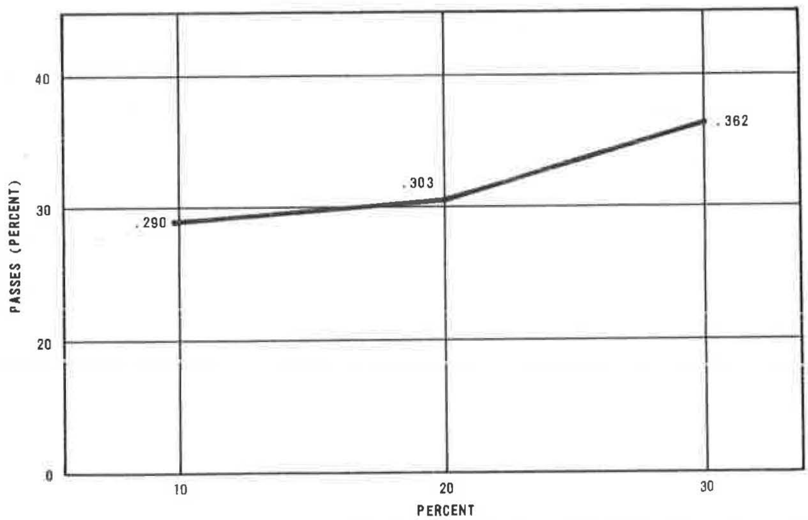

Figure 4. Impedance speed.

test sites were established, and their driving habits would have been adjusted as a result of this exposure history. In effect, drivers appear to develop a personal set of values as to what constitutes high and low volumes on a particular road. It is well known, from studies in experimental psychology, that when an individual is exposed to a range of stimulus conditions, he develops an internal scale that is consequently used to evaluate other stimuli lying between the extremes. For instance, if a driver is routinely exposed to volume levels between 20 and 80 vph, a volume of 65 vph will be considered high. On the other hand, an individual who drives on roads on which the volume varies from 60 to 300 vph would consider 65 vph as a very low volume. Given the range of volumes observed on our test sites, a difference between 34 and 59 vph could be highly significant in terms of its effect on driver passing behavior.

The significant effect of speed impedance is evidence for the development of frustration because the driver is being impeded. Figure 4 indicates that, as hypothesized, the greater the level of impedance, the higher the frustration and the greater the probability of passing. It should be noted, however, that the Scheffé comparisons indicated a nonsignificant effect between 10 and 20 percent impedance conditions, and although the main effect is statistically significant, it accounted for only a little over 1 percent of the variance. Because spot speed was used as an estimate of average speed (desired speed) in establishing the level of impedance, this result could possibly have been obtained due to the imperfect relationship between the two measures. That is, the percentage values attached to each level may be, for example, 0, 10, and 20 percent rather than those planned. As will be discussed later in more detail, the adequacy of spot speed as a predictor of average speed is currently being assessed.

Both the lack of a main effect for the distance impedance variable and the presence of the sight-distance/distance-impedance interaction may be due to the premature passes. Over a 5-mile impedance there are more opportunities for a premature pass than over a 1-mile impedance. This is reflected in the number of premature passes that occurred at each level. For example, the number of premature passes at each level of distance was as follows: 1-mile, 46; 3-mile, 152; and 5-mile, 171. Because the premature passers are likely to be drivers who have a lower tolerance to frustration and/or are more aggressive, it is apparent that the 5-mile sample contained proportionally fewer drivers with these characteristics. Thus, based on an impedance-produced frustration hypothesis, one would expect fewer passes from that sample. The data presented in Figure 5 seem to bear out this contention. The anslysis of the premature passes will

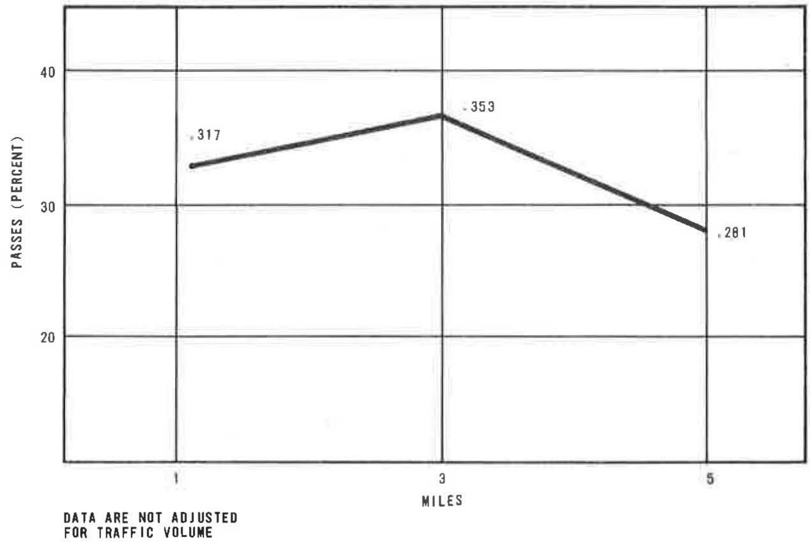

Figure 5. Impedance distance.

provide a more accurate answer to the question. It may also explain the interaction observed, in that the premature passes are not equally distributed across test sites.

Continuous Data

A one-way analysis of variance was performed to assess the effects of sight distance on each of the six dependent variables. Because the degrees of freedom associated with each measure were equivalent, the required F-ratio ($F_{5, 100} = 3.20$) for $\alpha = 0.01$ was also the same. Although the F-ratios were all significant beyond the 0.01 level, the magnitude of sight distance effect (omega-square) varied widely across the different dependent measures.

Given a statistically reliable treatment effect in each case, the Scheffé method of contrast was used to determine what additional inferences could be drawn regarding

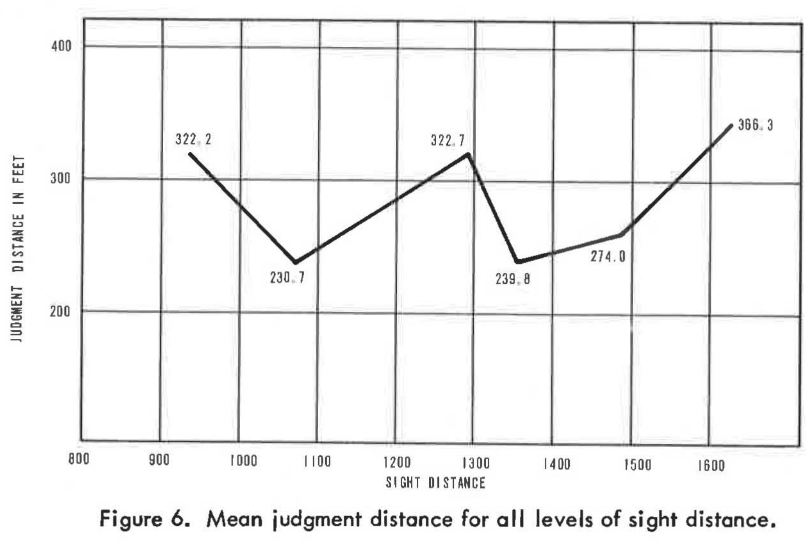

Figure 6. Mean judgment distance for all levels of sight distance.

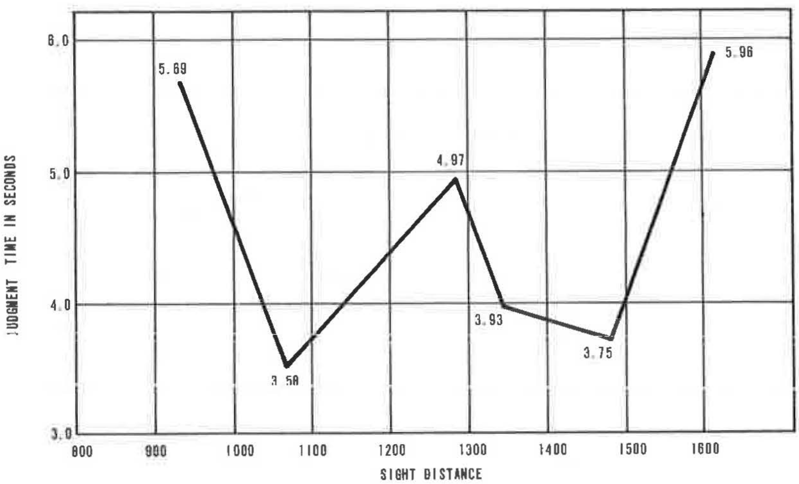

Figure 7. Mean judgment time for all levels of sight distance.

differences between individual sets of means. The results of the individual comparisons are discussed in conjunction with each of the dependent variables. The presentation and discussion of results is divided into separate sections, each covering the time and distance measures for the elements of the passing maneuver, i.e., judgment, passing, and reserve.

Judgment Data—Although the F-ratios for judgment time (F = 6.36) and judgment distance (F = 7.57) indicate that sight distance produces a statistically significant treatment effect, the shape of the function obtained (Figs. 6 and 7) makes the data rather difficult to interpret. Crawford (4) found that the relationship between decision time and the difficulty of the passing situation was defined by a U- or V-shaped function. In his study, an opposing vehicle was used to produce the levels of restriction (or passing difficulty). If perceived risk in the oncoming vehicle situation is similar to perceived risk where restriction is produced by highway geometry, one would expect a similarly shaped curve when plotting judgment time against sight distance. As seen in Figures 6 and 7, the judgment time and distance values that are most similar are those at the extreme ends of the sight distance range sampled; this suggests that the observed function may be similar to the relationship obtained by Crawford. However, two factors prevent this from being anything but suggestive at this point. First, the Scheffé comparisons for both the time and distance data indicate that the differences observed between sites 1 and 2 are not significant. A plausible explanation for the lack of significance is that the means for site 1 were computed from only four observations that would, of course, require an extremely large difference to obtain significance at the 0.01 or 0.05 level with so few degrees of freedom. It should be noted that two data collection vans were used in order to increase data collection rate. However, because the sample size required was much less for the continuous data, only one of the vans was instrumented. The small sample for site 1 was due to the small number of passes observed (i.e., 15) and the chance occurrence that the noninstrumented van was involved in the majority of these (i.e., 11).

Another consideration that restricts the postulate of a U-shaped function to speculation is the increase in time and distance values between sites 2 and 3. Again the Scheffé comparison indicated that the increase was not significant at the 0.05 level. However, because it was not possible to find a set of test sites that matched perfectly in all respects, a number of intrasite differences were considered in an attempt to explain why an increase might be observed. The factors considered were gradient in the approach to the passing zone or in the initial part of the zone, and proximity of the passing zone to a town. It was felt that the gradient factors may have affected vehicle

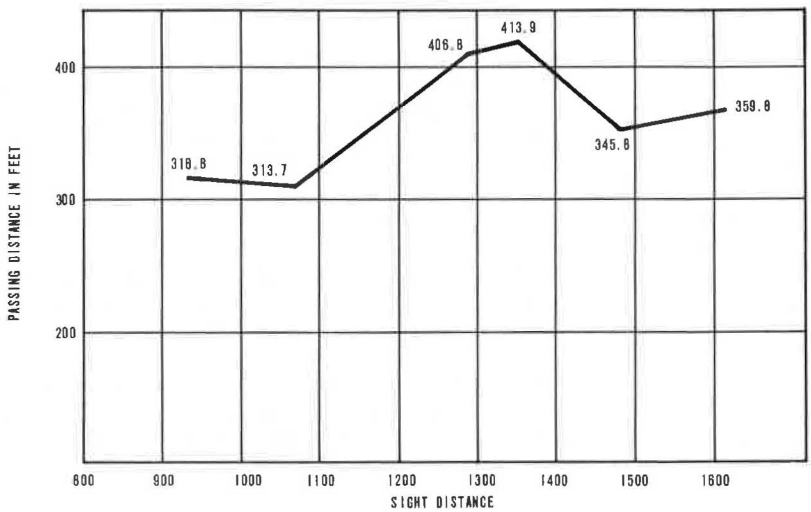

Figure 8. Mean passing distance for all levels of sight distance.

acceleration capability to the degree that it would be perceptible to the driver and would, therefore, make the decision to pass more difficult. Consideration of the second factor was based on a utility hypothesis. That is, if a town were near the end of the passing zone (i.e., within one mile), the estimated utility of a pass may be negligible because the time loss or frustration incurred by continuing to follow the lead vehicle would be small if that town were the driver's destination. The hypothesis that the driver attaches a utility structure to the decision to pass and evaluates the costs and their associated probabilities is certainly tenable.

Although an analysis of intrasite differences indicated that none of the factors mentioned above could alone be expected to account for the increase in judgment time, site 3 was the only one that contained all three of the characteristics noted; i.e., it was approximately 0.5 miles from the nearest town, it had an approach gradient of approximately 7 percent, and it had a slight upgrade over the entire passing zone.

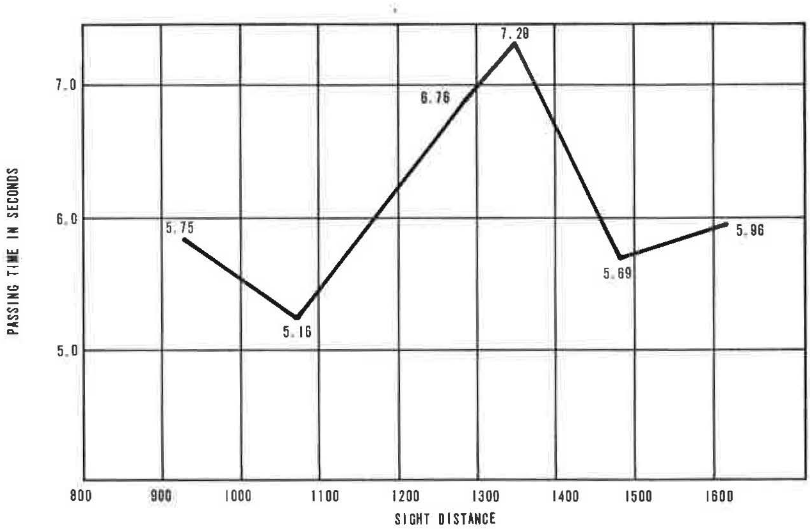

Figure 9. Mean passing time for all levels of sight distance.

The factors taken together may have caused an increase in judgment time and distance.

The foregoing discussion was not offered as an interpretation of the data obtained, but rather to indicate the possible influence of certain test site characteristics that were previously felt to be relatively unimportant in terms of the dependent variables used. Because minor differences between test sites may have caused the apparent lack of orderliness in the data, it is clear that in future research on the passing problem, the test site selection criteria must be made even more stringent than those used in the current study.

On the basis of individual Scheffé comparisons, it was determined that the significant differences were produced by test sites with no particular geometric problems; hence, it is fairly safe to assume that the primary determinant of the difference was sight distance.

Passing Data—The F-ratios for passing time (F = 3.95) and distance (F = 4.99) were both significant at the 0.01 level. However, as with the judgment data, there are difficulties in interpretation in that these variables do not appear to be monotonically related to sight distance (Figs. 8 and 9).

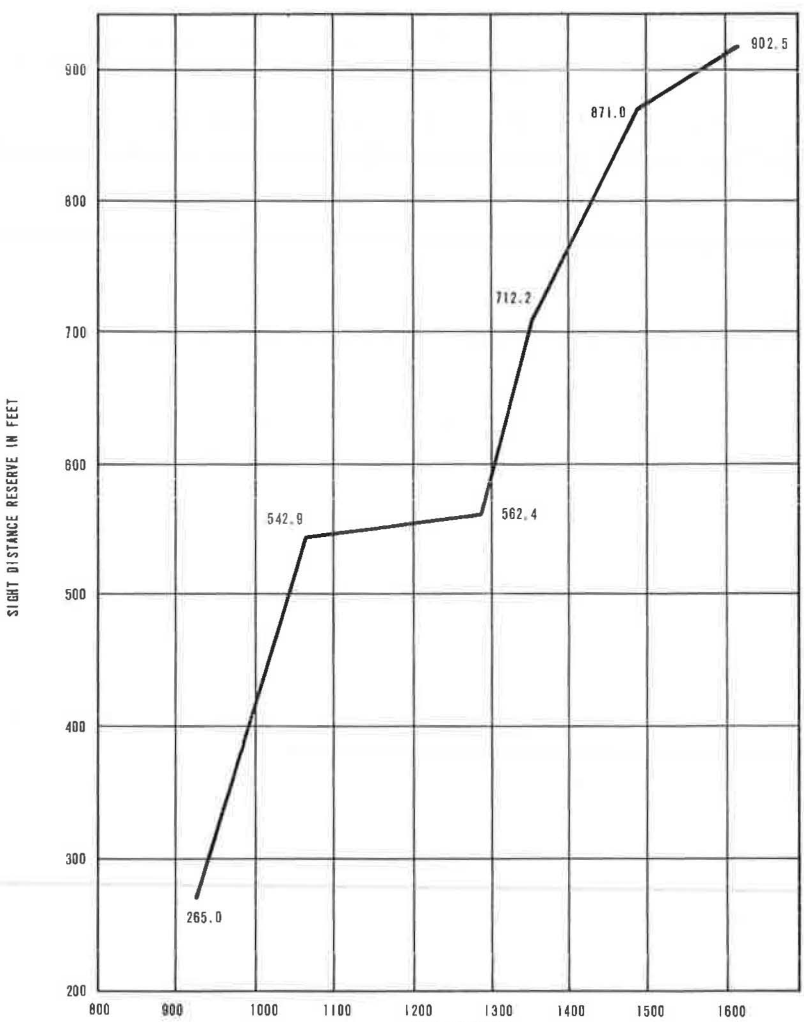

Figure 10. Mean sight distance reserve for all levels of sight distance.

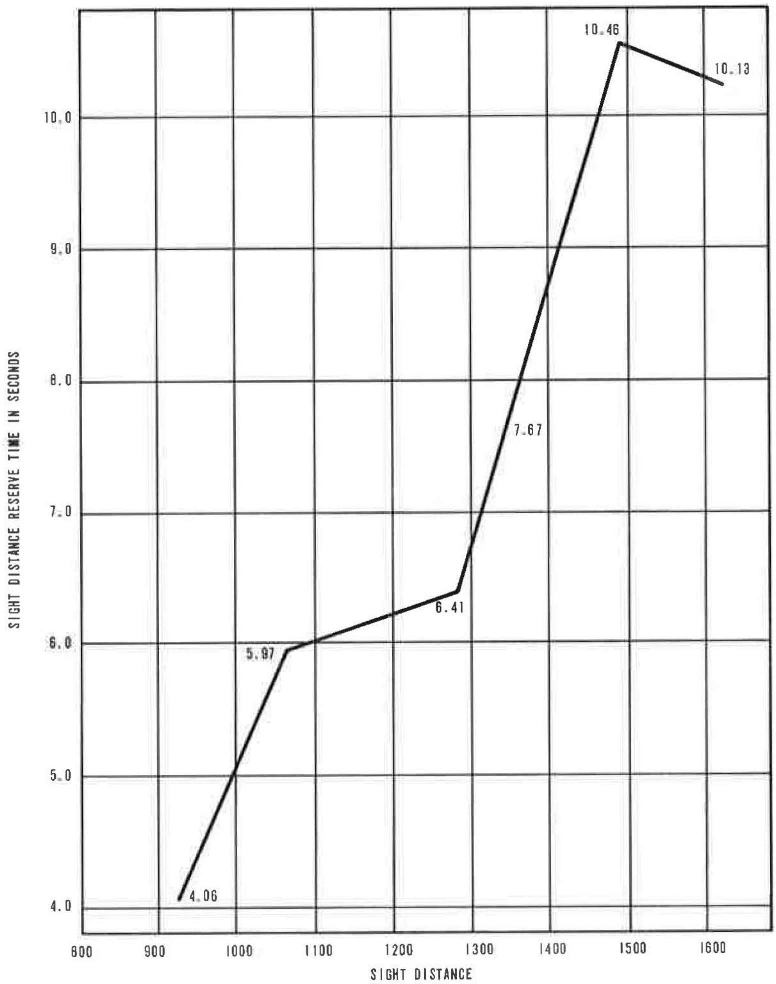

Figure 11. Mean sight distance reserve time for all levels of sight distance.

It is not unreasonable to postulate that within a range of restrictive sight distances, the driver passes as quickly as possible to minimize the probability of meeting an oncoming vehicle. The relatively small sight distance reserves observed at the shorter sight distances tend to support this position.

Sight-Distance Reserve Data—Measures of both time and distance were significant at the 0.01 level, with F-ratios of F = 11.02 and F = 51.98 respectively. It should be noted that although the distance reserve could be measured accurately from the films and test site reference maps, the reserve time data, in comparison to other dependent variables, may contain more measurement error. These measures required that the van operator estimate visually when the subject vehicle reached the end of sight distance. Therefore, the longer distance reserves probably resulted in some error in the reported reserve time estimates.

As would be expected from the small absolute variation in the judgment and passing data, sight distance reserve increases in an almost linear fashion as sight distance increases (Figs. 10 and 11). The omega-square estimates of variance indicate that sight-distance reserve in feet is the dependent variable most affected by sight distance variation. Sight distance accounted for 68 percent of the variance when the dependent measure was reserve distance.

SUMMARY

It is obvious from analysis of the discrete data that, of the variables studied, sight distance is the most influential determinant of the probability that a driver will accept a given passing opportunity. However, when the data were adjusted for the effects of traffic volume (by covariance techniques), impedance speed and the sight-distance/impedance-speed interaction were significant at the 0.05 level. In terms of the proportion of the total variance accounted for by these latter variables, their operational significance is questionable.

With respect to the continuous data, the relatively small absolute variation in the judgment and passing data, and the essentially monotonic relationship between sight-distance reserve and sight distance suggest that driver passing behavior is fairly consistent regardless of sight distance. One tenable explanation is that, within the range of restrictive sight distances studied, drivers generally pass as quickly as possible.

Another major variable that the authors feel will have a significant effect on acceptance of passing opportunities and the nature of the passing maneuver is that of lead vehicle speed. A current research effort is directed toward determining the main and interactive effects of this variable with those assessed in the current study. For this reason, a discussion of the engineering applications of the results will be reserved until these data are available.

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