claims, the remaining claims are, on the average, larger. This basic point is necessary to an understanding of these data.

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Acceleration Characteristics of Late-Model Automobiles

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In response to federal mandates and consumer demand for more fuel-efficient automobiles, the American automobile industry is currently producing markedly smaller and lighter automobiles than it was 10 years ago. As fuel prices rise, one can only anticipate that this trend will continue. Many of the changes made in the newer automobiles to promote fuel economy adversely affect acceleration capability. Therefore, this study was conducted to examine acceleration characteristics and determine the extent to which the acceleration capability of passenger vehicles has deteriorated over the past decade. Data were collected from automotive reports in popular magazines for two acceleration maneuvers. The first maneuver, the time required to accelerate from 45 to 65 mph, increased an average of 18 percent between 1971 and 1979. The second maneuver, the acceleration time required for a speed change from 0 to 60 mph, increased an average of 22 percent between 1971 and 1979. The results of the acceleration-data analysis were used to investigate design criteria involving vehicular acceleration rates. In all cases the current automobiles were found to accelerate more quickly than those used when the original acceleration tests were performed in the 1930s. Although there has been some deterioration in acceleration capability over the past decade, it has not occurred to the point where the design criteria exceed the current capability and thus pose a safety hazard.

Over the past decade the average American automobile has changed significantly in response to oil embargoes and the rising cost of gasoline. In 1970 a typical standard-sized car weighed 4000 lb and was probably powered by a V-8 engine with a displacement of at least 350 in^3. In 1980 the average American car weighed some 3300 lb and was probably equipped with a six-cylinder engine that had less than 250 in^3 of displacement. Hence, a marked trend has evolved in which new automobiles have become smaller and lighter from year to year.

The predominant reasons for the current automotive trend are the federal mandates and consumer demand for improved fuel economy. One step taken in achieving these aims has been to use more fuel-efficient components in the drive train of the automobile, such as smaller-displacement engines and higher rear-axle ratios. Although such components are superior for fuel economy, they are generally not better in terms of vehicle acceleration and performance. Other considerations, such as reducing weight and improving aerodynamics, can be said to enhance both fuel economy and performance. Therefore, there is considerable question whether the acceleration capabilities of cars manufactured today are on a par with those of a decade ago.

The tests conducted to determine the acceleration capabilities of passenger vehicles were performed in the 1930s and 1940s. Design criteria derived from these tests appear in A Policy on Geometric Design of Rural Highways (1), hereafter referred to as the AASHO Blue Book. Naturally, many improvements in automotive technology followed during the postwar period, such as the automatic transmission and the high-compression V-8 engine. The design criteria derived from the early tests remained applicable during the 1950s and 1960s, with an added safety factor. However, in light of recent changes that are detrimental to automotive performance, it seems appropriate to also investigate applicable design criteria and assess their relevance to present-day automobile performance.

PURPOSE AND OBJECTIVES

The primary purpose of this study was to examine vehicle acceleration characteristics and determine whether there has been a significant change in the acceleration capabilities of passenger vehicles over the past decade. Factors that affect the acceleration rates will also be discussed. The objectives of this study were to analyze design criteria involving vehicular acceleration rates recommended in the AASHO Blue Book and evaluate their relevance to current passenger-car performance trends.

METHOD OF STUDY

The test data for this study were obtained from popular magazines that regularly report automotive test data. Data extracted from these magazines include acceleration times from 0 to 60 mph and from 45 to 65 mph, rated engine horsepower, and curb weight.

The data obtained are used to analyze trends in automobile acceleration characteristics over the past decade. One measure of performance is the ability of a vehicle to perform a certain passing maneuver that was initially described in the literature (2-5) during the 1950s and 1960s. Another measure of performance analyzed is the trend in weight-to-horsepower ratio during the past decade and its significant relationship with the acceleration capability for the vehicle.

By using the current test data, comparisons are made with design criteria in the AASHO Blue Book that involve vehicular acceleration rates. The three design areas analyzed were (a) passing sight distance, (b) lengths of acceleration lanes, and (c) sight distance at intersections.

ANALYSIS OF ACCELERATION CHARACTERISTICS

Vehicle characteristics of significant importance in highway design include acceleration, fuel economy, braking deceleration, and physical dimensions. This study is concerned only with the acceleration characteristics of passenger vehicles, namely, the capacity to accelerate between a range of speeds that would likely be found in certain maneuvers involved in typical traffic operations.

Many variables affect the acceleration characteristics of an automobile. Malliaris, Hsia, and Gould (6) stated that the most appropriate parameter used to estimate acceleration capabilities was the horsepower-to-weight ratio. The test data used in this study were obtained from popular magazines, each of which has its own test control criteria and reporting standards. Therefore, considerable effort was made to select data that were believed to be reliable and representative of the particular model being tested. Special-production automobiles and cars equipped with high-performance engines were not included in the test data for this study.

Data Collection

The trend toward smaller vehicles with lighter curb weights and lower-powered engines raises the question of whether or not modern automobiles accelerate as well as cars manufactured a decade ago. To analyze this question, vehicle acceleration data from popular magazines (Consumer Reports, Motor Trend, and Car and Driver) were recorded for selected model years during the past decade. Using data reported in these automotive tests has several advantages. One of these is that all cars were tested when they were new. This procedure eliminates any decline in acceleration capability that may develop as an automobile ages. A second advantage is that a wide assortment of models are tested and reported in the magazines during any particular model year. Therefore, it is possible to select a group of models that is a representative sample of all automobiles manufactured during that year.

Acceleration times were recorded for automobile model years 1971, 1973, 1975, 1977, and 1979 for two maneuvers: (a) acceleration from 45 to 65 mph and (b) acceleration from 0 to 60 mph. The first maneuver is typical of a change of speed involved in a highway passing maneuver and will be used to compute a full acceleration rate that is representative of speeds in this range. The second maneuver, acceleration from 0 to 60 mph, is the most commonly reported acceleration maneuver and is a measure of full acceleration through the range of gears in the transmission of the test vehicle.

Weighting factors based on the relative sales volumes were developed for each model (7). Instead of calculating the arithmetic mean of the acceleration times achieved for a particular maneuver in various vehicles, the weighting factor is incorporated to more adequately represent the car population for a model year. The weighting factor is necessary because different vehicle models have widely variable annual sales volumes. Therefore, the weighting factor permits popular vehicle models to be weighted more heavily in computing the acceleration characteristics of the average new vehicle in the traffic stream during each model year.

The weighting factor was obtained by dividing the fractional part of the sales of a particular model by the total domestic automobile sales for a given year. In many cases, test data were not available for all models produced during a certain year. The procedure adopted to adjust for this situation was that sales for any omitted model were added to a model for which test data were available. Such substitution practices were almost always limited to automobiles of the same size and produced by the same manufacturer. Many such automobiles, often referred to as corporate twins, are manufactured on the same assembly line and are virtually identical except for minor exterior differences. One example of such a pair is the subcompacts from the Chrysler Corporation, the Plymouth Horizon and the Dodge Omni.

Horsepower ratings as claimed by the manufacturer were used for all calculations. Before 1972, the ratings reflect gross horsepower. Beginning with the model year 1972, the ratings are a measure of net horsepower. The test weight is the curb weight plus 300 lb to allow for an average on-board loading (weight of driver and fuel). These variables are used to calculate the weight-to-horsepower ratio, the magnitude of which is often used as a basis for estimating the acceleration capability of a vehicle. Generally, as the weight-to-horsepower ratio increases, the acceleration capability decreases.

Passing Distance

One test performed during several model years and reported in the literature (2-5) provides information on automobile acceleration capabilities by determining the time and distance required to safely complete a passing maneuver. A typical passing maneuver is shown schematically in Figure 1. Car A passes car B on a two-lane highway and must return to the right lane before encountering oncoming car C. Three car lengths (60 ft) between cars A and B and 200 ft between cars A and C are assumed as minimum safe clearance distances. All cars are assumed to be traveling at 40 mph, and car A accelerates at its full rate while overtaking car B.

An analysis of the ability of cars to perform this passing maneuver during the selected study years may reflect a trend in automobile acceleration characteristics. The value assumed for acceleration is the full rate from 45 to 65 mph that was obtained for each test vehicle. The weighted average times for all test vehicles of each model year under study are given below:

Year	Time (s)	Avg Acceleration Rate (fps^2)
1971	8.4	3.49
1973	9.4	3.12
1975	9.4	3.12
1977	10.1	2.90
1979	9.9	2.96

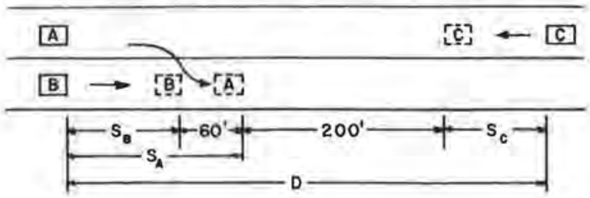
The weighted average time (t_a) for any one year is calculated by the following equation:

$$t_a = w_1t_1 + w_2t_2 + w_3t_3 + \ldots + w_nt_n \quad (1)$$

where

w = weighting factor,
t = time required for acceleration maneuver, and
n = number of test cars observed.

Figure 1. Schematic diagram of typical passing maneuver.



The passing distance (S) required for the maneuver depicted in Figure 1 is computed by using the general dynamics formula for accelerated motion as follows:

$$S = at^2 + v_i t \tag{2}$$

where

a = rate of acceleration,
t = time of accelerated motion, and
v_i = initial velocity.

With reference to the dimensions in Figure 1, the following expressions can be obtained:

$$S_B + 60 = S_A \tag{3}$$

$$D = S_A + 200 + S_C \tag{4}$$

where S_A, S_B, and S_C are the distances in feet traveled by cars A, B, and C, respectively. Substitution of Equation 2 into Equations 3 and 4 and simplification leads to the following formulas:

$$at^2 = 120 \tag{5}$$

$$D = 0.5at^2 + 117.3t + 200 \tag{6}$$

where a is the acceleration rate of car A in feet per second per second and t is the time for car A to overtake and gain 60 ft on car B in seconds.

With the acceleration rate (a) known, it is possible to solve directly for time (t) by using Equation 5. Substitution of these values into Equation 6 will yield the total passing distance (D). The results of the computations performed to calculate the passing times and distances are presented below. (These values could be considered a little conservative, since in the passing maneuver the passing vehicle is initially traveling at 40 rather than 45 mph.)

Year	Passing Time (s)	Distance (ft)
1971	5.87	949
1973	6.20	988
1975	6.20	988
1977	6.43	1015
1979	6.36	1007

The passing times and distances given above increased somewhat for each consecutive test year until that trend was reversed in 1979. The largest difference between any two years occurred between 1971 and 1973, with an increase from 949 to 988 ft.

Stonex (4) determined passing distances for automobiles during the 1950s. For the year 1952, a value of 944 ft was obtained, and for 1957, the value was 790 ft. These values are less than the values obtained in this study. This result may not be that surprising when it is recalled that the average of advertised horsepower reached a maximum in 1958 (8). Thus, the values obtained in this study for the 1970s may result from a decline in performance, the use of conservative acceleration rates, or a combination of these two factors.

Acceleration Time from 0 to 60 Mph

Another test widely reported in automotive literature is the time to accelerate from 0 to 60 mph. This parameter is the most commonly reported performance criterion because it is a measure of full acceleration through the range of gears in the transmission of the test vehicle. The time required for this maneuver was recorded for each test vehicle and then weighted based on volume of sales for each vehicle for the selected model year.

The average times as determined by this analysis are given below:

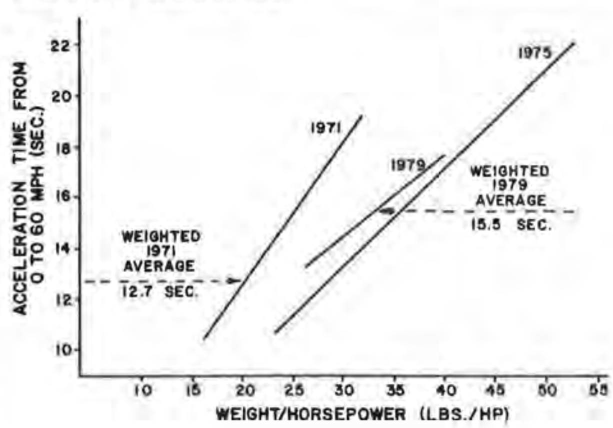
Year	Time (s)
1971	12.7
1973	14.1
1975	14.8
1977	15.5
1979	15.5

During the study period, it is readily apparent that the time required for this acceleration maneuver has increased more than 20 percent, whereas it remained unchanged between 1977 and 1979.

It has been reported that the horsepower-to-weight ratio of a particular vehicle is the simplest and most convenient means of relating a physical characteristic of the vehicle to its 0-to-60-mph acceleration time (6). The relationship between these two variables is inversely proportional; values for one variable increase as those for the other decrease, and vice versa. By inversion of the horsepower-to-weight ratio, a directly proportional relationship is made possible to compare the 0-to-60-mph acceleration time with the weight-to-horsepower ratio. This procedure was followed in analyzing the test data for selected model years because it is often more convenient to analyze a positive linear relationship than a negative one.

By using simple linear regression, an analysis of 0-to-60-mph acceleration time (ordinate) versus weight-to-horsepower ratio (abscissa) was performed for the years 1971, 1975, and 1979. The best-fitting lines with these data appear in Figure 2. Values of the correlation coefficient (r) obtained were 0.95, 0.92, and 0.71 for 1971, 1975, and 1979, respectively. Corresponding values of the coefficient of determination (r^2) were 0.89, 0.85, and 0.50, respectively. One noticeable feature is that the

Figure 2. Simple linear regression analysis of 0-to-60-mph acceleration time versus weight-to-horsepower ratio.



line that represents 1971 is considerably removed from the 1975 and 1979 lines. One possible explanation for this occurrence is the definition of advertised horsepower used in each case. Prior to 1972, advertised horsepower was described as gross horsepower, or that which was developed by an engine without any load on it. Since 1972, horsepower ratings have been a measure of net horsepower, or that which is developed by an engine under loadings imposed on it as installed in a vehicle.

From Figure 2, one important observation noted is that the range of values in the independent and dependent variables is not so great for 1979 as that for the two earlier years. Therefore, there is a trend toward more uniformity in weight-to-horsepower ratios and acceleration times. This finding is in agreement with a study (9) conducted by Glauz, Harwood, and St. John, which concluded that the size and performance of future vehicles will be more homogeneous than those of present and past vehicles. Another important observation to be made is that the weighted average of acceleration time increased from 12.7 s in 1971 to 15.5 s in 1979. Accordingly, it is reasonable to conclude that automotive performance deteriorated slightly during the 1970s.

EVALUATION OF DESIGN CRITERIA

Many of the design criteria in the AASHO Blue Book are related to the physical dimensions and operating characteristics of motor vehicles. The acceleration capability of a vehicle must be considered in three particular areas of highway design: passing sight distance, length of acceleration lanes, and sight distance at intersections.

Design calculations generally make use of normal rates of acceleration, or rates that would be typical of an average driver. Weinberg and Tharp (10) state that there is some level or narrow band of acceleration above which drivers will experience discomfort. Acceleration rates that exceed this level are of little or no importance in traffic operations because many drivers would be hesitant to accelerate so rapidly. Any design criteria to be based on acceleration rates should use the rate that the average driver perceives as a reasonable or typical value.

For the purpose of this study, however, it is convenient to compare full rates of acceleration determined from previous tests to the values determined from current tests. One reason is that full acceleration rates are less susceptible to variation from driver to driver but more dependent on the capabilities of the particular test vehicle. Should current full rates reflect inferior vehicle performance when compared with rates from the past, it is logical to conclude that a decline in automotive acceleration performance has occurred. Once the relationship between the full rates from the original and current tests has been established, it is then appropriate to evaluate the relevance of the design values of the normal acceleration rates from the original tests to the present time.

Passing Sight Distance

Passing sight distance on two-lane highways for design purposes is determined on the basis of the length necessary to complete a normal passing maneuver safely. The passing driver must be able to see enough of the highway ahead so that the vehicle can pass and return to the right traffic lane before it encounters oncoming traffic.

Four elements are considered in the determination of passing sight distance: initial maneuver distance, distance traveled during occupation of the left lane, clearance length, and distance traveled by the opposing vehicle.

The acceleration capability of the passing automobile is incorporated in the calculation of the first element of safe passing sight distance, the initial maneuver distance. This distance is traveled while a driver accelerates and encroaches on the left lane. From the AASHO Blue Book, the distance (d) traveled during the initial maneuver is

$$d = 1.47t(v - m + at/2) \quad (7)$$

where

t = time of initial maneuver (s),
a = average acceleration rate (mph/s),
v = average speed of passing vehicle (mph), and
m = difference in speed between passing vehicle and passed vehicle (mph).

Field studies of vehicle passing practices were conducted by the Public Roads Administration from 1938 to 1941 (11). Their results for vehicle acceleration rates during the initial maneuver period, as presented in the AASHO Blue Book, are given below:

Item	Speed (mph) 30-40	40-50	50-60	60-70
Avg passing speed (mph)	34.9	43.8	52.6	62.0
Avg acceleration (mph/s)	1.40	1.43	1.47	1.50
Time t (s)	3.6	4.0	4.3	4.5
Initial maneuver distance d (ft)	145	215	290	370
Total passing sight distance (ft)	1035	1460	1915	2380

As shown above, the distances traveled during the initial maneuver period are only about 15 percent of the total passing sight distances, which incorporate three additional elements. Nevertheless, acceleration capability is important in ensuring that a vehicle achieves the average passing speed during its occupation of the left lane. The distance traveled during occupation of the left lane is the single largest element of the total passing sight distance and is calculated by assuming a constant average passing speed. Therefore, no acceleration rate is included.

Comparison of the acceleration rates given above with full rates from 1937 (below) and those from the present should provide a measure of the adequacy of the design values. Full rates for 1937 are listed below:

Speed (mph)	Distance (ft)
0-30	222
30-40	226
40-50	364
50-60	575
60-70	908

Full rates for the present for a typical 1979 automobile and data collected for a poorly performing 1981 automobile whose acceleration capability was the poorest observed are given below:

	Typical 1979 Automobile			Poorly Performing 1981 Automobile	
Speed (mph)	Time (s)	Rate (mph/s)	Distance (ft)	Time (s)	Rate (mph/s)
0-30	4.4	6.82	97	5.8	5.17
30-40	2.5	4.00	128	3.3	3.03
40-50	3.7	2.70	244	4.4	2.27
50-60	4.9	2.04	395	5.8	1.72
60-70	7.4	1.35	705	8.2	1.22

Figure 3. Normal and full acceleration rates for range of speeds.

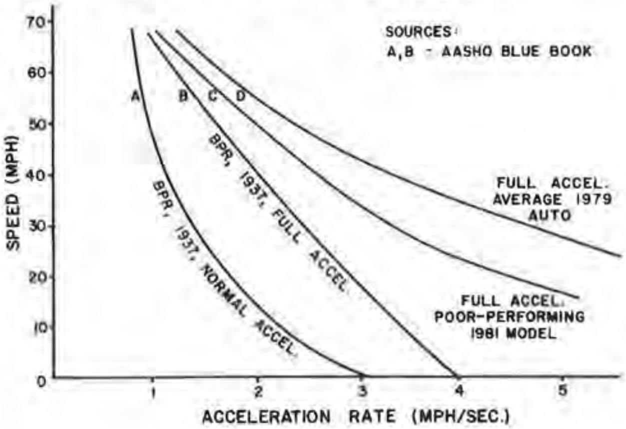
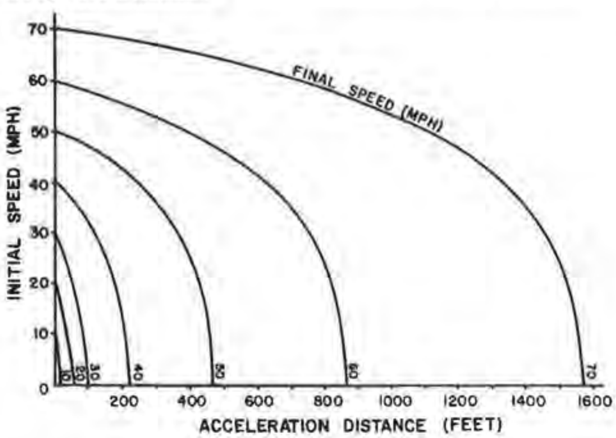


Figure 4. Distances traveled during full acceleration for range of speeds for average 1979 automobile.



For example, maximum acceleration rates of 1.5 mph/s could be exceeded up to a speed of approximately 52 mph in the 1937 full-acceleration design test, as shown in Figure 3. However, a typical 1979 automobile could exceed this acceleration rate until around 64 mph and a poorly performing 1981 car exceeded the rate until reaching 60 mph. Consequently, the ability of these automobiles to maintain a given acceleration rate at a higher speed when compared with those used in the original tests has introduced an added safety factor in the passing-sight-distance design values.

Length of Acceleration Lane

The length of an acceleration lane is based on several related factors. These factors include the speed at which drivers enter the acceleration lane, the speed at which drivers merge into the main traffic stream, and the distance required to accelerate between these two speeds. The distance is a function of the acceleration capability of the automobile and the extent to which its driver makes use of that capability.

The recommended lengths of acceleration lanes were determined by using test data that were compiled by the Bureau of Public Roads in 1937 (12). The data used for design purposes are normal acceleration rates since full acceleration rates are seldom used by drivers in any particular situation. Nevertheless, the adequacy of the design criteria may be tested by comparing the distances traveled under full acceleration rates then and now. If recent acceleration lengths are shorter than those determined by using 1937 data, the conclusion may be reached that the distances traveled under normal acceleration would be adequate and contain an additional safety factor. However, should lengths based on current data be greater than the lengths used for design purposes, it would be necessary to consider adjustment of the design data.

The distances traveled under full acceleration over a range of speeds as determined by the Bureau of Public Roads (12) were shown above.

Full acceleration distances for an average 1979 automobile, based on collected data, are presented above and in Figure 4.

If we compare data from the two previous tabulations, it is evident that the average 1979 automobile accelerates to a particular speed in a much shorter distance than the average 1937 vehicle. For the speed change from 0 to 70 mph, the total distance is in fact about 32 percent shorter for the 1979 automobile than for the 1937 vehicle. Since these data reflect a considerable relative improvement in performance for the more recent automobile, it is reasonable to conclude that the distances under normal acceleration used for design purposes are sufficiently large.

Trucks and buses require longer distances to accelerate than do passenger cars. Pignataro (13, pp. 15-16) stated that the rate of acceleration for trucks is only 2-3 ft/s^2 as compared with 6-9 ft/s^2 for passenger cars. Wright and Paquette (14, p. 64) give a typical full acceleration rate of 1.5 ft/s^2 for tractor-trailer trucks between 0 and 30 mph. Therefore, to base acceleration-lane lengths in most cases on the rates for trucks is inappropriate, because the lengths required would be inordinately great. Nevertheless, in places where there is a large percentage of truck traffic, it may be suitable to lengthen the acceleration lane as a traffic safety measure.

Sight Distance at Intersections

An important design criterion involving acceleration rates must be considered at intersections controlled by stop signs. The driver of a stopped vehicle must have sufficient sight distance along the through highway so that the driver is able to accelerate and clear the intersection before a vehicle on the through highway arrives at the intersection. The distance that must be traversed by the crossing vehicle is the sum of the distance from the front of the stopped vehicle to the near edge of the pavement plus the width of the through highway plus the overall length of the crossing vehicle.

The crossing time used in design calculations is the sum of the time required to accelerate across the intersection plus driver perception-reaction time. From the AASHO Blue Book, a perception-reaction time of 2 s is assumed. The acceleration time varies with the individual driver and vehicle. However, under no circumstances should the time required to traverse the intersection under full vehicle acceleration be more than the time necessary for a vehicle to cover the minimum sight distance along the through highway.

The tests used in the AASHO Blue Book involving vehicle acceleration rates were conducted by the Bureau of Public Roads in 1937. The time-distance relationships as determined in its tests for both normal and full acceleration (curves A and C) are presented in Figure 5. As shown here for a given distance, acceleration times are approximately 15 percent shorter under full acceleration than under

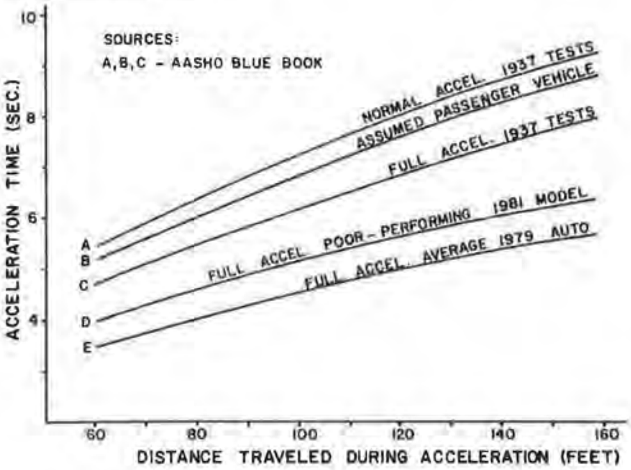


Figure 5. Relationship between accelerated time and distance traveled during normal and full acceleration.

normal acceleration. As noted in the AASHO Blue Book, most drivers accelerate at a rate faster than normal, although few drivers operate at the maximum capability of their automobiles. Therefore, the relation used in design calculations (curve B) incorporates a slightly higher acceleration rate than normal. Hence, the design curve lies between the normal and full acceleration curves.

Curves representing full acceleration for a poorly performing 1981 model (curve D) and a typical 1979 automobile (curve E) are also included in Figure 5. These curves were computed by using the test data from selected magazines and the general-dynamics formula for accelerated motion (Equation 2). It is evident that acceleration times under full throttle for both of these models are shorter than those from the 1937 tests. Furthermore, acceleration times are 33 percent shorter for the typical 1979 automobile over a given distance than for the assumed design passenger vehicle. Even for the poorly performing 1981 model, acceleration times are approximately 23 percent shorter than for the design vehicle.

Consequently, since the full acceleration capability is greater for a typical 1979 automobile and a poorly performing 1981 model than for the design vehicle, it follows that the assumed curve for the design passenger vehicle is appropriate. If either of the recent curves had shown inferior performance when compared with the 1937 full-acceleration curve, a further investigation and possible revision of the design curve would have been appropriate.

Accordingly, it is not recommended that the curve be upgraded to reflect an acceleration rate that is faster than the one currently used for design. Because of their relatively poor acceleration capabilities, single-unit and tractor-trailer trucks, which are part of almost any traffic stream, must also be considered. Ivey (15) stated that the percentage of trucks in the traffic stream is expected to increase from 17 percent in 1978 to 34 percent in 1990. Therefore, it would be inappropriate to institute an upgraded design curve that would not be consistent with the projected increase in trucks on the highways.

In summary, the existing AASHO design criteria involving acceleration rates were found to be adequate for current design use. Although there has been some deterioration in automotive acceleration performance during the past decade, it has not occurred to the extent that the design criteria exceed current vehicle capability and thus pose a safety hazard. In fact, the AASHO design criteria remain adequate because they are based on data prior to the 1950s, a period distinguished by significant advancements in automotive technology and vehicle performance.

SUMMARY AND CONCLUSIONS

The primary purpose of this study was to determine whether the acceleration capability of passenger vehicles had changed significantly over the past decade. The objectives of this study were to analyze AASHO Blue Book design criteria that involved acceleration rates and evaluate their relevance to current performance trends.

The average American automobile has undergone significant changes in recent years. Sales of compact and subcompact automobiles now exceed those of full-sized automobiles. Six-cylinder engines have now replaced V-8 engines as the most popular engine choice. Many other innovations have recently been incorporated into new automobiles, mostly in an effort to meet federal mandates and consumer demand for more fuel-efficient automobiles.

The test data used in this study were extracted from popular magazines that regularly report automotive performance data. A special effort was made to select data for vehicles that were believed to be equipped in a typical manner for each of the particular models being tested. Weighting factors were calculated based on model sales in an attempt to give emphasis to the most popular car models during a given year. The acceleration data were collected and weighted for two maneuvers: (a) acceleration from 45 to 65 mph and (b) acceleration from 0 to 60 mph.

From the analysis of the data collected in this study, the following conclusions can be made:

1. Acceleration times required for two speed-change maneuvers increased between 1971 and 1979. The time required for acceleration from 45 to 65 mph increased 18 percent, from 8.4 s in 1971 to 9.9 s in 1979. The time required to accelerate from 0 to 60 mph increased from 12.7 s in 1971 to 15.5 s in 1979. Consequently, there has been a definite reduction in the acceleration capability of the average passenger vehicle during the past decade.
2. The simple linear regression analysis showed that there was a significant relationship between acceleration time and the weight-to-horsepower ratio. For model year 1979, there was a narrower range in these two variables than for 1971 or 1975. Therefore, it is reasonable to conclude that a trend toward more uniformly performing automobiles has emerged. This trend could possibly be attributed to the virtual disappearance of fast, high-performance automobiles.
3. Full acceleration rates at any given speed were greater for an average 1979 automobile and a poorly performing 1981 automobile than for the average of several models tested in 1937. Therefore, the acceleration rates used in calculating minimum passing sight distances are still adequate. The passing sight distance criteria of AASHO remain applicable to the current conditions.
4. Distance traveled under full acceleration by an average 1979 automobile was 32 percent shorter for a speed change of 0-70 mph than for the 1937 design passenger vehicle. The greater acceleration capability of the modern automobile indicates that the distances traveled under normal acceleration in 1937 are amply large. Hence, the AASHO acceleration-lane design criteria are still applicable to current vehicle performance characteristics.

5. The time required to travel a fixed distance under full acceleration was shorter for an average 1979 automobile and a poorly performing 1981 model than for the assumed 1937 design passenger vehicle. Over a given distance, the times were 33 percent shorter for the 1979 automobile and 23 percent shorter for the 1981 model than for the design passenger vehicle. Thus, modern automobiles can accelerate across and clear an intersection in less time than the 1937 automobile. Consequently, the intersection sight distance criteria given in the AASHO Blue Book remain appropriate for current use. However, the acceleration capability of new cars should be monitored at regular intervals in the future should vehicles powered by alternative fuels or energy sources become as popular as it has been widely projected.

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Federal Government and Integrated Vehicle Development: U.S. Experience

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Three integrated vehicle-development programs sponsored by civilian mission agencies in the federal government are critically reviewed. A brief historical background and some critical reflections are provided for the Transbus, Experimental Safety Vehicle, and Near-Term Electric Vehicle programs. The purpose of the assessment was to determine the lessons learned that might be applied in future programs. Funding limitations, relationships with industry, overly stringent specifications, lack of planning, competition (parallel contracts), international participation, and government involvement in commercialization are factors that are examined. Although all are important, planning the project following an in-depth requirements analysis and carrying it through under a cooperative partnership with industry appear to be the most important for future programs.

Vehicle research and development (R&D) programs initiated by the federal government are sometimes viewed by the private sector with alarm and doubt. Three recent U.S. vehicle programs are critically examined in this paper in order to assess our success in the programs and to determine from the experience what lessons might be applied to future programs. Each vehicle program chosen reflects government response to a different perceived public requirement or need.

1. The Transbus program was initiated to generally improve bus aesthetics, passsenger amenities, and the special mobility needs of the elderly and handicapped by developing a bus with lower overall floor height and improved boarding and discharge capability. Because the government grants a significant percentage of the capital for new bus purchases (50-80 percent), it was planned to improve buses by using the federal grant power to aggregate the market demand and by requiring grant recipients to purchase buses according to Transbus specifications.