Human Factors in the Design of Passenger Cars: An Evaluation Study of Models Produced in 1957

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• THE PURPOSE of this paper is to describe the variations of certain biotechnical relationships in passenger cars thought to be important to the vehicle operator population. The general hypothesis is that safety and comfort in the operation of vehicles depend in part on the integration of man-machine-highway elements. It follows that the efficient operation of machines dependent on human perception and response in turn is dependent on the degree to which the machine has been designed to take human physiological, structural, and functional factors into consideration.

In general, all vehicle manufacturers design machines to be sold to the operator population at large. Therefore, it would be expected that vehicle designers should have developed operator work space criteria congruent with the range of structural differences characteristic of the consumer population. These criteria should not vary in any important dimension from one manufacturer to another nor among the several sections and divisions within the individual companies.

The test of this expectancy depends on several conditions. First it would be necessary to describe the range of physical anthropometric differences known to exist in the vehicle operator population, and from these data derive tentative criteria useful in the evaluation of operator workspace design. To a certain extent this has been done with respect to commercial as well as military vehicle operators, both of whom are sub-groups common to the driver population, and in combination compose a large portion of it. It would then be necessary to obtain detailed measurements of the internal spatial dimensions from a fair sample of stock cars, and to compare the obtained dimensions with human sizing criteria.

Essentially this is the procedure underlying the present study, as well as other research projects involving driver safety and comfort conducted in the Harvard School of Public Health, Department of Industrial Hygiene. Since 1949 a team of scientists specialized in the fields of experimental and clinical psychology, medicine, physiology, electrical and mechanical engineering, and physical anthropology have developed methods of study and tentative criteria in order to apply biotechnical principles to the analysis of vehicles. The objective of this team has been to make recommendations that will result in the improvement of vehicle design, and in increasing the degree of integration of the human operator with his vehicle.

The findings of the first study were published in a report (*1*) in which detailed evaluations were made of twelve trucks and six buses (1950 and 1951 models) and some preliminary design criteria were formulated. There are three other publications in the series. In "Human Body Size and Capabilities in the Design and Operation of Vehicular Equipment" (*2*) the basic approaches of human engineering and the pertinent biological data were presented in some detail. "The Application of Human Body Size Data to Vehicular Design" (*3*) condensed much of this material and presents specific design recommendations for the driver workspace, as did "Human Factors in the Design of Vehicle Cab Areas" (*4*). A fifth study, entitled "Human Factors in the Design of Trucks" (*5*), was a modified and detailed follow-up analysis of vehicles manufac-

tured in 1956. The study has now been extended to include passenger cars.

So far, little evidence has been found to support the supposition that operator workspace in the several vehicles has been derived from the systematic use of adequate scientific biotechnical data and criteria common to the automotive industry, or common to the several sections and divisions of the individual companies. The obtained data were often incongruent with human sizing criteria, and inconsistent both among and within the individual companies.

The numerical information from the present study of 21 passenger cars is shown in 34 tables. A brief discussion of the main findings follows.

DISCUSSION

*Comparative Windshield Areas Cleaned by Wipers (Table 1)**

Of the windshields for which comparative computations were made, the areas ranged between 1,054 and 1,622 sq in., leaving a difference of 568 sq in. among the windshields of 17 passenger cars; thus, the area of the largest windshield was approximately one-third larger than the area of the smallest windshield. The areas cleaned by the wipers ranged between 39 percent and 54.1 percent of the total area of any given windshield. There was a difference of at least 15.1 percent among vehicles. Table 1 indicates that the vehicles with the largest windshields did not necessarily have the largest areas cleaned nor were the smallest windshields cleaned least. There did not appear to be any systematic relationship between the size of the windshield and the area cleaned. The variability among vehicles is distinctly illustrated.

Depth of Front and Back Seats (Tables 2 and 3)

The criterion for seat depth is between 18 and 19 in. Two vehicles, L and O, failed to meet the criterion in the measurements for the front seat. But the rear seats of both these vehicles met the criterion. Had the designers been aware that a choice could have been made in favor of the operator, the front rather than the rear seat could have been designed with more generous proportions. And although the spatial arrangements for passengers are not as critical as those for operators it can be pointed out that six vehicles had rear seats that would be considered too shallow.

Breadth of Rear and Front Seats (Tables 4 and 5)

Seat breadth varies in two critical dimensions, buttock breadth, the principal dimension of concern to the operator who is the sole occupant of the front seat, and elbow breadth, of concern to both the front seat operator and passengers who occupy the front seat simultaneously. When several persons occupy the seat of a vehicle at the same time the elbow breadth measure becomes the referent datum because it is the greater of the two dimensions. For the moment it will be pointed out that the criterion of 27 in. of elbow breadth suggested for the operator was met in all vehicles, and that there would be no difficulty in seating a passenger comfortably in the front seat. But the indications are that three persons can occupy the front seat of a passenger car only by remaining in close physical contact, necessitating the maintenance of postures that become uncomfortable on even moderately extended trips.

The least and greatest dimensions were 52 and 62 in. of seat breadth, respectively, leaving a range of 10 in., the difference between the least and most adequate vehicles. The rear seat dimensions were nearly identical with the front seat dimensions but the range was 12 in. among vehicles, or 2 in. greater than the range for front seats.

Height of Front and Rear Seat Back (Tables 6 and 7)

The criterion for seat back height that should apply to rear as well as to front seats is 18 to 20 in., a most conservative

* All tables in Appendix.

minimum inasmuch as operators and passengers are so susceptible to backlash effects in collisions from the rear. The range of this dimension was from 18.00 to 22.50 in. for front seats, the difference being 4.50 in. For rear seats the range was from 15.75 in. to 23.25 in., the difference being 7.50 in. All the seat backs in all vehicles except one rear seat back met or exceeded the criterion.

Breadth of Front and Rear Seat Back (Tables 8 and 9)

For the single operator-passenger, the suggested minimum dimension for the seat back breadth is 21 in. It can be seen that all vehicles met this standard. If the elbow breadth standard of 27 in. is involved in order to estimate the adequacy of seat back breadth for operators, and one or two passengers, it can be seen that at least one passenger can easily be accommodated in the front and rear seats. Three passengers in each seat will surely be forced into uncomfortable positions, and the operator work space will also be reduced. More precise measures of these relationships are required before dimensions for multiple seating can be suggested with assurance.

Height of Front and Back Seat Above Floor (Tables 10 and 11)

In the last few years the lowering of the vehicle has resulted in lowering the eye-height of both operators and passengers, a transition more important to operators than passengers. The view to the front, for instance, has been reduced with respect to driving in hilly terrain. With distance constant, the probability of detecting obstacles in the roadway just beyond the crest of a hill has been reduced generally. But the front seats in vehicles have also been reduced in height, so that the total distance the operator has been lowered is in the region of 12 to 16 in. The expectancy is further reduction of operator height above the roadway. Thus, there are two considerations: (a) operator eye-height in relation to the amount of environment it is necessary to observe, and (b) operator position with respect to his relationship to the controls he must manipulate efficiently, and with respect to avoiding fatigue and discomfort.

A maximum front seat height of 15 in. above the floor has been suggested by McFarland, Damon, and Stoudt (*3*). The range recommended by Kephart and Dunlap (*4*) had a minimum of 14.69 in. and a maximum of 17.39 in. Thus, the maximum standard suggested by McFarland, Damon, and Stoudt was somewhat less than that suggested by Kephart and Dunlap, whose data were experimentally derived. The conflict of standards does not appear to be especially important.

However, though only one seat slightly exceeded the maximum standard suggested by McFarland, Damon, and Stoudt, none reached the maximum suggested by Kephart and Dunlap. All but one of the seats (a rear seat) failed to meet the minimum criterion suggested by Kephart and Dunlap.

Amount Front Seat is Depressed by 165-Lb Manikin (Table 12)

The amount the front seat was depressed by a 165-lb manikin varied between 1 and 2 in. This measure should be taken into consideration when actual eye-height is being calculated, and when estimates of the space available between the seat lap and the ceiling of the vehicle are made. Generally, it has been found that this amount of seat depression never increased the sitting height distance by a margin great enough to fulfill the seat-to-ceiling standard.

Range of Vertical Seat Adjustment (Table 13)

The minimum amount of vertical seat adjustment that has been suggested as necessary to accommodate operator population variation is 4 inches. Of 21 vehicles, 15 had front seats that could not be adjusted in the vertical plane at all. And of those that could be adjusted the minimum amount was 0.50 in. and the maximum amount was 2.25 in. All seat

measurements were taken with the seat in the rearmost position. The range, therefore, was 1.75 in. Thus, no passenger car met the minimum standard for vertical adjustment of the front seat. In general, in a previous study (*5*) seats in trucks were found to be somewhat more adequate, although it cannot be said that minimum standards were satisfactorily approximated.

Distance of Front and Back Seat Bottom to Ceiling (Tables 14 and 15)

The criterion of sitting height space for a vehicle operation population is 40.25 in. from seat bottom to ceiling. It can be seen that even with the amount the seat is depressed by a 165-lb manikin taken into consideration, no sitting height space of this magnitude was available in any passenger car with the exception of a single vehicle providing 40 in. of vertical sitting space. All seat measurements were taken with the seat in the lowest position. The least of the vehicles had a sitting height space that was somewhat less than 1 in. in excess of the sitting height of persons in the 95th percentile of the representative sample of commercial vehicle operators.

Range of Fore-and-Aft Adjustability of Front Seat (Table 16)

The suggested minimum amount the front seat should be capable of being adjusted is 6 in. Three vehicles met this standard, and one of the three exceeded it. Eighteen vehicles had seats that did not reach the criterion. The range of horizontal seat adjustability was 4.25 in., the least being 2.13 in., and the greatest being 6.38 in.

Distance Between Instrument Panel and Front Seat Back (Table 17)

Because the knees and lower legs of both operators and passengers can be badly injured in accidents where persons are thrown against the instrument panel, and because objects forward of persons in the front compartment can be annoying, a standard of 29 in. between the instrument panel and the seat back has been suggested. All vehicles had forward space available that exceeded this dimension. But the similar space (Table 18) between the back of the front seat and the rear seat back was restricted. Thus, of the 21 vehicles, 11 met the standard and 10 did not, although 2 could be considered borderline.

Horizontal Distance from Lower Edge of Steering Wheel to Seat Back (Table 19)

In order to accommodate the abdominal depth dimensions of a population of vehicle operators the minimum, middle, and maximum seat back distances from the lower edge of the steering wheel have been suggested to be 12, 15, and 18 in., respectively. The minimum range of horizontal seat adjustability is then 6 in. No vehicle met the 6-in. horizontal adjustment criterion. The 12-in. minimum distance between the lower edge of the steering wheel and the seat back was found in 3 vehicles, the middle position standard of 15 in. was found in 1 vehicle, and the rearmost position distance of 18 in. was not found in any vehicle. It would appear that passenger car seating space distinctly favored operators at the lower limits of the abdominal depth distribution.

Distance from Top of Brake Pedal to Lower Edge of Steering Wheel (Tables 20 and 21)

The distance from the top of the brake pedal to the lower edge of the steering wheel and the clutch pedal is the same as that suggested for the brake-steering wheel dimension. Of the 21 vehicles observed, only four were equipped with conventional clutch pedals, the remainder all had automatic transmissions. None of the four vehicles met the 26-in. brake or clutch-steering wheel distance dimension.

Least Distance Between Steering Wheel and Left Door (Table 22)

Ordinarily the least distance between steering wheel and left door would not

be considered, but from time to time it was noticed that winter clothing and gloved hands were too bulky to fit easily between the out rim of the steering wheel and the left door, especially when the wheel must be spun rapidly. There have been no actual standards suggested for this distance, but all else being equal the 3-in. maximum found in several vehicles is too small.

Distance from Steering Wheel Maximum Outer Diameter to Hand-Operated Parking Brake in "Off" Position (Table 23)

In the first place, the parking brake is operated with either hand or the left foot, therefore the position itself is not standardized. From the outer rim of the steering wheel at "9 o'clock" or "3 o'clock," respectively, the minimum or maximum distance found in any vehicle equipped with hand-operated parking or "emergency" brakes was 14 in. and 19.25 in. The range was 5.50 in.

Distance from Right Side of Steering Wheel to Radio Control Nearest Operator (Table 24)

This measurement is included partly to demonstrate the usual pattern of variability, but also to show that although the distance itself is not much more variable than that for the hand brake, the hand brake, an instrument of far greater importance, is more than two or three times the distance from the operator.

Vertical Distance from Lower Edge of Steering Wheel to Floor (Table 25)

To accommodate a population of vehicle operators this dimension should be a minimum of 24.50 in. The comparison between this criterion and the actual dimensions found in vehicles can be stated briefly: no vehicle met the criterion. The range of 3.50 in. had a lower limit of 15.50 in. and an upper limit of 19.00 in. The greatest discrepancy was then 9.50 in. and the least discrepancy was 5.50 in. Clearly, in this respect, the vehicles would best accommodate operators whose lower leg lengths were less than the sizes for persons in the 5th percentile, that is, less than 19.78 in. Therefore, more than 95 percent of a driver population had lower leg lengths greater than the space into which they are supposed to fit.

It can be seen that other dimensions (see Tables 26 to 31), such as the distance from the upper front edge of the front seat to the accelerator, brake pedal, clutch pedal, and other operating points, were highly variable. But so far no standards for the passenger car operating population have been derived.

Angle of Steering Wheel (Table 32)

The criterion derived by Kephart and Dunlap (*4*) constitutes a range between 42.51° and 48.17°, with a preferred angle of 45.34°. The range within which the angle of passenger car steering wheels were placed had a lower limit of 65° and an upper limit of 80°. The range was 15°. Thus, all vehicles had steering wheels placed at angles in excess of the Kephart-Dunlap standard. This placement tends to favor the driver who must place his seat toward the rearmost limit of adjustment, because the farther back the operator sits, the greater is the probability that he will prefer the steering wheel to be placed at a greater angle, that is, approach the vertical aspect. It can be seen that many of the other categories of workspace dimensions were more appropriate for the driver of smaller stature, whereas this distribution of steering wheel angle measures was more appropriate for drivers of larger stature.

Distance from Lower Edge of Steering Wheel to Seat Pan (Table 33)

No standards have been derived for this spatial relationship, but it can easily be seen that a large proportion of the population has leg dimensions that exceed 4.25 in. Thus, persons of ample proportions will not be able to sit under the steering wheel without their upper legs coming into contact with it. The lower limit of this dimension found in vehicles

was 4.25 in., and the upper limit was 7.25 in.

All possible problems arising from inconvenient placement of instruments, glare, insufficient coding and so on, are not included in this progress report. However, the general problems revealed by the intensive study of trucks were found to be present in passenger cars as well. Thus, in one or more cars the general problems may be listed as follows:

1. *Vision problems.* Inadequate shielding from incident light, glare, both from outside the vehicle and from the instrument panel, small, crowded, and nonstandardized dials and gages, were not uncommon.

2. *Instrument placement.* Awkward placement of switches and levers was often found. For instance, the common problems of the placement of the dimmer switch too close to the left wall, and the placement of the accelerator too close to or partly recessed into the "dog house," were present. These are annoying elements because the right or left foot catches and scrapes on one obstruction or the other. Instruments on the instrument panel were sometimes placed directly forward so that reaching around or under the steering wheel was necessary. The result was generally an unnecessary degree of fumbling and delay.

In some instances it was found that when either the brake or the clutch pedal was depressed the heel of one foot or the other would "drag" on the floor. Door handles were sometimes placed so that the fingers or fist would strike other objects when the handle was manipulated. In several cars the operator strikes his knee on the steering post when entering or leaving the vehicle.

3. *Structural relationships.* In several vehicles it was difficult to avoid hitting one's head when entering or leaving the vehicle. An especially annoying and sometimes painful event was striking the knees on the overhang from the wrap-around windshields. Some instrument panels had sharp protruding edges, and usually the amount of padding found in vehicles would be useless as a protective agent in case of an accident.

Table 34 summarizes the data obtained from the passenger cars. Considerable variability can be seen in nearly every dimension, not only among vehicles manufactured by the several companies, but also among vehicles manufactured by the same company. This was also true of trucks manufactured in 1956. For instance, vehicles A, B, and C were made by the same manufacturer. It would be expected that if the elements of human sizing characteristics of the vehicle-operating population were known, and if vehicles were designed from human sizing and human function principles, there would be little or no variation among vehicles A, B, and C with regard to, say, the placement of seats, range of vertical and horizontal adjustment, distance between the steering wheel and the back of the front seat, steering wheel angle, and other relevant dimensions.

RECOMMENDATIONS

Inasmuch as this study, as well as those of trucks and buses, indicates a wide variation in seating, workspace dimensions, placement of pedals, levers, gages and dials among 21 passenger cars manufactured in the same year, and clearly reveals a distinct departure from reasonable criteria for human sizing, it appears that no fundamental criteria for operator workspace and passenger space are available to the automotive industry.

Although the samples of vehicle operators on which the criteria used in this study depend duplicate a large portion of the operator population, they do not collectively represent a random sample of the entire vehicle driving population. For certain statistical reasons it would be expected that a representative sample would contain operators both larger and smaller than those found in the selected samples so far available. For instance, the present samples contain no measurements of female drivers. Furthermore, it is well known that military personnel are selected, and that rodeo truck drivers are

generally taller and broader than the general population.

A proper criterion developed from a representative vehicle operator sample would be expected to accommodate a somewhat more variable population. Therefore, the present criteria would lead to underestimates of the space needs of the general driver population.

This reservation leads to a primary recommendation: a concerted effort should be made to obtain anthropometric data relevant to the design of land vehicles. The data obtained from a true operator sample and the criteria derived from them should be available to all vehicle manufacturers. These data and criteria logically provide the key to many improvements in the design of operator work compartment, and passenger space.

The present numerical material lead to other specific recommendations, as follows:

1. Generally, front seats should be made wider, because it appears that three occupants in the front seat tend to limit the operator workspace.

2. Front seats should be raised to approximately 15 in. above the floor.

3. Almost no vehicles had seats that could be adjusted vertically; of those that did, none met the minimum criterion for vertical seat adjustment. It is recommended that this deficiency be corrected, and that at least 4 in. of vertical adjustment be built into all passenger cars.

4. Horizontal seat adjustment was generally inadequate. It is highly recommended that the range of seat adjustment be at least 6 in., with maximum and minimum distances from the lower edge of the steering wheel 18 and 12 in., respectively.

5. The distance between the seat pan and ceiling was estimated to be highly limited. The recommendation is that this space be increased in all passenger cars to at least 40.25 in.

6. The distance between the top of the brake and clutch pedals to the lower edge of the steering wheel appears to be limited. The recommendation is to increase the available dimension to a minimum of 26 in.

7. The space between the left edge of the steering wheel and the left wall should be somewhat greater than 3 in. in order to accommodate drivers wearing heavy gloves.

8. Placement of the emergency brake was found to be highly variable. It is suggested that an attempt be made to standardize the location of the emergency brake, and to place it as close as possible to the operator.

9. In some instances the distance between the lower edge of the steering wheel and the floor was less than the lower leg length of a person at or below the 5th percentile. It is thought that the steering wheel should be raised to accommodate the middle 90 percent of the vehicle operating population. A minimum clearance of 24.50 in. is recommended.

10. The angle of the steering wheel can easily be designed to be more comfortable to operate for a wide variety of drivers by making it adjustable. This convenience may be found in a number of foreign vehicles. It is suggested that the angle of the steering wheel should be between 42° and 49°.

11. In some instances the distance between the lower edge of the steering wheel and the seat pan appeared to be too limited. So far, no anthropological data have been obtained with respect to this measurement, but empirical observation indicated that the lower part of the thigh (that is, the thickness of that portion of the leg somewhat above the knee) is greater than 4.25 in., the least of the measurements given in Table 33. It appears that a minimum distance of at least 6 to 7 in. would be highly desirable.

12. The safety and comfort of rear seat passengers should also be considered. For instance, the distance between the rear surface of the front seat back and the back surface of the rear seat is important. This space should be great enough to prevent the knees of passengers from striking the rear of the front seat. Head room should be at least as great as that suggested for operators (that is, 40.25 in.) between the seat pan and ceiling. Rear shelves should be deeply

recessed in order to retain objects that could become missiles in an accident.

13. The accelerator pedal should be located in a position that does not allow the operator to scrape his foot against the "dog house," or catch his shoe under the brake pedal.

14. Instruments should be placed within the immediate grasp of the operator, preferably within arm's reach when the driver is seated in a normal driving position. When reaching for various objects the operator should not be required to change his eye-height to any great extent, although bending slightly forward and to the side at times may be impossible to avoid.

15. Shiny surfaces causing glare should be eliminated.

16. The interior of the vehicle should be designed without sharp, angular, or protruding edges, knobs, buttons, and latches.

17. Door openings upon occasion make entering and leaving vehicles an awkward task. It is recommended that the door opening be modified to improve access and egress.

18. The widest possible range of vision is virtually mandatory. Thus, tinted windshields are not recommended for night driving. If compromise is necessary, it is suggested that both windshield and rear window be fabricated with a broad clear glass section running across the entire width of each window.

19. It is suggested that windshield and windshield wiper design be modified and integrated in order to approximate 100 percent clearing during inclement weather. It is also recommended that some mode of cleaning side windows be devised. For instance, some foreign cars are equipped with directional blowers that assist in keeping the side windows in the driver's compartment clear of moisture.

20. Since it is possible to reduce distortion introduced by curved windshields, more careful control of the degree of curvature and quality of glass is recommended.

21. Visors should be designed to reduce glare from incident light leakage around the edges and through the gap between the two visors.

22. Brake and accelerator pedals should be placed at approximately the same height, but separated by a distance great enough to prevent the manipulation of both pedals simultaneously. Ideally, the degree of separation should approximate the width of the operator's shoe.

REFERENCES

1. McFARLAND, R. A., DUNLAP, J. W., HALL, W. A., AND MOSELEY, A. L., "Human Factors in the Design of Highway Transport Equipment: A Summary Report of Vehicle Evaluation." Harvard School of Public Health, Boston (1953).
2. McFARLAND, R. A., DAMON, A., STOUDT, H. W., MOSELEY, A. L., DUNLAP, J. W., AND HALL, W. A., "Human Body Size and Capabilities in the Design and Operation of Vehicular Equipment." Harvard School of Public Health, Boston (1953).
3. McFARLAND, R. A., DAMON, A., AND STOUDT, H. W., "The Application of Human Body Size Data to Vehicular Design." Spec. Publ. 142, Soc. Auto. Eng., New York (1955).
4. KEPHART, N. C., AND DUNLAP, J. W., "Human Factors in the Design of Vehicle Cab Areas." Occupational Research Center, Purdue Univ. (1955).
5. McFARLAND, R. A., DOMEY, R. G., *et al.*, "Human Factors in the Design of Trucks: An Evaluation Study of Models Produced in 1956." Harvard School of Public Health, Boston (1957).
6. McFARLAND, R. A., DAMON, A., AND STOUDT, H. W., "Anthropometry in the Design of Driver's Workspace." *Am. Jour. Physical Anthropology.*
7. McFARLAND, R. A., AND DOMEY, R. G., "Biotechnical Aspects of Driver Safety and Comfort." *Soc. Auto. Eng. Trans.* 66:630-648 (1958).

APPENDIX

TABLE 1

COMPARATIVE AREAS OF WINDSHIELDS CLEANED BY WIPERS

Total Area of Windshield		Length of Wiper Blade		Area of Windshield Cleaned by Both Blades		Percentage of Windshield Area Cleaned by Both Blades	
Vehicle	(sq. in.)	Vehicle	(in.)	Vehicle	(sq. in.)	Vehicle	(%)
I–P–57	1054	C–P–57	12	I–P–57	448	A–P–57	39.0
S–P–57	1088	D–S–57	12	T–P–57	467	T–P–57	42.3
C–P–57	1094.4	F–P–57	12	S–P–57	476	I–P–57	42.5
D–S–57	1094.4	I–P–57	12	A–P–57	485	S–P–57	43.8
K–P–57	1100	K–P–57	12	C–P–57	501	M–P–57	43.9
N–P–57	1100	L–P–57	12	D–S–57	501	P–P–57	45.3
P–P–57	1105	M–P–57	12	P–P–57	501	V–P–57	45.7
V–P–57	1105	N–P–57	12	V–P–57	505	C–P–57	45.9
T–P–57	1105.7	P–P–57	12	M–P–57	517	D–S–57	45.9
M–P–57	1178	T–P–57	12	O–P–57	545	K–P–57	47.1
A–P–57	1239.4	V–P–57	12	L–P–57	555	E–P–57	48.0
G–P–57	1436	A–P–57	13	F–P–57	567	H–P–57	48.3
E–P–57	1444	B–P–57	13	J–P–57	595	Q–P–57	48.7
H–P–57	1444.2	O–P–57	13	N–P–57	595	R–S–57	49.0
Q–P–57	1444.2	S–P–57	13	B–P–57	599	G–P–57	49.3
R–S–57	1444.2	E–P–57	16	E–P–57	693	J–P–57	54.1
J–P–57	1622	G–P–57	16	H–P–57	698	N–P–57	54.1
B–P–57	[a]	H–P–57	16	Q–P–57	704	B–P–57	[a]
F–P–57	[a]	J–P–57	16	R–S–57	707	F–P–57	[a]
L–P–57	[a]	Q–P–57	16	G–P–57	709	L–P–57	[a]
O–P–57	[a]	R–S–57	16	K–P–57	764	O–P–57	[a]
D = 568		D = 4		D = 316		D = 15.1	

[a] Not computed.

TABLE 2

FRONT SEAT DEPTH (IN.)

1. *Pertinent Body Dimension:* Buttock to back of calf.
2. *Purpose:* To accommodate both long- and short-legged men with respect to seat depth.
3. *Recommendation:* A seat depth of 18 to 19 in.

Human Sizing Data on Buttock-to-Back-of-Calf Distance

Buttock-calf distances were not taken on the commercial driver series by McFarland, *et al.*, but comparisons with a group of males measured by Hooten in "A Survey of Seating" indicates that this dimension will closely approximate 17.50 in. for the 5th percentile drivers. Since men rarely drive with the buttocks tightly in contact with the back of the seat, but rather shift them forward varying amounts, the above criterion is recommended.

Rank Order			
Vehicle	Seat Depth	Vehicle	Seat Depth
L–P–57	17.00	T–P–57	18.00
O–P–57	17.75	S–P–57	18.25
A–P–57	18.00	I–P–57	18.50
B–P–57	18.00	P–P–57	18.50
C–P–57	18.00	R–S–57	18.75
D–S–57	18.00	V–P–57	18.75
E–P–57	18.00	F–P–57	19.00
J–P–57	18.00	G–P–57	19.00
K–P–57	18.00	H–P–57	19.00
M–P–57	18.00	Q–P–57	19.00
N–P–57	18.00	D = 2.00	

TABLE 3

REAR SEAT DEPTH (IN.)

Rank Order			
Vehicle	Seat Depth	Vehicle	Seat Depth
D–S–57	16.00	P–P–57	18.00
E–P–57	17.00	U–P–57	18.00
G–P–57	17.00	C–P–57	18.25
B–S–57	17.00	K–P–57	18.25
T–P–57	17.00	J–P–57	18.50
A–P–57	17.50	F–P–57	19.00
B–P–57	18.00	H–P–57	19.00
I–P–57	18.00	S–P–57	19.00
L–P–57	18.00	O–P–57	19.50
M–P–57	18.00	Q–P–57	20.00
N–P–57	18.00	D = 4.00	

TABLE 4

BREADTH OF REAR SEAT (IN.)

Rank Order

Vehicle	Seat Breadth	Vehicle	Seat Breadth
E–P–57	51.00	G–P–57	59.50
R–S–57	52.00	L–P–57	60.00
A–P–57	52.75	M–P–57	60.00
D–S–57	54.50	T–P–57	60.00
I–P–57	56.00	S–P–57	60.75
P–P–57	56.00	C–P–57	61.00
Q–P–57	56.00	O–P–57	61.50
F–P–57	56.60	B–P–57	63.00
U–P–57	57.50	J–P–57	63.00
H–P–57	59.00	N–P–57	63.00
K–P–57	59.25	D = 12.00	

TABLE 5

BREADTH OF FRONT SEAT (IN.)

1. *Pertinent Body Dimension:* Elbow breadth.
2. *Purpose:* To provide sufficient room for the operator and two other front seat occupants.
3. *Recommendation:* A minimum of 27 in. between left door and middle occupant.

Human Sizing Data on Elbow Breadth

	Civilian Drivers	Army Drivers
(a) Number	282	1664
(b) Range	12.99″–24.41″	13.39″–23.62″
(c) Median	17.52″	17.48″
(d) 95th Percentile	20.71″	20.25″
(e) 5th Percentile	14.88″	15.35″

Rank Order

Vehicle	Seat Breadth	Vehicle	Seat Breadth
U–P–57	52.00	A–P–57	58.00
P–P–57	53.50	E–P–57	58.00
C–P–57	55.00	G–P–57	58.00
D–S–57	55.50	L–P–57	58.00
I–P–57	55.50	T–P–57	58.00
R–S–57	55.75	B–P–57	59.00
F–P–57	56.00	M–P–57	59.00
S–P–57	56.50	O–P–57	59.00
Q–P–57	57.00	J–P–57	62.00
H–P–57	57.50	N–P–57	62.00
K–P–57	57.50	D = 10.00	

TABLE 6

HEIGHT OF FRONT SEAT BACK (IN.)

1. *Pertinent Body Dimension:* Trunk height and height of maximum concavity of back.
2. *Purpose:* To support part of body weight and to give stable back support for applying pressure to foot controls.
3. *Recommendation:* 18 to 20 in. for height of seat back.

Human Sizing Data on Trunk Height

	Civilian Drivers	Army Drivers
(a) Number	311	1671
(b) Range	20.47″–26.38″	18.50″–26.38″
(c) Median	23.66″	22.96″
(d) 95th Percentile	25.24″	24.92″
(e) 5th Percentile	22.01″	20.92″

Rank Order

Vehicle	Height of Seat Back	Vehicle	Height of Seat Back
I–P–57	18.00	D–S–57	19.25
K–P–57	18.00	F–P–57	20.00
Q–P–57	18.00	G–P–57	20.00
R–S–57	18.00	L–P–57	20.00
C–P–57	18.50	M–P–57	20.00
P–P–57	18.50	V–P–57	20.00
S–P–57	18.50	J–P–57	20.50
B–P–57	19.00	N–P–57	20.50
E–P–57	19.00	O–P–57	21.00
H–P–57	19.00	T–P–57	22.50
A–P–57	19.25	D = 4.5	

TABLE 7

HEIGHT OF REAR SEAT BACK (IN.)

Rank Order

Vehicle	Height of Seat Back	Vehicle	Height of Seat Back
R–S–57	15.75	C–P–57	21.50
D–S–57	18.00	A–P–57	22.00
K–P–57	19.50	J–P–57	22.00
Q–P–57	19.75	N–P–57	22.00
F–P–57	20.00	P–P–57	22.00
G–P–57	20.00	S–P–57	22.00
L–P–57	20.00	B–P–57	22.50
E–P–57	21.00	U–P–57	22.50
H–P–57	21.00	M–P–57	23.00
I–P–57	21.00	O–P–57	23.25
T–P–57	21.00	D = 7.50	

TABLE 8

BREADTH OF FRONT SEAT BACK (IN.)

1. *Pertinent Body Dimension:* Shoulder breadth.

2. *Purpose:* To provide adequate lateral space for back and shoulder support.

3. *Recommendation:* A minimum breadth of 27 in. between left door and middle occupant.

Human Sizing Data on Shoulder Breadth

	Civilian Drivers	Army Drivers
(a) Number	310	2373
(b) Range	14.94"-21.62"	14.96"-22.05"
(c) Median	18.34"	17.92"
(d) 95th Percentile	19.90"	19.66"
(e) 5th Percentile	16.92"	16.56"

Rank Order

Vehicle	Breadth of Seat Back[1]	Vehicle	Breadth of Seat Back[1]
U–P–57	50.75	E–P–57	55.50
P–P–57	51.25	T–P–57	55.50
D–S–57	53.00	R–S–57	55.50
F–P–57	53.00	B–P–57	56.00
S–P–57	53.00	G–P–57	56.00
C–P–57	53.13	M–P–57	56.00
O–P–57	53.50	Q–P–57	56.00
I–P–57	54.00	V–P–57	56.50
H–P–57	55.00	K–P–57	60.00
L–P–57	55.00	N–P–57	60.50
A–P–57	55.25	D = 9.75	

[1] At shoulder level.

TABLE 9

BREADTH OF REAR SEAT BACK (IN.)

Rank Order

Vehicle	Breadth of Seat Back	Vehicle	Breadth of Seat Back
E–P–57	51.00	C–P–57	59.50
R–S–57	52.00	T–P–57	60.00
A–P–57	52.75	M–P–57	60.00
D–S–57	54.50	L–P–57	60.00
I–P–57	56.00	S–P–57	60.75
Q–P–57	56.00	C–P–57	61.00
P–P–57	56.00	O–P–57	61.50
F–P–57	56.50	B–P–57	63.00
U–P–57	57.50	N–P–57	63.00
H–P–57	59.00	J–P–57	63.00
K–P–57	59.25	D = 12.00	

TABLE 10

HEIGHT OF SEAT FRONT ABOVE FLOOR (IN.)

1. *Pertinent Body Dimension:* Lower leg length.

2. *Purpose:* To avoid excessive height, resulting in front edge of seat cutting into under part of thigh.

3. *Recommendation:* A maximum height of 15 in. from front edge of seat to floor (in any position).

Human Sizing Data on Lower Leg Length

This dimension was not taken on the commercial driver series by McFarland, *et al.*, but comparisons with other groups indicate it to be slightly over 17.50" (including shoes), thus suggesting a seat height of 16.50". However, when the legs are extended forward, knee height is reduced, thus requiring a lower seat level.

Rank Order

Vehicle	Height Above Floor[1]	Vehicle	Height Above Floor[1]
Q–P–57	9.75	N–P–57	11.00
E–P–57	10.00	O–P–57	11.00
R–S–57	10.50	A–P–57	11.50
T–P–57	10.00	C–P–57	12.75
H–P–57	10.75	D–S–57	12.75
B–P–57	11.00	L–P–57	13.00
G–P–57	11.00	P–P–57	13.00
I–P–57	11.00	S–P–57	13.50
K–P–57	11.00	V–P–57	13.50
J–P–57	11.00	F–P–57	14.00
M–P–57	11.00	D = 4.25	

[1] Height of seat front above floor, with seat in lowest position.

TABLE 11

HEIGHT OF REAR SEAT ABOVE FLOOR (IN.)

Rank Order

Vehicle	Height Above Floor	Vehicle	Height Above Floor
H–P–57	10.50	J–P–57	12.75
O–P–57	11.25	B–P–57	13.00
K–P–57	11.50	L–P–57	13.00
Q–P–57	11.50	M–P–57	13.00
G–P–57	11.75	D–S–57	13.25
A–P–57	12.00	I–P–57	13.50
C–P–57	12.00	R–S–57	13.75
E–P–57	12.00	F–P–57	14.00
S–P–57	12.00	T–P–57	14.00
P–P–57	12.25	N–P–57	15.50
U–P–57	12.50	D = 5.00	

TABLE 12

AMOUNT FRONT SEAT IS DEPRESSED BY 165-POUND MANIKIN-OPERATOR (IN.)

Rank Order

Vehicle	Seat Depression	Vehicle	Seat Depression
C–P–57	1.00	G–P–57	1.50
D–S–57	1.00	K–P–57	1.50
E–P–57	1.00	M–P–57	1.50
F–P–57	1.00	N–P–57	1.50
H–P–57	1.00	O–P–57	1.50
I–P–57	1.00	S–P–57	1.50
J–P–57	1.00	T–P–57	1.50
P–P–57	1.00	Q–P–57	1.75
U–P–57	1.00	A–P–57	2.00
B–P–57	1.25	L–P–57	2.00
R–S–57	1.25	D = 1.00	

TABLE 13

RANGE OF VERTICAL SEAT ADJUSTABILITY (IN.)

1. *Pertinent Body Dimension:* Normal sitting eye-height.
2. *Purpose:* Optimum location of operator's eye-level.
3. *Recommendation:* A minimum range of vertical seat adjustability of 4 inches in increments of 1 inch or less.

Human Sizing Data on Normal Sitting Eye-Height

(a) Number	309
(b) Range	26.38″–32.68″
(c) Median	29.61″
(d) 5th Percentile	27.72″
(e) 95 Percentile	31.61″

Rank Order

Vehicle	Vert. Adjust.	Vehicle	Vert. Adjust.
A–P–57	0	Q–P–57	0
D–S–57	0	S–P–57	0
E–P–57	0	T–P–57	0
G–P–57	0	V–P–57	0
H–P–57	0	R–S–57	0.50
I–P–57	0	C–P–57	0.75
J–P–57	0	F–P–57	1.0
M–P–57	0	K–P–57	2.0
N–P–57	0	L–P–57	2.0
O–P–57	0	B–P–57	2.25
P–P–57	0	D = 1.75	

TABLE 14

DISTANCE[1] FROM SEAT BOTTOM TO CEILING OF CAB (IN.)

1. *Pertinent Body Dimension:* Normal sitting height.
2. *Purpose:* Accommodation of seated driver to working space with respect to head clearance.
3. *Recommendation:* Headroom clearance 40¼ in. from seat top to ceiling.

Human Sizing Data on Normal Sitting Height

	Civilian Drivers
(a) Number	313
(b) Range	30.71″–37.80″
(c) Median	34.65″
(d) 95th Percentile	36.58″
(e) 5th Percentile	32.60″

Rank Order

Vehicle	*A*. Dist. Without Occupant	*B*. Seat Depression[2]	*A* + *B*
A–P	35.50	2.00	37.50
Q–P	35.75	1.75	37.50
G–P	36.00	1.50	37.50
I–P	36.00	1.00	37.00
K–P	36.00	1.50	37.50
M–P	36.25	1.50	37.75
F–P	36.50	1.00	37.00
J–P	36.50	1.00	37.50
O–P	36.50	1.50	38.00
T–P	36.50	1.50	38.00
U–P	36.50	1.00	37.00
H–P	36.75	1.00	37.75
E–P	37.00	1.00	38.00
S–P	37.00	1.50	38.50
N–P	37.25	1.50	38.75
P–P	37.50	1.00	38.50
C–P	37.75	1.00	38.75
R–S	37.75	1.25	39.00
L–P	38.00	2.00	40.00
D–S	38.25	1.00	39.25
B–P	38.50	1.25	39.75
	D = 3	D = 1.75	D = 2.25

[1] Taken on vertical 4 in. forward from front of seat back.
[2] Taken with 165-lb manikin seated in operator's position.

TABLE 15

DISTANCE FROM TOP OF REAR SEAT PAN TO CEILING (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
O–P–57	33.00	I–P–57	35.00
Q–P–57	33.00	U–P–57	35.00
G–P–57	33.75	K–P–57	35.75
H–P–57	33.75	J–P–57	36.00
A–P–57	34.00	N–P–57	36.00
M–P–57	34.00	R–S–57	36.00
P–P–57	34.00	C–P–57	37.00
F–P–57	34.25	L–P–57	37.25
E–P–57	34.50	D–S–57	37.50
T–P–57	34.50	S–P–57	37.50
B–P–57	35.00	D = 4.50	

TABLE 16

RANGE OF FORE-AND-AFT SEAT ADJUSTABILITY

1. *Pertinent Body Dimensions:* Leg length (buttock-knee length and knee height).

2. *Purpose:* Operation of foot controls.

3. *Recommendation:* A range of fore-and-aft adjustability of 6 in. in increments of 1 in. or less.

Human Sizing Data on Knee Height

	Civilian Drivers	Army Drivers
(a) Number	301	2376
(b) Range	19.29"–25.98"	17.72"–25.59"
(c) Median	21.69"	21.56"
(d) 95th Percentile	23.50"	23.42"
(e) 5th Percentile	20.08"	19.78"

Human Sizing Data on Buttock-Knee Dimensions

	Civilian Drivers	Army Drivers
(a) Number	310	2353
(b) Range	21.26"–27.56"	19.29"–27.56"
(c) Median	23.78"	23.33"
(d) 95th Percentile	25.79"	25.16"
(e) 5th Percentile	22.05"	21.49"

Rank Order

Vehicle	Range of Fore-and-Aft Adjust. (in.)	Vehicle	No. Seat Positions
P–P–57	2.13	B–P–57	El.–0
I–P–57	3.50	F–P–57	El.–0
F–P–57	4.00	K–P–57	El.–0
J–P–57	4.00	L–P–57	El.–0
T–P–57	4.00	P–P–57	El.–0
C–P–57	4.25	H–P–57	6
M–P–57	4.50	J–P–57	6
Q–P–57	4.50	O–P–57	6
A–P–57	4.75	C–P–57	7
S–P–57	4.75	D–S–57	7
D–S–57	5.00	Q–P–57	7
E–P–57	5.00	S–P–57	7
G–P–57	5.00	T–P–57	7
T–P–57	5.00	V–P–57	7
L–P–57	5.00	A–P–57	8
N–P–57	5.00	E–P–57	8
H–P–57	5.50	G–P–57	8
O–P–57	5.50	N–P–57	8
B–P–57	6.00	R–S–57	8
K–P–57	6.00	M–P–57	9
R–S–57	6.38	I–P–57	10
	D = 4.25		

TABLE 17

DISTANCE BETWEEN INSTRUMENT PANEL AND SEAT BACK (IN.)

1. *Pertinent Body Dimension:* Buttock-knee length.

2. *Purpose:* To establish sufficient clearance between driver's knees and forward obstructions.

3. *Recommendation:* A minimum clearance of 29 in. between any forward items in knee area of driver and seat back in rearmost adjustment.

Human Sizing Data on Buttock-Knee Dimensions

	Civilian Drivers	Army Drivers
(a) Number	310	2353
(b) Range	21.26"–27.56"	19.29"–27.56"
(c) Median	23.78"	23.33"
(d) 95th Percentile	25.79"	25.16"
(e) 5th Percentile	22.05"	21.49"

Rank Order

Vehicle	Buttock-Knee Dimension	Vehicle	Buttock-Knee Dimension
Q–P–57	30.00	S–P–57	33.50
D–S–57	31.00	V–P–57	33.50
F–P–57	31.00	G–P–57	34.00
O–P–57	31.00	R–S–57	34.00
E–P–57	31.50	T–P–57	34.00
M–P–57	31.75	C–P–57	35.00
I–P–57	32.50	H–P–57	35.25
P–P–57	32.50	K–P–57	35.75
B–P–57	33.00	J–P–57	36.00
L–P–57	33.00	N–P–57	36.00
A–P–57	33.13		

TABLE 18

DISTANCE FROM BACK OF REAR SEAT TO REAR FACE OF FRONT SEAT (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
U–P–57	25.00	T–P–57	29.00
F–P–57	25.75	I–P–57	29.25
A–P–57	26.00	L–P–57	30.00
H–P–57	26.75	P–P–57	30.00
D–S–57	27.00	J–P–57	31.00
O–P–57	27.50	M–P–57	31.00
G–P–57	28.00	N–P–57	33.00
Q–P–57	28.00	B–P–57	34.00
R–S–57	28.00	K–P–57	35.00
E–P–57	28.50	C–P–57	36.00
S–P–57	28.50	D = 11.00	

TABLE 19

HORIZONTAL DISTANCE FROM LOWER EDGE OF STEERING WHEEL TO SEAT BACK (IN.)

1. *Pertinent Body Dimension:* Abdomen depth.

2. *Purpose:* To avoid contact of steering wheel with abdomen, thus reducing possibility of serious abdominal injury in sudden stops or collision, and facilitating entrance and exit.

3. *Recommendation:* A minimum of 15 in. in a horizontal line between rearmost edge of steering wheel (at midpoint of range of fore-and-aft adjustability).

Human Sizing Data on Abdomen Depth[1]

	Civilian Drivers	Army Drivers
(a) Number	311	1665
(b) Range	6.68″–13.76″	6.69″–13.78″
(c) Median	9.50″	9.03″
(d) 95th Percentile	12.06″	10.51″
(e) 5th Percentile	7.84″	7.97″

Rank Order

Fore		Middle		Aft	
Veh.	Dim.	Veh.	Dim.	Veh.	Dim.
O–P–57	7.75	O–P–57	10.50	P–P–57	13.00
D–S–57	9.00	D–S–57	11.50	O–P–57	13.25
R–S–57	9.62	P–P–57	11.93	D–S–57	14.00
I–P–57	9.75	I–P–57	12.25	V–P–57	14.00
L–P–57	10.00	V–P–57	12.25	I–P–57	14.75
A–P–57	10.25	L–P–57	12.50	A–P–57	15.00
S–P–57	10.25	A–P–57	12.62	L–P–57	15.00
Q–P–57	10.50	S–P–57	12.62	Q–P–57	15.00
V–P–57	10.50	Q–P–57	12.75	S–P–57	15.00
P–P–57	10.87	R–S–57	12.81	T–P–57	15.00
B–P–57	11.00	T–P–57	13.00	C–P–57	15.75
C–P–57	11.00	M–P–57	13.50	F–P–57	16.00
T–P–57	11.00	C–P–57	13.62	J–P–57	16.00
K–P–57	11.50	B–P–57	14.00	R–S–57	16.00
N–P–57	11.50	F–P–57	14.00	M–P–57	16.25
H–P–57	11.75	J–P–57	14.00	N–P–57	16.50
F–P–57	12.00	N–P–57	14.00	B–P–57	17.00
G–P–57	12.00	G–P–57	14.50	G–P–57	17.00
J–P–57	12.00	H–P–57	14.50	H–P–57	17.25
E–P–56	12.25	K–P–57	14.50	K–P–57	17.50
M–P–57	12.25	E–P–57	15.25	E–P–57	17.75
D = 4.50		D = 4.75		D = 4.75	

[1] Subject standing; for seated subjects this dimension should be increased by 1 in.

TABLE 20

DISTANCE FROM TOP OF BRAKE PEDAL TO LOWER EDGE OF STEERING WHEEL (IN.)

1. *Pertinent Body Dimension:* Knee height.

2. *Purpose:* To give driver sufficient leg room to apply pedals without bumping or trapping knee under steering wheel.

3. *Recommendation:* A minimum of 26 in. between the top surface of foot pedals to bottom of steering wheel.

Human Sizing Data on Knee Height

	Civilian Drivers	Army Drivers
(a) Number	301	2376
(b) Range	19.29″–25.98″	17.72″–25.59″
(c) Median	21.69″	21.56″
(d) 95th Percentile	23.50″	23.72″
(e) 5th Percentile	20.08″	19.78″

Rank Order

Vehicle	Dimension[1]	Vehicle	Dimension[1]
H–P–57	24.00	I–P–57	25.50
M–P–57	24.00	Q–P–57	25.50
T–P–57	24.00	E–P–57	25.75
V–P–57	24.00	G–P–57	26.00
C–P–57	24.50	L–P–57	26.50
D–S–57	24.50	B–P–57	27.00
R–S–57	24.75	F–P–57	27.00
A–P–57	25.00	O–P–57	27.00
J–P–57	25.00	P–P–57	27.00
K–P–57	25.00	S–P–57	27.50
N–P–57	25.00	D = 3.50	

[1] Distance from middle of brake pedal to bottom of steering wheel rim.

TABLE 21

DISTANCE FROM TOP OF CLUTCH PEDAL TO LOWER EDGE OF STEERING WHEEL (IN.)

1. *Pertinent Body Dimension:* Knee height.
2. *Purpose:* To give driver sufficient leg room to apply pedals without bumping or trapping knee under steering wheel.
3. *Recommendation:* A minimum of 26 in. between top surface of foot pedals to bottom of steering wheel.

Human Sizing Data on Knee Height

	Civilian Drivers	Army Drivers
(a) Number	301	2376
(b) Range	19.29″–25.98″	17.72″–25.59″
(c) Median	21.69″	21.56″
(d) 95th Percentile	23.50″	23.72″
(e) 5th Percentile	20.08″	19.78″

Rank Order

Vehicle[1]	Dimension[2]
D–S–57	24.50
T–P–57	24.50
R–S–57	25.00
I–P–57	25.50
D = 1	

[1] The remaining 17 passenger cars had automatic shifting equipment and therefore no clutch pedals.
[2] Distance from middle of clutch pedal to bottom of steering wheel rim.

TABLE 22

LEAST DISTANCE FROM STEERING WHEEL TO LEFT DOOR (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
C–P–57	3.00	J–P–57	5.00
D–S–57	3.00	N–P–57	5.00
S–P–57	3.00	P–P–57	5.00
A–P–57	4.00	E–P–57	5.25
B–P–57	4.00	M–P–57	5.25
F–P–57	4.00	Q–P–57	5.50
I–P–57	4.00	K–P–57	6.00
O–P–57	4.00	H–P–57	6.50
L–P–57	4.50	T–P–57	6.50
V–P–57	4.50	R–S–57	6.88
G–P–57	5.00	D = 3.88	

TABLE 23

DISTANCE FROM STEERING WHEEL TO HAND-OPERATED EMERGENCY BRAKE IN OFF POSITION (IN.)

Rank Order

Vehicle[1]	Dimension	
	Left-Hand	Right-Hand
E–P–57	14.00	
K–P–57	14.00	
Q–P–57	14.50	
R–S–57	14.88	
G–P–57	15.00	
J–P–57	15.50	
F–P–57	16.00	
N–P–57		16.00
H–P–57	16.50	
V–P–57		16.50
P–P–57		16.75
L–P–57	17.00	
C–P–57	19.25	
I–P–57	19.25	
D–S–57	19.25	
T–P–57	19.25	
	D = 5.50	

[1] In 16 passenger cars; remaining 5 vehicles equipped with foot-operated emergency brakes.

TABLE 24

DISTANCE FROM RIGHT SIDE OF STEERING WHEEL TO RADIO CONTROL NEAREST THE OPERATOR (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
F–P–57	9.50	J–P–57	13.50
L–P–57	11.00	O–P–57	13.50
P–P–57	11.00	H–P–57	13.75
S–P–57	11.25	K–P–57	14.00
G–P–57	12.00	N–P–57	14.00
E–P–57	12.50	D–P–57	14.50
Q–P–57	12.50	M–P–57	14.50
U–P–57	12.75	C–P–57	14.75
A–P–57	13.00	R–S–57	None
B–P–57	13.00	T–P–57	None
I–P–57	13.25	D = 5.25	

TABLE 25

VERTICAL DISTANCE FROM LOWER EDGE OF STEERING WHEEL TO FLOOR (IN.)

1. *Pertinent Body Dimension:* Knee height.

2. *Purpose:* To help insure lateral freedom of movement from bottom of steering wheel to floor.

3. *Recommendation:* A minimum clearance of 24.50 in.

Human Sizing Data on Knee Height

	Civilian Drivers	Army Drivers
(a) Number	301	2376
(b) Range	19.29″–25.98″	17.72″–25.59″
(c) Median	21.69″	21.56″
(d) 5th Percentile	20.08″	19.78″
(e) 95th Percentile	23.50″	23.72″

Rank Order

Vehicle	Dimension	Vehicle	Dimension
E–P–57	15.50	P–P–57	17.50
R–S–57	15.50	S–P–57	17.75
H–P–57	15.75	A–P–57	18.00
Q–P–57	15.75	C–P–57	18.00
G–P–57	16.00	D–S–57	18.00
I–P–57	16.00	J–P–57	18.00
M–P–57	16.00	N–P–57	18.00
T–P–57	16.75	F–P–57	18.25
K–P–57	17.00	V–P–57	18.75
O–P–57	17.00	B–P–57	19.00
L–P–57	17.50	D = 3.50	

TABLE 26

DISTANCE FROM LOWER EDGE OF STEERING WHEEL TO ACCELERATOR (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
H–P–57	27.50	D–S–57	29.00
E–P–57	28.00	I–P–57	29.00
F–P–57	28.00	M–P–57	29.00
K–P–57	28.00	O–P–57	29.00
Q–P–57	28.00	N–P–57	29.25
V–P–57	28.25	S–P–57	29.25
L–P–57	28.50	B–P–57	29.50
P–P–57	28.50	G–P–57	29.50
R–S–57	28.50	J–P–57	29.50
A–P–57	29.00	T–P–57	30.00
C–P–57	29.00	D = 2.50	

TABLE 27

DISTANCE FROM LOWER EDGE OF STEERING WHEEL TO DIMMER SWITCH (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
B–P–57	31.00	I–P–57	32.00
C–P–57	31.50	Q–P–57	32.50
D–S–57	31.50	A–P–57	32.50
J–P–57	31.50	E–P–57	33.00
N–P–57	31.50	G–P–57	33.00
P–P–57	31.50	L–P–57	33.00
S–P–57	31.50	O–P–57	33.00
F–P–57	31.75	R–S–57	33.00
K–P–57	32.00	H–P–57	33.00
M–P–57	32.00	D = 2.50	
T–P–57	32.00		

TABLE 28

DISTANCE FROM UPPER FRONT EDGE OF FRONT SEAT TO TOP OF BRAKE PEDAL (IN.)

Rank Order

Vehicle	Dimension	Vehicle	Dimension
U–P–57	16.00	R–S–57	19.00
J–P–57	16.75	C–P–57	19.75
T–P–57	17.00	O–P–57	20.00
D–S–57	17.50	B–P–57	20.25
P–P–57	18.00	S–P–57	20.25
A–P–57	18.50	E–P–57	20.50
I–P–57	18.50	F–P–57	21.00
N–P–57	18.50	G–P–57	21.00
Q–P–57	18.50	L–P–57	21.00
H–P–57	19.00	K–P–57	21.50
M–P–57	19.00	D = 5.50	

TABLE 29

DISTANCE FROM TOP FRONT EDGE OF FRONT SEAT TO CLUTCH PEDAL (IN.)

Rank Order

Vehicle	Dimension
D–S–57	17.50
T–P–57	17.50
I–P–57	18.50
R–S–57	18.50
D = 1.00	

TABLE 30

DISTANCE FROM TOP FRONT EDGE OF FRONT SEAT TO ACCELERATOR PEDAL

Rank Order			
Vehicle	Dimension	Vehicle	Dimension
P–P–57	20.00	D–S–57	22.00
U–P–57	20.00	E–P–57	22.50
A–P–57	21.00	N–P–57	22.50
F–P–57	21.00	B–P–57	22.75
I–P–57	21.00	G–P–57	23.00
O–P–57	21.00	L–P–57	23.00
R–S–57	21.00	M–P–57	23.00
J–P–57	21.50	T–P–57	23.00
Q–P–57	21.50	C–P–57	23.50
H–P–57	21.75	K–P–57	23.50
S–P–57	21.75	D = 3.50	

TABLE 31

DISTANCE FROM TOP FRONT EDGE OF FRONT SEAT TO DIMMER SWITCH (IN.)

Rank Order			
Vehicle	Dimension	Vehicle	Dimension
L–P–57	18.00	T–P–57	25.00
A–P–57	22.00	C–P–57	26.00
J–P–57	22.00	F–P–57	26.00
P–P–57	22.00	H–P–57	26.00
U–P–57	22.50	I–P–57	26.00
S–P–57	23.75	M–P–57	26.00
B–P–57	24.25	Q–P–57	26.50
D–P–57	24.50	G–P–57	27.00
N–S–57	24.50	K–P–57	28.50
O–P–57	25.00	E–P–57	28.75
R–S–57	25.00	D = 10.75	

TABLE 32

ANGLE OF STEERING WHEEL (DEGREES)

Recommendation (4): 45.34°.
Acceptable Variation: 42.51° to 48.17°.

To determine the recommendation and its acceptable variation, three groups of subjects were selected to represent the 5th, 50th, and 95th percentiles of the army truck driver population in height.

Number	30
5th Percentile	64.21″
50th Percentile	68.23″
95th Percentile	72.50″

Rank Order			
Vehicle	Steering Wheel Angle	Vehicle	Steering Wheel Angle
F–P–57	80	J–P–57	74
T–P–57	77	L–P–57	74
M–P–57	76	O–P–57	74
C–P–57	75	V–P–57	74
D–S–57	75	Q–P–57	73
E–P–57	75	S–P–57	72
G–P–57	75	A–P–57	69
P–P–57	75	B–P–57	66
Q–P–57	75	J–P–57	65
H–P–57	74	N–P–57	65
I–P–57	74	D = 15°	

TABLE 33

DISTANCE FROM LOWER EDGE OF STEERING WHEEL TO SEAT PAN (IN.)

Rank order			
Vehicle	Dimension	Vehicle	Dimension
J–P–57	4.25	M–P–57	6.00
F–P–57	5.00	P–P–57	6.00
K–P–57	5.00	Q–P–57	6.00
L–P–57	5.00	R–S–57	6.00
O–P–57	5.25	S–P–57	6.00
E–P–57	5.50	U–P–57	6.00
G–P–57	5.50	D–S–57	6.25
H–P–57	5.50	T–P–57	6.50
C–P–57	5.75	N–P–57	7.00
A–P–57	6.00	B–P–57	7.25
I–P–57	6.00	D = 3.00	

TABLE 34

SUMMARY OF DIMENSIONS OF DRIVER WORKSPACE IN AUTOMOBILES[1]

Measurement	Max.	Min.	Range
1. Windshield area (sq. in.)	1,622	1,054	568
2. Length of wiper blade (in.)	16	12	4
3. Windshield area cleaned (sq. in.)	764	448	316
4. Area cleaned by wipers (%)	54.1	39.0	15.1
5. Depth of front seat (in.)	19	17	2
6. Depth of rear seat (in.)	20	16	4
7. Breadth of front seat (in.)	62	52	10
8. Breadth of rear seat (in.)	63	51	12
9. Height of front seat back (in.)	22.50	18	4.5
10. Height of rear seat back (in.)	23.25	15.75	7.50
11. Breadth of front seat back (in.)	60.50	50.75	9.75
12. Breadth of rear seat back (in.)	63.00	51.00	12.00
13. Height of front seat (in.)	14.00	9.75	4.25
14. Height of rear seat (in.)	15.50	10.50	5.00
15. Amount of seat depression (in.)	2.00	1.00	1.00
16. Vertical seat adjustment (in.)	2.25	0.00	2.25
17. Front-seat-to-ceiling plus seat depression (in.)	39.75	37.50	2.25
18. Front seat to ceiling (in.)	37.50	33.00	4.50
19. Horizontal seat adjustment (in.)	6.38	2.13	4.25
20. Distance between dash and front seat back (in.)	36.00	30.00	6.00
21. Distance between back of front seat and rear seat back (in.)	36.00	25.00	11.00
22. Horizontal distance between lower edge of steering wheel and front seat back (in.):			
Forward position	12.25	7.75	4.50
Middle position	15.25	10.50	4.75
Rear position	17.75	13.00	4.75
23. Steering wheel to brake pedal (in.)	27.50	24.00	3.5
24. Steering wheel to clutch pedal (in.)	25.50	24.50	1.00
25. Steering wheel to left door (in.)	6.88	3.00	3.88
26. Steering wheel to emergency brake (in.)	19.25	14.00	5.50
27. Steering wheel to radio control (in.)	14.75	9.50	6.25
28. Steering wheel to floor (in.)	19.00	15.50	3.50
29. Steering wheel to accelerator (in.)	30.0	27.50	2.50
30. Steering wheel to dimmer switch (in.)	33.00	31.00	2.50
31. Upper edge of front seat to brake pedal (in.)	21.50	16.00	5.50
32. Upper edge of front seat to clutch pedal (in.)	17.50	18.50	1.00
33. Upper edge of front seat to accelerator pedal (in.)	23.50	20.00	3.50
34. Upper edge of front seat to dimmer switch (in.)	28.75	18.00	10.75
35. Acute angle of steering wheel (°)	80	65	15
36. Lower edge of steering wheel to seat pan (in.)	2.25	4.25	3.00

[1] From detailed data in Tables 1–33.