The Visual Impact of Trucks in Traffic

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Nine years ago, the foreword to a *Research Report* entitled "How Many People See a Truck?," prepared under the direction of this author, carried the following statement:

Motor trucks operate over all of our roads and streets under all types of traffic conditions. Any time that they are "on the road," people notice trucks and combinations – they see them in towns, cities, and on the open highway. However, the question "How many people see a truck in a year – an hour – a mile?" has remained unanswered.

The research performed at that time went a long way toward answering this question, and it has been widely used over the years. However, times and traffic change — and earlier findings have now been up-dated and greatly expanded. Under a grant from the 3M Company through the ATA Foundation, the Department of Economics of the American Trucking Associations, Inc. undertook this comprehensive analysis of the visual impact of motor trucks in traffic.

Field research was carried out over a four week period in and around Philadelphia, PA, Camden, NJ, Houston, TX, Chicago, IL, and the Bay Area of California embracing San Francisco, San Jose and Oakland. In all, 161 individual observation runs were made in traffic; covering 1,633 miles and more than 47 and one-half hours of recorded driving. A special research team was assembled and trained for the project which utilized vans and station wagons in each of these cities for on-the-road operations.

Under the direction of the author, the crew included as driver/photographer Ms. Allene Betancourt who is an experienced professional for-hire truck driver. Ms. Betancourt's ability to operate a passenger vehicle in traffic at the speeds and in the manner typical of a combination truck contributed greatly to the accuracy of the data obtained. Ms. Betancourt drove over individual street or highway sections both ways with usually less than a fraction of one mile per hour variation in speed.

The other members of the research team were all students or graduate students in transportation, and an especial thanks is extended to Deborah Duff, Ronald Duych, and Jeffrey Marlow. All carried out their duties with zeal, accuracy, and perseverence; often under trying or even boring conditions.

Thus, it can be said with a high degree of certainty that a substantial body of detailed information has been assembled on how many persons see a truck — either as pedestrians or as occupants of other vehicles — on ten different types of highways and streets. Also, information has been gathered and tabulated on the length of time a motorist follows a truck under varying traffic conditions and the average speed of combination trucks on different types of highways. Further, day and night traffic comparisons have been prepared, and a separate analysis has been made of the available literature on the subject of optimal sizes and shapes of signs readable from moving vehicles.

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The average truck combination travels over 49,000 miles per year (1), and this increases to more than 77,700 miles annually (2) for the average major for-hire motor carriers. In fact, some individual truck tractors exceed 150,000 miles per year. Smaller, local, trucks typically travel about 25,000 miles (3) each year — mostly within urban and suburban environments. The purpose of this research was to determine how many persons actually see these trucks in traffic in the course of a year, a mile, or an hour.

Also to be determined was the portion of a truck actually viewed — the front, the sides, and/or the rear — plus the length of time that other vehicles typically follow a truck under varying traffic conditions. As a "spin-off" of the research performed, average road speeds were determined for ten highway classes. Finally, a separate analysis was made of the sizes and shapes of signs most appropriate to traffic conditions — in terms of legibility and visibility distance.

To add validity to the data base which this project creates, field research was carried out in four areas of the country; utilizing only highways and streets known to be major truck routes. The Philadelphia/Camden area is considered to be typical of the Eastern traffic patterns and Pennsylvania has the third highest truck registration in the Nation. Houston is typical of the open Southern/Southwestern environment, with Texas being the situs of the second largest number of registered trucks in the U.S. Chicago is recognized as the largest single transportation center in the country, while California has the largest number of trucks licensed in any state. In California, field surveys were made throughout the bay area; embracing San Francisco, San Jose and Oakland.

To further refine the data base, analyses were conducted on ten different types of rural, suburban and urban roads and streets. With the exception of four special night comparison tests, all surveys were made during mid-week non-rush-hours of non-holiday weeks in July and August 1977. Federal traffic manuals indicate that measurements of traffic taken at such periods are considered to be typical of average annual daily conditions. It is estimated that the final results obtained for visual impacts represent an approximate five percent understatement of a true universe, and may thus be considered conservative.

Separate measurements were made of the length of time that a vehicle will follow a truck under differing traffic conditions and on various types of roads and streets. Sufficient data were assembled to allow for analysis of causal relationships and to permit the drawing of certain general conclusions.

In the course of the test operations, average operating speeds were obtained for all road sections analyzed. These were separately tabulated and averaged by type and classification of highway — and the data were compared with published Federal vehicle speed information (4). The comparisons confirmed the validity of the test data when variations in traffic conditions were taken into account.

The final section of the project report consists of a literature search and commentary on the subject of sign sizes and designs. Working from the premise that established standards for highway and airport taxiway/guideway signs reflect research already accomplished relative to the problems of legibility of messages directed toward occupants of vehicles in motion, these standards were examined, listed and compared.

In the report appendix, a full explanation is presented of the methodologies employed in carrying out the visual impact survey. Copies of instructional material and worksheets are included as well as a log of all highways examined.

(1) Highway Statistics, 1975, Federal Highway Administration, Table VM-1

(2) Transport Statistics of the U.S., 1974, Interstate Commerce Commission, Class I Motor Carriers of Property.

(3) Road user and Property Taxes on Selected Motor Vehicles, 1973, Federal Highway Administration, Table 3, unit #8.

(4) Speed Trends, 1975, Federal Highway Administration

The visual impact analysis shows that the average combination vehicle creates almost 5 million visual impressions annually (4,984,101), based on the typical "mix" of travel by road system, and U.S. yearly average travel of 49,125 miles. Of this total, 81 percent of the viewers see the front and one or both sides, 11 percent see only the sides, and 7 percent (372,284) see the rear. Overall, 94 percent of all visual impressions originate with the drivers and occupants of other motor vehicle, while 6 percent originate from roadside pedestrians.

Although the "average" combination travels just short of 50,000 miles per year, the total for a major (Class 1) for-hire motor carrier is in excess of 77,700 miles per tractor. Applying the same distribution of travel to these trucks yields almost 7.9 million annual visual impressions. Further, it is known that many individual combinations travel upward of 150,000 miles each year — resulting in an estimated 15.2 million annual visual impressions.

Comparisons of day and night visual impressions indicate a relationship generally similar to the relative day/night traffic volumes on a given highway. Thus, if nighttime traffic is (for example) 60 percent less than the daytime average, the visual impressions at night will be approximately 40 percent of the daytime findings. This is based solely on impressions received by drivers and occupants of other vehicles since (A) daytime pedestrian visual impacts represent only a small fraction of the total, and (B) virtually all nighttime truck operations are carried out in rural areas which the survey showed to have a minimal number of pedestrians even in the daytime. Actual nighttime visual impression differentials were found to be in the magnitude of — as examples — 60 percent on rural Interstate highways and 18 percent on rural primary multilane facilities.

Analyses of other daytime data sets revealed that only on city streets did the number of visual impressions assigned to pedestrians contribute a significant portion of total impressions — 32 percent. Somewhat surprising was the finding that the second most intensive concentration of pedestrian viewers was located along rural primary 2-lane highways; though intercity truck travel on these older-type roads is rapidly declining.

In addition to the visual impressions of combination vehicles, estimates were prepared for typical 2-axle local van-type trucks. Here, at 25,000 miles per year of suburban and urban travel, visual impressions were found to total 6.4 million annually. Using a "time in operation" approach to measuring the visual impact of a variety of types of distribution trucks resulted in some 9.26 million such impressions annually — exclusive of those impressions made while the vehicle is stopped for loading and unloading, which later could account for an additional 7 million impressions over a twelve month period.

To facilitate use of the visual impression data, tables have been prepared showing the number of impressions per mile and per hour, by portion of the truck, for each of the highway system types examined. Tables have also been prepared showing total annual impressions at various annual mileages, and hourly (by road system) at varying average speeds.

Utilizing a technique described in the text and appendix, the time spent by an individual vehicle in following a truck was observed and tabulated. The purpose of this set of tests was to determine just how long an automobile (or other vehicle) would remain behind a truck before overtaking and passing it. The implications of the findings here concern a measure of the time during which a motorist will be able to observe the actions of the truck immediately ahead of him — or put another way, the length of time such a motorist will be "impeded" by the presence of the truck ahead.

Based on a total of 423 observations, these data indicate wide variation in following times under varying conditions. Generally, following times decreased with increasing average speeds and with an increasing number of traffic lanes. Too, the times declined (by an average of about 20 percent) for highways with access control as compared to those with unrestricted access. Following times increased as traffic density increased — a not unexpected phenomenon. While no valid overall average times could be determined — due to the large number of variables — the range by highway type was found to be: A minimum average of 20 seconds for rural toll roads up to a maximum average of 81 seconds on the urban Interstate system routes. Another typical example, urban — or city — streets — was found to yield an average following time of 62 seconds per vehicle.

Average speeds in miles per hour were computed for all test section operations, and these were cumulated and weighted by highway type. The resultant data were found to closely approximate existing Federal tabulations based on speeds on straight, level, road sections with free-flowing traffic. Where the test speeds varied, the differences may be accounted for by real-world traffic conditions — which are often less than free-flowing. The highest average truck speeds (55.0 mph) were measured on rural sections of the Interstate highway system, and the similar access-controlled rural primary multi-lane facilities were calculated at 53.3 mph. At the other extreme, city street speeds in downtown and in industrial areas were found to produce an average truck speed of only 18.4 mph — measured during non-rush-hours. Wide speed variations were found for similar type service facilities based on the existance of access control. For example, suburban arterial multi-lane highways have an average truck speed of 51.5 mph when access is controlled, but this drops to 32.5 mph without access control.

Finally, a literature search and analysis was undertaken on the size and design of signs designed to be visible from vehicles in motion — motor vehicles on highways and aircraft on taxiways and guideways. Despite the somewhat scant data discovered and listed, it is apparent that the style of type used in signing is at least as important as is the size of the lettering in assuring adequate legibility under normal vehicle operating conditions. While little in the way of definitive conclusions can be drawn from this work, it may be stated that visual perception of message signs from a moving vehicle is subject to several variables — including design, contrast, height, size and illumination.

Finally, the Appendix includes a complete route log of the highways used in the project work — including route numbers, state, highway type, mileage traversed, and number of test operations performed.

All of the visual impact data shown in the following table are based on daytime observation, on truck routes, during non-rush hours. The methodology employed, and more fully described elsewhere, involved converting vehicles counted into persons who might observe the test truck.

The conversion factors were based upon standard vehicle occupancy rates developed by the Federal Highway Administration. These are: for rural roads — 2.3 persons per automobile or truck; for suburban roads — 1.8 persons per automobile or truck; and for urban roads and streets — 1.5 persons per automobile or truck. In all instances, buses were counted separately (along with surface-operated transit trains) at an average of 15 persons per vehicle.

Overall, only about one vehicle occupant in 14 who observes a truck sees the rear section. On the other hand, 87 percent of the viewers see the front of the truck, and 93 percent see at least one side. The relatively low exposure to the rear, however, is compensated for by the longer per person exposure to this section of the truck (see section on vehicle following times).

Finally, analysis of the impression data above shows wide variation by highway type with the lowest impact occuring on rural primary multi-lane highways — while the highest was found on urban Interstate system routes. Between these two extremes, the exposure ratio was in the magnitude of 16.5 to one. When all road systems are ranked by exposure, with the lowest shown as 1.0, the data are:

Rural Primary Multi-lane	1.0
Rural Primary 2-lane	3.5
Urban City Street	3.8
Rural Toll Road	5.5
Rural Interstate System	5.9
Suburban Toll Bridge (& Approach)	7.7
Suburban Arterial Multi-lane	10.1
Urban Arterial Multi-lane	10.2
Suburban Interstate System	10.6
Urban Interstate System	16.5

TABLE A **VEHICLE IMPRESSIONS FROM OTHER VEHICLES — PARTS OF TRUCK SEEN**

IMPRESSIONS PER VEHICLE MILE TRAVELED

Road Type	Front & Side(s)	Sides Only			Rear Only	Total
		Left	Right	Total		
Rural						
Interstate System	82.7	0.9	2.7	3.6	5.9	92.2
Toll Road	86.4	0.8	1.5	2.3	6.1	94.8
Primary Multi-lane	11.4	1.0	1.5	2.5	2.4	16.3
Primary 2-lane	63.3	2.6	3.8	6.4	2.9	72.6
Suburban						
Interstate System	188.6	1.6	5.3	6.9	11.3	206.8
Toll Bridge (and Approach)	138.6	0.9	6.4	7.3	14.6	160.6
Arterial Multi-lane	186.1	7.9	10.9	18.8	14.2	219.1
Urban						
Interstate System	312.1	7.4	4.0	11.4	17.6	341.1
Arterial Multi-lane	209.3	9.4	7.3	16.7	18.1	244.1
City Street	157.5	24.8	27.4	52.2	27.2	236.9
IMPRESSIONS PER VEHICLE HOUR TRAVELED						
Rural						
Interstate System	4,612	48	149	197	329	5,138
Toll Road	4,368	42	79	121	306	4,795
Primary Multi-lane	609	51	78	129	131	869
Primary 2-lane	2,712	102	142	244	108	3,064
Suburban						
Interstate System	8,233	83	281	364	586	9,183
Toll Bridge (and Approach)	6,016	31	111	142	567	6,725
Arterial Multi-lane	7,796	193	311	504	482	8,782
Urban						
Interstate System	13,125	202	186	388	725	14,238
Arterial Multi-lane	7,842	242	180	422	611	8,875
City Street	2,202	389	426	815	327	3,344
OVERALL WEIGHTED PERCENTAGE DISTRIBUTION						
	87%	**2%**	**4%**	**6%**	**7%**	**100%**

As part of the research undertaken, an attempt was made to determine the difference between the visual impact — measured in terms of persons who see a truck — in the nighttime hours as compared to the daytime. To accomplish this, two basic assumptions were made. First, since most night truck travel is in rural, or at best suburban, areas, the comparison study would be confined to rural and suburban truck routes. Secondly, it is considered unlikely that pedestrians would constitute a measurable portion of nighttime observers of trucks on the highways. Therefore, the comparison study limited itself to drivers and occupants of other motor vehicles.

Before analyzing the comparative data tabulated below, two additional points should be noted. First, the decline in visual impact (day to night) can be closely approximated for any highway, road or street on the basis of the differences in hourly traffic volumes for various periods of the day. Thus, if a state or municipality can furnish total traffic volume (vehicles per hour) for the mid-day (say 800 vehicles per hour) and for the nighttime (say 300 vehicles per hour), it may be assumed with considerable accuracy that the nighttime visual impact will be 37.5 percent of that found in the daytime. This is computed as 300 divided by 800 equals .375, or 37.5 percent.

The second point to be noted is that the day to night *total* decrease is somewhat larger than that listed below because daytime pedestrian observations have here been excluded in order to provide maximum statistical comparability. It may be said with a very high degree of confidence, however, that nighttime sightings of trucks by pedestrians are very minimal — since (A) most nighttime truck operations are rural in nature and (B) data indicate that pedestrian sightings of trucks in such areas are very low even in the daytime.

TABLE B — DAY VS. NIGHT VISUAL IMPRESSIONS — PER VEHICLE HOUR TRAVELED

Road Type (section length) Time/Traffic/Ave. m.p.h.	Front & Side(s)	Sides Only			Rear Only	Total
		Left	Right	Total		
Rural Interstate System (56.1 miles)						
Day-mid. aft./light-mod./54.8	4,612	48	149	177	329	5,138
Nt.-10PM/light-mod./55.1	1,882	14	37	51	144	2,077
Night as Percent of Day	−59%	−71%	−75%	−71%	−56%	−60%
Rural Primary Multi-Lane (53.6 miles)						
Day-lt. aft./light-mod./53.6	609	51	78	129	131	869
Nt.-midnight/light/53.0	645	23	5	28	39	712
Night as Percent of Day	+ 6%	−55%	−94%	−78%	−70%	−18%
Rural Primary 2-Lane (39.6 miles)						
Day-late aft./light/47.2	3,785	82	76	158	38	3,981
Nt.-11 PM/light/49.6	152	27	28	55	20	227
Night as Percent of Day	−96%	−67%	−63%	−65%	−47%	−94%
Suburban Interstate System (7.4 miles)						
Day-4 PM/mod—heavy/55.6	9,827	15	98	113	368	10,298
Nt.-11 PM/light/48.1	2,925	0	33	33	85	3,043
Night as Percent of Day	−70%	−100%	−66%	−71%	−77%	−70%

As may be noted, traffic tends to decline at night, and thus impressions drop. Speeds, however, were found to be relatively uniform (day and night) on most sections. It is significant that the day/night declines were also relatively uniform with regard to the portion of a truck being viewed by other vehicle occupants. Actual perception, however, may be a somewhat different story — especially with regard to oncoming traffic. Here, headlights may tend to blind occupants, and highway alignment may obscure the sides of trucks as the oncoming vehicles pass.

Additionally, it may be significant that the smallest decline in traffic between day and night conditions was found on a rural multi-lane highway with partial access control. On the other hand, the greatest decline was experienced on a primary 2-land highway. Finally, for identification purposes, all of the rural highway sections utilized in the day/night comparison test were located between Houston and Dallas Texas, and were major intercity truck routes. The suburban section was located outside of Camden New Jersey, and was also a major truck artery.

As was done with the occupant observation analysis, all of the pedestrian visual impact data are based on daytime observations, on truck routes, during non-rush-hours. Methodology employed is fully described in the Appendix section.

Pedestrian counts were not made on rural Interstate or primary multi-lane highways since it was determined that the number of persons who might be physically able to see a truck along these facilities is minimal. In support of this decision, it should be pointed out that the wide rights-of-way, coupled with the limited access feature of such highways, makes it impossible for persons to be within close physical proximity to the road — and thus be able to see a truck operating thereon. The low pedestrian exposure found along turnpikes, and shown on the following table, is additional evidence of this phenomenon. In fact, a substantial portion of the pedestrian visual impact data for the toll roads was obtained at the toll plaza areas — rather than along the highway itself.

Overall, only about one pedestrian in 7 who observes a truck sees the rear section. On the other hand, 38 percent see the front of the truck, and 86 percent see at least one side. This distribution is somewhat different than that which was found for vehicle occupants — especially the higher rear visibility.

TABLE C VEHICLE IMPRESSIONS BY PEDESTRIANS — PARTS OF TRUCK SEEN

Road Type	Front & Side(s)	Sides Only			Rear Only	Total
		Left	Right	Total		
IMPRESSIONS PER VEHICLE MILE TRAVELED						
Rural						
Toll Road	1.1	0.6	1.3	1.8	0.2	3.1
Primary 2-Lane	8.9	5.2	3.9	9.1	1.1	19.1
Suburban						
Interstate System	2.3	1.2	1.2	2.4	0.7	5.4
Toll Bridge (and Approach)	5.3	2.2	4.9	7.1	1.2	13.6
Arterial Multi-lane	4.6	3.9	4.1	8.0	1.7	14.3
Urban						
Interstate System	2.6	1.0	0.7	1.7	0.3	4.6
Arterial Multi-lane	7.0	4.7	4.2	8.9	1.6	17.5
City Street	35.1	28.6	21.8	50.4	14.6	100.1
IMPRESSIONS PER VEHICLE HOUR TRAVELED						
Rural						
Toll Road	51	29	55	84	10	145
Primary 2-Lane	298	173	131	304	36	638
Suburban						
Interstate System	113	58	62	120	35	268
Toll Bridge (& Approach)	153	64	141	205	34	392
Arterial Multi-lane	130	115	107	222	44	396
Urban						
Interstate System	100	37	26	63	11	174
Arterial Multi-lane	173	111	102	213	45	431
City Street	543	453	328	781	224	1,548
OVERALL WEIGHTED PERCENTAGE DISTRIBUTION						
	38%	**24%**	**24%**	**48%**	**14%**	**100%**

Again as was the case with the occupant analysis, impressions varied widely by highway type — with the lowest impact occuring on rural toll roads and the highest on city streets. Between these two extremes, the exposure ratio was in the magnitude of 10.7 to one — somewhat smaller than the variation found for vehicle occupants, but embracing two less (and believed to be very low ranking) road types. When all road systems on which pedestrian exposure analyses were made are ranked — with the lowest shown as 1.0 — the data are:

Rural Toll Road	1.0
Urban Interstate System	1.2
Suburban Interstate System	1.8
Suburban Toll Bridge (& Approach)	2.7
Suburban Arterial Multi-lane	2.7
Urban Arterial Multi-lane	3.0
Rural Primary 2-Lane	4.4
Urban City Street	10.7

The table below combines both the vehicle occupant and the pedestrian exposure data detailed above to produce an overall vehicle impression table, by highway type. As noted earlier, the night observations have not been included here to maintain consistancy of data.

In total, the visual impressions may also be distributed as:

Front & Side(s)	85%
Sides Only	
Left	4%
Right	5%
(Total)	(9%)
Rear Only	6%
	100%

TABLE D **TOTAL VISUAL IMPRESSIONS OF TRUCKS**

IMPRESSIONS PER MILE TRAVELED

Road Type	Front & Side(s)	Sides Only Left	Right	Total	Rear Only	Total
Rural						
Interstate System	82.7	0.9	2.7	3.6	5.9	92.2
Toll Road	87.5	1.4	2.8	4.1	6.3	97.9
Primary Multi-lane	11.4	1.0	1.5	2.5	2.4	16.3
Primary 2-lane	72.2	7.8	7.7	15.5	4.0	91.7
Suburban						
Interstate System	190.9	2.8	6.5	9.3	12.0	212.2
Toll Bridge (& Approach)	143.9	3.1	11.3	14.4	15.8	174.2
Arterial Multi-lane	190.7	11.8	15.0	26.8	15.9	233.4
Urban						
Interstate System	314.7	8.4	4.7	13.1	17.9	345.7
Arterial Multi-lane	216.3	14.1	11.5	25.6	19.7	261.6
City Street	192.6	53.4	49.2	102.6	41.8	337.0
IMPRESSIONS PER VEHICLE HOUR TRAVELED						
Rural						
Interstate System	4,612	48	149	197	329	5,138
Toll Road	4,419	71	134	205	316	4,940
Primary Multi-lane	609	51	78	129	131	869
Primary 2-lane	3,010	275	273	548	144	3,702
Suburban						
Interstate System	8,346	141	343	484	621	9,451
Toll Bridge (& Approach)	6,169	95	252	347	601	7,117
Arterial Multi-lane	7,926	308	418	326	526	9,178
Urban						
Interstate System	13,225	239	212	451	736	14,412
Arterial Multi-lane	8,015	353	282	635	656	9,306
City Street	2,745	842	754	1,596	551	4,892

In terms of where the most people see a truck, the highest visual impact was found to be on the urban Interstate routes. The lowest was on rural primary multi-lane highways. The ratio between the two extremes is in the magnitude of 16.6 to one. Ranking all highway systems in this manner — with rural primary multi-lane highways as 1.0 resulted in:

Rural Primary Multi-lane	1.0
Rural Primary Multi-lane	4.3
Urban City Street	5.6
Rural Toll Road	5.7
Rural Interstate System	5.9
Suburban Toll Bridge (& Approach)	8.2
Suburban Arterial Multi-lane	10.6
Urban Arterial Multi-lane	10.7
Suburban Interstate System	10.9
Urban Interstate System	16.6

Looked at still another way, other vehicle drivers and occupants represented 94 percent of all visual impressions overall. Pedestrians, on the other hand, accounted for only 9 percent. However, the importance of pedestrians in the total visual impact analysis varied widely by highway type. Aside from the two types of rural roads where pedestrians were not measured (see comment above), the range was found to be from one percent for urban Interstate routes up to 32 percent on city streets. Too, the portion of a truck viewed varied considerably when the vehicle occupant/pedestrian visual impact data were compared. Pedestrians were found to be more apt to see the sides of trucks only — as opposed to the front and sides or the rear.

TABLE E — RELATIVE PERCENT OF TOTAL VISUAL IMPACTS, VEHICLE OCCUPANTS AND DRIVERS VERSUS PEDESTRIANS

Road Type Vehicle Occupant % — Pedestrian %	Front & Side(s)	Sides Only			Rear Only	Total
		Left	Right	Total		
Rural						
Interstate System	100- 0	100- 0	100- 0	100- 0	100- 0	100- 0
Toll Road	99- 1	59-41	59-41	59-41	100- 0	97- 3
Primary Multi-lane	100- 0	100- 0	100- 0	100- 0	100- 0	100- 0
Primary 2-lane	90-10	37-63	52-48	45-55	75-25	83-17
Suburban						
Interstate System	99- 1	59-41	82-18	75-25	94- 6	97- 3
Toll Bridge (& Approach)	98- 2	33-67	44-56	41-59	94- 6	94- 6
Arterial Multi-lane	98- 2	63-37	74-26	69-31	92- 8	96- 4
Urban						
Interstate System	99- 1	63-32	88-12	86-14	99- 1	99- 1
Arterial Multi-lane	98- 2	69-31	64-36	66-34	93- 7	95- 5
City Street	80-20	46-54	56-44	51-49	58-42	68-32
OVERALL AVERAGE	**97- 3**	**57-43**	**67-33**	**63-37**	**90-10**	**94- 6**

In order to estimate the annual visual impressions of a vehicle combination in traffic, it is necessary to determine the annual travel of such a vehicle — over the various highway systems. Data below are based on 1975 Federal Highway Administration tabulations (the most recent available at this time), augmented as noted.

TABLE F TRAVEL COMPUTATION FOR COMBINATIONS

Total Combination Travel — (FHWA Table VMI)

Main Rural Roads	79.77%	39,187 miles
Local Rural Roads	2.40	1,179
Urban Roads	17.83	8,759
	100.00%	49,125 miles

Detailed Breakdown (based on FHWA system travel statistics percentages)

Rural Interstate System	17,070 miles
Rural Primary System	16,748
Rural Main Secondary System	5,369
Rural Local (Secondary) System	1,179
Urban Interstate System	3,472
Urban Primary System	3,224
Urban Secondary System	2,063
	49,125 miles

Conversion to Visual Impact Study Classifications

Federal Breakdown		Visual Impact Classes	
Rural Interstate System	=	Rural Interstate System*	15,875
		Rural Toll Roads*	1,195
Rural Primary System	=	Rural Primary Multi-lane	16,748
Rural Main Secondary System	=	Rural Primary 2-Lane	5,369
Rural Local (Secondary) System; 2/3 Urban Primary System†	=	Suburban Arterial Multi-lane	3,329
2/3 Urban Interstate†	=	Suburban Interstate System*	2,154
		Suburban Toll Bridge (& Approach)*	162
1/3 Urban Interstate System†	=	Urban Interstate System	1,156
1/3 Urban Primary System†	=	Urban Arterial Multi-lane	1,074
Urban Secondary System	=	Urban City Streets	2,063
			49,125

[illegible] — 93% Free Interstate and 7% Toll. Based on division of Interstate System travel in 1975.

† — Estimate based on division of urban area (including suburbs) as ⅔ of area in suburbs and ⅓ in "urban" area.

TABLE G TOTAL ANNUAL VISUAL IMPRESSIONS OF AN AVERAGE COMBINATION

Road Type	Annual Miles	Front & Side(s)	Sides Only			Rear Only	Total
			Left	Right	Total		
Rural							
Interstate System	15,875	1,312,863	114,288	42,863	57,150	93,662	1,463,675
Toll Road	1,195	104,562	1,673	3,447	4,900	7,529	116,991
Primary Multi-lane	16,748	190,927	16,748	25,122	41,870	40,195	272,992
Primary 2-Lane	5,369	387,642	41,878	41,341	83,220	21,476	492,337
Suburban							
Interstate System	2,154	411,199	6,031	14,001	20,032	25,848	457,079
Toll Bridge (& Approach)	162	23,312	502	1,831	2,333	2,560	28,220
Arterial Multi-lane	3,329	634,840	39,282	49,935	89,217	52,931	776,989
Urban							
Interstate System	1,156	363,793	9,710	5,433	15,144	20,692	399,629
Arterial Multi-lane	1,074	232,306	15,143	12,351	27,494	21,158	280,958
City Street	2,063	397,334	110,164	101,450	211,664	86,233	695,231
TOTALS	49,125	4,058,778	255,419	297,774	553,024	372,284	4,984,101
PERCENTAGE DISTRIBUTION							
[illegible]		81%	5%	6%	11%	7%	100%

(Totals may not add due to rounding)

While the U.S. average mileage for all combinations is just short of 50,000 annually, many combinations travel substantially further. The average power unit (tractor) operated by major intercity Federally regulated motor carriers (Class I with revenues of over $3 million annually per company) was 77,744 miles in 1974 — the latest available year. Assuming that these combinations operate the same "mix" of miles by road system, their annual visual impressions would total almost 7.9 million.

Many individual combinations travel as much as 100,000 to 150,000 miles per year. Still assuming the same system "mix," the impressions would then be 10 to 15 million each twelve months. In fact, a quick rule of thumb here is about 101 visual impressions per mile operated.

Another typical type of truck is the 2-axle single unit van truck which, in urban-type service, travels about 25,000 miles per year; according to the Federal Highway Administration's *Road User and Property Taxes on Selected Motor Vehicles*. Here, the travel "mix" is somewhat different, and has been estimated as follows:

TABLE H TRAVEL COMPUTATION FOR A LOCAL VAN TRUCK

	Estimated Miles	Total Impressions Per Mile	Total Impressions Per Year
Suburban			
Interstate System (20% of Sub.)	3,335	212.2	707,687
Toll Bridge (& Approach) (5% of Sub.)	834	174.2	145,283
Arterial Multi-lane (75% of Sub.)	12,506	233.4	1,918,900
Urban			
Interstate System (20% of Urb.)	1,665	345.7	575,591
Arterial Multi-lane (26.7% of Urb.)	2,220	261.6	580,752
City Street (53.3% of Urb.)	4,440	337.0	1,496,280
TOTALS	25,000		6,424,493

NOTE: Distribution based on underlying assumption that total travel is divided into 1/3 Urban (8,325 miles) and 2/3 Suburban (16,675 miles).

TABLE I COMPUTATION OF DISTRIBUTION TRUCK IMPRESSIONS

Road Type	Time Each Day		Visual Impressions Per Hour	Total Impressions Per Working Day
Suburban				
Interstate System	½ hr.		9,451	4,726
Arterial Multi-lane	½ hr.		9,175	4,589
Urban				
Interstate System	½ hr.		14,412	7,206
Arterial Multi-lane	1 hr.		9,306	9,306
City Street	2 hrs.		4,892	9,784
	4½ hrs.			35,611
	+			times 5 days
	5½ hrs.	load & unload		178,055 per week
				times 52
	10 hrs.			9,258,860 — annual

As may be seen, this 25,000 mile per year local truck will have over 6.4 million annual visual exposures; due to its high concentration of travel in urban and suburban areas.

A final example may be made of a local delivery truck which operates on a 10 hour daily cycle, 5 days per week, in an urban/suburban environment. Here, the exposures have been calculated on the basis of hours rather than miles. The assumed duty cycle involves a truck beginning and ending its day at a suburban warehouse or terminal complex and operating primarily "downtown." Actual driving time is estimated at 4.5 hours out of a 10 hour day. Travel to and from the downtown is assumed to be on a mix of suburban and urban Interstate and arterial highways.

Here, the annual impressions are over 9.2 million for a truck which actually is only moving 4½ hours per day, or 22½ hours a week. Incidentally, applying the average speed data from the section on travel speeds shows that this truck will travel an average of 141 miles per day, or 36,712 miles annually — not uncommon for a heavily utilized delivery truck.

Further, no effect has been shown for the number of visual impressions such a truck will make while it is sitting at rest during the loading and unloading process 5½ hours each day. If these additional impressions could be considered to be similar to the visual impressions of that same truck on a city street, (a "worst case" approach) the added visual impact would amount to 5½ times 4,892 or 26,906 per day. On an annual basis, this will total almost another 7 million visual impressions — for a grand total of over 16 million impressions per year.

For the convenience of those utilizing this analysis, the following two tables represent total visual impressions under differing conditions of annual mileages and vehicle speeds. These may, with the use of the other data presented herein, be expanded to provide details by portion of vehicle, day versus night, etc. Thus, these tables exhibit only a few of the extrapolative possibilities of the data.

TABLE J **TOTAL VISUAL IMPRESSIONS PER YEAR AT VARIOUS ANNUAL VEHICLE MILEAGES**

Annual Mileage	Over-The-Road Combination	Local 2-Axle Van
15,000	n.a.	3,854,696
20,000	n.a.	5,139,594
25,000	n.a.	6,424,493
30,000	3,043,800	7,709,391
35,000	3,551,100	8,994,290
40,000	4,058,400	10,279,188
45,000	4,565,700	11,564,086
50,000	5,073,000	12,848,985
55,000	5,580,300	14,133,884
60,000	6,087,600	n.a.
65,000	6,594,000	n.a.
70,000	7,102,200	n.a.
75,000	7,609,500	n.a.
80,000	8,116,800	n.a.
85,000	8,624,100	n.a.
90,000	9,131,400	n.a.
95,000	9,638,700	n.a.
100,000	10,146,000	n.a.
105,000	10,653,300	n.a.
110,000	11,160,600	n.a.
115,000	11,667,900	n.a.
120,000	12,175,200	n.a.
125,000	12,682,500	n.a.
130,000	13,189,800	n.a.
135,000	13,697,100	n.a.
140,000	14,204,400	n.a.
145,000	14,711,700	n.a.
150,000	15,219,000	n.a.

n.a. — not applicable, out-of-scope of normal operations.

TABLE K TOTAL VISUAL IMPRESSIONS AT VARIOUS AVERAGE SPEEDS

Road Type	10 mph	15 mph	20 mph	25 mph	30 mph
Rural					
Interstate System — A — 55.0 mph	n.a.	n.a.	n.a.	n.a.	n.a.
Toll Road — A — 50.8 mph	n.a.	n.a.	n.a.	n.a.	2,917
Primary Multi-lane — A — 53.3 mph	n.a.	n.a.	n.a.	n.a.	489
Primary 2-lane — N — 45.5 mph	n.a.	n.a.	n.a.	n.a.	2,441
Suburban					
Interstate System — A — 51.1 mph	n.a.	n.a.	n.a.	4,624	5,549
Toll Bridge (& Approach) — A — 40.8 mph	n.a.	n.a.	n.a.	4,361	5,233
Arterial Multi-lane — A — 51.5 mph	n.a.	n.a.	n.a.	4,455	5,346
— N — 40.8 mph	n.a.	n.a.	4,499	5,624	6,749
Urban					
Interstate System — A — 38.6 mph	n.a.	n.a.	7,467	9,334	11,201
Arterial Multi-lane — A — 48.7 mph	n.a.	n.a.	3,822	4,777	5,733
— N — 23.5 mph	3,960	5,940	7,920	9,900	11,880
City Street — N — 18.4 mph	2,659	3,988	5,317	6,647	7,976

Road Type	35 mph	40 mph	45 mph	50 mph	55 mph
Rural					
Interstate System — A — 55.0 mph	3,270	3,737	4,204	4,671	5,138
Toll Road — A — 50.8 mph	3,404	3,890	4,376	4,862	5,348
Primary Multi-lane — A — 53.3 mph	571	652	734	815	897
Primary 2-lane — N — 45.5 mph	2,848	3,255	3,661	4,068	4,475
Suburban					
Interstate System — A — 51.1 mph	6,473	7,398	8,323	9,248	10,172
Toll Bride (& Approach) — A — 40.8 mph	6,105	6,977	7,850	8,722	9,594
Arterial Multi-lane — A — 51.5 mph	6,237	7,128	8,019	8,911	9,802
— N — 40.8 mph	7,873	8,998	10,123	11,248	n.a.
Urban					
Interstate System — A — 38.6 mph	13,068	14,935	16,882	18,668	20,535
Arterial Multi-lane — A — 48.7 mph	6,688	7,644	8,599	9,554	10,510
— N — 23.5 mph	13,660	15,840	n.a.	n.a.	n.a.
City Street — N — 18.4 mph	n.a.	n.a.	n.a.	n.a.	n.a.

A — Access Control
N — No Access Control   n.a. — not applicable, out-of-scope of normal operations.

A separate technique was developed to measure the length of time a motorist remains behind a truck under various traffic conditions before pulling out and passing. The significance of this lies in the time available to occupants of vehicles positioned behind a truck to read any message imprinted on the rear area of the truck or trailer body — while they are "impeded" by the truck ahead.

The mechanics of the "following time" research required the test vehicle to move in traffic at normal speeds — slowing, stopping, starting and accelerating — for a combination vehicle. Where "truck lanes" were indicated, the test vehicle stayed in such lanes.

When another vehicle pulled in behind the test vehicle, an observer facing rearward would call "start" to a technician operating a stop watch. When the following vehicle pulled out of lane to pass the test unit, the rear-facing observer would then call "stop" to the operator of the stop watch. The time spent behind the test unit was then entered on a worksheet.

For analysis purposes, each test run was summarized to obtain an average number of seconds that a vehicle followed the test unit. For example, if — on a city street — there were 10 observations of a vehicle following the test vehicle, with following times listed for each observation, the total times for the 10 observations were added and then divided by 10 to obtain an average under the conditions noted for that particular run. In all cases in the tabulations below, the number of observations made were utilized to weight results when test runs were summarized.

Speed — Analysis indicates that as average speed increases, the time spent following a truck tends to decrease — though not at a constant rate. After dropping one single observation (where the test vehicle was followed by one automobile for over 14 minutes on a 4-lane road at an average speed of about 40 mph — an out-of-scope observation eliminated from all tabluations) the effect of speed was found to be:

TABLE L — AVERAGE FOLLOWING TIMES BY SPEED

Average Speed	Average Following Time
Under 15 mph	82 seconds
15 to 25 mph	68
25 to 35 mph	63
35 to 45 mph	72
45 to 55 mph	27

Road Type and Traffic — Average following times were found to vary widely with highway type — Interstate, city street, etc. — and by degree of traffic congestion. Surprisingly, relatively small overall differences were noted between roads with and without access control; though the number of lanes did affect driver behavior and considerable internal inconsistancy was noted. Following time studies were made for the highway types and conditions shown as:

TABLE M — AVERAGE FOLLOWING TIMES BY HIGHWAY SYSTEM

Interstate System — Suburban — All had full access control.

Average for all sections	— 46 seconds
Light Traffic	— 27
Light-Moderate Traffic	— 21
Moderate Traffic	— 16
Heavy Traffic	— 63

Interstate System — Urban — All had full access control.

Average for all sections	— 81 seconds
Light-Moderate Traffic	— 23
Heavy Traffic	— 24
Heavy Congestion	— 115

Toll Roads — (Basically Rural) — All had full access control.

All sections had light to light-moderate traffic with same average of — 20 seconds

Suburban Multi-lane

	Access Control	No Access Control
All Sections	54 seconds	56 seconds
Light Traffic	—	27
Moderate Traffice	37	59
Moderate-Heavy Traffic	29	62
Heavy Traffic	92	98

Toll Bridges (and approaches) — All had full access control.

Average with little traffic variance of — 47 seconds

Urban Arterial Streets

With no significant variation by volume, average of — 50 seconds

With Access Control	— 12 seconds
Without Access Control	— 87 seconds

TABLE N — AVERAGE FOLLOWING TIMES BY ACCESS CONTROL

Number of Lanes	Access Control	No Access Control
2 & 4	—	45 seconds
4	—	67
4 & 6	28 seconds	27
6	28	98
6 & 8	83	—
8	20	28
8 & 10	30	—
All Sections	50 seconds	59 seconds

TABLE O — AVERAGE CITY STREET FOLLOWING TIMES

Urban (City) Streets No access control on any section — average of 62 seconds overall.	Number of Traffic Lanes	Light Traffic	Light to Moderate Traffic	Moderate Traffic	Moderate to Heavy Traffic	Heavy Traffic
	2 & 4	—	38	66	—	—
	4	—	43	56	61	39
	4 & 6	—	—	88	91	—
	6	—	46	—	—	—
	8	—	—	—	—	33
	Average	—	42	67	70	38

TABLE P — SUMMARY OF FOLLOWING TIMES BY SYSTEM

Summary By Road Type	
Interstate System — Suburban	46 seconds
Interstate System — Urban	81
Toll Roads (basically rural)	20
Suburban Multi-lane	55
Toll Bridges (and Approaches)	47
Urban Arterial Streets	50
Urban Streets	62

Examples – Several "paired" examples of results obtained from individual following time tests are shown below to illustrate the diversity of findings obtained.

Interstate System – Suburban

Houston, Texas (I-610/I-45) — 6 and 8 lane access controlled.
Survey made in heavy mid-afternoon traffic during rain shower. Average speed was 31.3 miles per hour, and 16 following observations were made. Average time = 79 seconds — with range of 2 seconds to 356 seconds. Median value was 64 seconds.

San Jose, California (I-680/I-280) — 6 and 8 lane access controlled.
Survey made on sunny day with light noontime traffic. Average speed was 53.0 miles per hour, and 8 following observations were made. Average time = 27 seconds — with range of 5 seconds to 40 seconds. Median value was 37 seconds.

Suburban Multilane

Houston, Texas (US 59) — 4 and 6 lane access controlled.
Survey made in moderate to heavy mid-morning traffic on sunny day. Average speed was 49.2 miles per hour, and 16 following observations were made. Average time = 29 seconds — with range of 3 seconds to 134 seconds. Median value was 25 seconds.

Houston, Texas (Tex. 225) — 4 and 6 lane without access control.
Survey made in light mid-morning traffic on a sunny day. Average speed was 34.6 miles per hour, and 15 following observations were made. Average time = 27 seconds — with range of 2 seconds to 156 seconds. Median value was 20 seconds.

Urban Street

Chicago, Illinois (Harlem Ave.) — 4 lanes without access control.
Survey made in moderate to heavy late afternoon traffic on sunny day. Average speed was 14.6 miles per hour, and 22 following observations were made. Average time = 75 seconds — with range of 4 seconds to 320 seconds. Median value was 52 seconds.

Philadelphia, Pennsylvania (Broad St.) — 4 lanes without access control.
Survey was made in moderate to heavy mid-afternoon traffic on sunny day. Average speed was 15.6 miles per hour, and 18 following observations were made. Average time = 38 seconds — with range of 10 seconds to 137 seconds. Median value was 24 seconds.

As a spin-off of the research undertaken in connection with this study, average traffic speeds were tabulated for each of the 161 highway sections used in the visual impact analyses. Representing 1,633 miles of measured travel, these speeds have been averaged, by highway type, in the table below.

With the four exceptions noted, all speeds are based on daytime, non-rush-hour, travel during weekdays. The four exceptions are all night runs (mid-week) on: 1 rural Interstate section, 1 suburban Interstate section, 1 rural primary multi-lane section,a nd 1 rural two-lane primary section.

It should be emphasized that the speeds shown below were obtained from typical truck routes under varying, typical, traffic conditions. Thus, they tend to differ somewhat from 1975 speeds published by the Federal Highway Administration — which are based on "free-flowing" traffic conditions on straight, level, road sections. A comparison of the observed speeds and the Federal data are shown in table R.

TABLE Q — AVERAGE SPEEDS BY SYSTEM

	Computed Average Speed (miles per hour)
Rural	
Interstate System (all access controlled)	55.0
Toll Roads (all access controlled)	50.8
Primary Multi-lane (partial access control)	53.3
Primary 2-Lane (no access control)	45.5
Suburban	
Interstate System (all access controlled)	51.1
Toll Bridges & Approaches (all access controlled)	40.8
Arterial Multi-lane	
— With Access Control	51.5
— Without Access Control	32.5
Urban	
Interstate System (all access controlled)	38.6
Arterial Multi-lane	
— With Access Control	48.7
— Without Access Control	23.5
City Streets (no access control)	18.4

TABLE R — COMPARISON OF OBSERVED AND FEDERAL SPEEDS BY SYSTEM

	1977 Observed Speeds (miles per hour)	1975 Federal Report Speeds (miles per hour)
Rural		
Interstate System	55.0	
(Completed Sections)		56.6
Primary Multi-lane	53.3	
Primary 2-Lane	45.5	
(Rural Primary)		53.4
Suburban		
Interstate System	51.1	54.4
Arterial Multi-lane — Controlled Access	51.5	
— No Access Control	32.5	
(Suburban Primary)		46.5
Urban		
Interstate System	38.6	53.8
Arterial Multi-lane — Controlled Access	48.7	
— No Access Control	23.5	
(Urban Primary)		42.0

A separate sector of this project on truck visibility deals with the size and form of letters and numbers used in making signs which may be seen by vehicles in motion. This subject has been dealt with in the past primarily by two Federal agencies most involved in standards for informational signing in transportation.

Highway signs, familiar to all motorists, have been the subject of study and of standards manuals prepared by the Federal Highway Administration and its predecessor Bureau of Public Roads. Less well known to the general public are the standards for airport taxiway and guideway signs prepared by the Federal Aviation Administration and its predecessor Federal Aviation Authority. Additional work — albeit somewhat scant — has been performed by research and industry organizations usually under contract to these government bodies. A brief bibliography of basic studies follows this discussion.

The guiding principles in all of the works examined in connection with this project may be stated simply as: (A) letter and number styles which are easily read by observers from vehicles in motion, and (B) letter and number sizes which may be read from distances — and at speeds — typically encountered in moving vehicle situations. Put another way, neither a highway sign nor an airport instructional sign can fulfill its purpose if it cannot be read and comprehended under normal operating conditions — and distances — by motorists or by aircraft crews.

Translating this into visual impressions of a sign on a motor truck, any truck signing should be of a type and size so as to be fully legible at the distances and speeds encountered in the interface between such a truck and the occupants of other vehicles — or pedestrians. No literature was discovered on this specific subject, however, and thus reliance must be placed on the criteria developed for stationary signing capable of being perceived from a moving vehicle. Since these criteria contain an implicit "margin of safety," it is believed that they will serve as a viable guide to minimum sizes and design specifications for truck signing.

Examination of the existing standards shows relatively little commonality except as regards letter and number shapes and proportions. The Federal Aviation Authority's sign shape chart (from Advisory Circular 150/5345-4) provides the basis for all airport taxiway guidance signs, and has become known as the "airport bold" typeface. Basic proportions (from the same source) are specified as being 10.75 inches high and with a 0.75 inch stroke width. The study of "Improved Airport Guidance Signs" (Oxford Corp.) states that individual characters should be 10 inches high and 8 inches wide in order to be visible from a distance of at least 500 feet.

Another airport taxiway manual (advisory circular 150/5345-44A) refines these specifications further, but without noting minimum legibility distance. Here, signs are to be placed 3 feet 6 inches above the ground on a panel 6 feet wide and 3 feet high. Letter height is varied in proportion to the importance of the message as follows: Mandatory signs — 18 inches, Informational signs — 15 inches, and Convenience signs — 12 inches. It should be noted that these specifications are of a relatively recent date (1971) and refer to the added problems created by jet aircraft operations.

Highway signing requirements are more detailed, based on the existing literature. A study published by the Transportation Research Board (Research Record #611) reports on overhead signs without external illumination. Here, simple messages utilizing 16 inch letters on overhead signs which ranged from 18.33 feet to 22.70 feet above the roadway were found to be legible at distances of from 830 feet to a maximum of 1,849 feet — at vehicle speeds ranging from 31 to 61 miles per hour.

Other sources on highway signing (American Association of State Highway Officials and the Federal Highway Administration) are still more specific. "Initial letters and numerals used will be Series E of the Standard Alphabets for Highway Signs (similar to the airport design shown) modified by widening the stroke width to approximately one fifth of the letter (or numeral) height;" according to the highway officials manual. "Upper-case letters shall be 1⅓ times the 'loop' height of lower-case letters" (Federal Highway Administration), and between line spacing should be "approximately three-fourths of the average of the heights of the capital or upper case letters in adjacent lines . . ." (American Association of State Highway Officials).

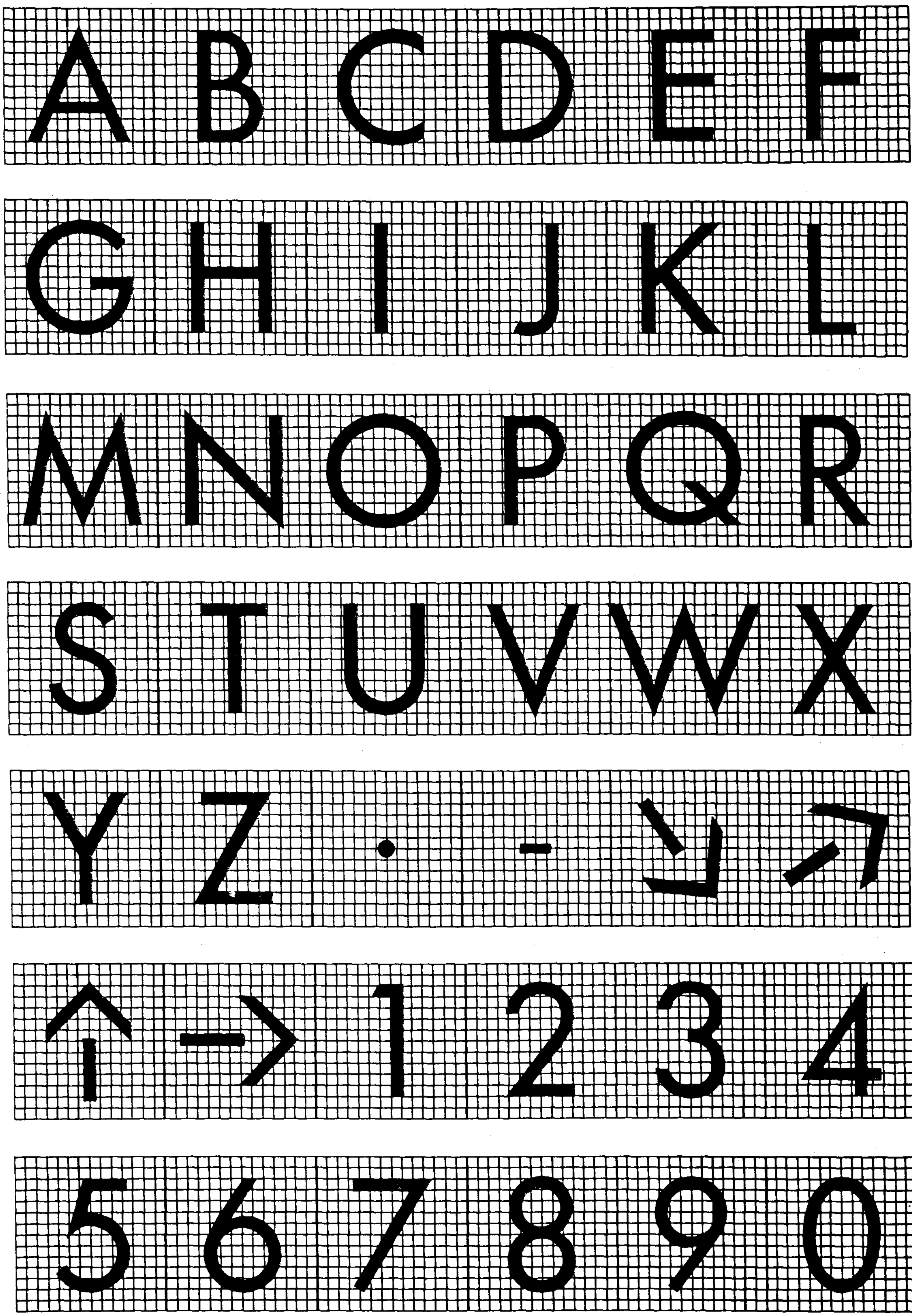
Comparisons of the Federal and the Highway Officials manuals indicate that letter sizes have been increased over the years. The most recent Federal Highway Administration specifications for "Expressway Guide Signs" show the following letter heights for word messages:

"Exit Panel"
  10 inches (8 inches for "minor" signs)
"Cardinal" Direction
  15 inches down to a minimum of 8 inches
"Name of Place" Etc.
  20 inches down to a minimum (minor sign) of 10.6 inches
"Distance" to a Place
  12 inches down to 8 inches minimum

Other types of signing, supplemental, motorist information and the like, do not exceed 13.3 inches in height — and most are 10 inches.

A literature search of information on highway and airport sign sizes and shapes shows a wide range of recommended practices. In general, the major commonality was found in the field of letter shapes and spacing — and these are considered to be key factors in legibility under in-motion operating conditions. There are also considerable opinion variations with regard to colors and contrasts to be used for maximum legibility.

STANDARD AIRPORT LETTERS AND NUMBERS



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Federal Highway Administration, U.S. Dept of Transportation, Washington, D.C. 1971, 377 pp.

Manual for Signing and Pavement Marking (of the National System of Interstate and Defense Highways)
American Association of State Highway Officials, Washington, D.C. 1970, 116 pp.

Overhead Signs Without External Illumination
Transportation Research Record 611, Transportation Research Board, National Academy of Sciences, Washington, D.C. 1976, 8 pp.

Specifications for L-829 Internally Lighted Airport Taxi Guidance Signs.
Advisory Circular AC150/5345-4, Federal Aviation Agency, Washington, D.C., January 1967, reprint, 10 pp plus attachment.

Specifications for L-858 Retroflective Taxiway Guidance Signs.
Advisory Circular AC/150/5345-44A, U.S. Federal Aviation Administration, U.S. Dept. of Transportation, Washington, D.C., July 1971, 8 pp plus appendix.

Study of the National Standards for Directional and Other Official Signs, Overview of Their Adequacy.
National Bureau of Standards, Institute For Applied Technology, Federal Highway Administration (joint), Washington, D.C., October 1975, 88 pp.

TABLE S FIELD OPERATIONS SUMMARY

	TOTAL	PA/NJ	TX	IL	CA
Number of Counts					
Vehicle	62	16	18	11	17
Pedestrian	51	14	11	12	14
Following	48	14	11	12	11
(Total)	(161)	(44)	(40)	(35)	(42)
Operations Miles Driven —*	1,633	244	557	350	482
Operations Hours Driven	47 hrs. 33 min.	8 hrs. 21 min.	12 hrs. 17 min.	13 hrs. 32 min.	13 hrs. 23 min.
Number of Following Observations	423	95	104	124	100
Number of Night Vehicle Counts	4	1	3	0	0

* — Total operations miles driven including route testing = 2,320 (approx.).

TABLE T ROUTE LOG

		State	Miles
Interstate System — Rural			
I-45		TX	112.2
Vehicle Counts	2		
Pedestrian Counts	0		
Following Counts	0		
Interstate System — Suburban			
I-95		PA	19.1
I-95		NJ	14.8
I-10		TX	12.7
I-610/I-45		TX	57.1
I-94		IL	44.2
I-280/I-680		CA	52.0
Vehicle Counts	7		199.9
Pedestrian Counts	7		
Following Counts	7		
Interstate System — Urban			
I-76		PA	14.1
I-10		TX	16.5
I-194/I-94		IL	42.5
I-90		IL	33.6
Vehicle Counts	3		100.4
Pedestrian Counts	3		
Following Counts	3		
Toll Roads (basically Rural)			
New Jersey Turnpike		NJ	53.3
Pennsylvania Turnpike		PA	19.7
Chicago Skyway (I-90)		IL/IN	33.9
Tri-State Toll Road (I-80)		IL	32.4
Vehicle Counts	4		139.3
Pedestrian Counts	4		
Following Counts	4		
Toll Bridges (and approaches)			
San Mateo (Cal. 92)		CA	26.1
Oakland Bay (I-80)		CA	12.1
Golden Gate (US 101)		CA	21.2
San Rafael (Cal. 17)		CA	18.3
Vehicle Counts	4		77.7
Pedestrian Counts	1		
Following Counts	3		
Rural Primary Multi-lane			
US 59		TX	107.3
Vehicle Counts	2		
Pedestrian Counts	0		
Following Counts	0		
Rural Primary 2-lane			
US 190		TX	79.1
Cal. 84		CA	20.4
Vehicle Counts	3		99.5
Pedestrian Counts	1		
Following Counts	0		

TABLE T (continued) ROUTE LOG

		State	Miles
Suburban Multi-lane			
PA. 132		PA	11.1
US 1		PA	20.7
US 73		NJ	19.2
TEX. 225		TX	28.2
TEX. 288		TX	21.7
TEX. 8		TX	13.8
US 90 Alt.		TX	21.6
US 59		TX	35.8
ILL. 64		IL	11.5
ILL 43		IL	6.9
US 101		CA	127.9
CAL. 82		CA	15.0
CAL 17		CA	45.6
Vehicle Counts	17		379.0
Pedestrian Counts	17		
Following Counts	14		
Urban (City) Arterial			
US 30		NJ	11.8
TEX. 225 (Pasadena St.)		TX	14.2
I-610/US 59 (Beltway)		TX	16.8
US 45 (Manheim Road)		IL	17.8
CAL. 82 (El Camino)		CA	38.4
CAL. 17 (Nimitz Expressway)		CA	33.7
US 101 (Bayshore Freeway)		CA	10.3
Vehicle Counts	7		143.0
Pedestrian Counts	5		
Following Counts	3		
Urban (City) Streets			
US 73 (Levick St.)		PA/NJ	6.3
US 1 (City Line Ave.)		PA	5.2
US 30 (Vine St.)		PA	5.7
Delaware Ave.		PA	15.5
Aramingo Ave.		PA	10.0
Broad St.		PA	17.3
Navigation Blvd. & Clinton St.		TX	20.2
ILL. 50 (Cicero Ave.)		IL	16.2
ILL. 43 (Harlem Ave.)		IL	66.0
47th St.		IL	19.2
79th St.		IL	26.0
US 101 (Bayshore Freeway)		CA	4.9
CAL. 82 (El Camino)		CA	29.9
The Embarcadero, China Basin Blvd., Illinois St.		CA	14.6
Vehicle Counts	13		257.7
Pedestrian Counts	13		
Following Counts	14		

In order to widen and up-date the findings published in the 1968 report *How Many People See A Truck?* (ATA Department of Research and Transport Economics, Richard A. Staley et al), the present project was designed to concentrate visual impression observations on (A) highways, roads and streets which were known to be major truck routes, and (B) to carry out observations in various areas across the country in order to obtain a reasonable geographic cross-section for analysis.

Addressing the first requirement, motor carriers and motor carrier associations were contacted in each of the areas visited to obtain comprehensive lists of major truck routes — including Interstate system access routes, suburban/urban arterials and city streets serving terminals, piggyback yards and docks. These were the only routes utilized in the survey work, and are those shown in the "log." Extensive use was made of detailed regional highway maps to assure that a reasonable "mix" of highways and bridges by type and purpose were included.

The project aimed at obtaining data from diverse sections of the United States in order to more closely approximate conditions Nationwide. Since it was obviously not possible to visit each and every state and locale, field research activities were conducted in four major areas; each presenting a different highway and industrial environment. Thus, one week each of field research was carried out in:

Philadelphia PA/Camden NJ area representing typical Eastern traffic conditions with older and more restricted street patterns and industrial locations. This is not a "worst case," such as would be found in Boston or in the New York City garment district. New Jersey is a major North-South bridge state for truck traffic and Pennsylvania has the third highest truck registration in the country. Also, the area studied is served by a number of toll highways and bridges; plus being a major port.

Houston, TX area is typical of the fast growing and open new South and Southwest. Commercial and industrial locations are widely dispersed and a port facility is provided via the Houston Ship Channel. Texas has the second largest number of registered trucks of any state.

Chicago IL has long been recognized as the freight hub of the nation for all modes of transportation. Served by more truck lines, railroads, and piggyback yards — plus its Lake Michigan port — Chicago epitomizes the industrial heartland. Traffic conditions range from highly congested city streets to free flowing suburban expressways. Here, a major fraction of the Nation's freight is trans-shipped both intramodally and inter-modally.

Bay Area CA embraces the cities of San Francisco, Oakland, San Jose and all of the medium-sized towns which lie along the shores of San Francisco Bay. Typical of the West Coast, the Bay Area is served by a multitude of freeways, expressways and bridges. Local development tends to be of the "strip" type, and distances between individual traffic generators (factories, distribution centers, shopping centers, etc.) are relatively great. Again, San Francisco is a major seaport. California has more registered trucks than any state in the country — over 11 percent of the total.

Overall, the five states covered by the project field studies account for 27.9 percent of all U.S. registered trucks of all sizes and for 28.1 percent of all truck travel (6.86 million vehicles and 81.31 billion miles).

A crew was assembled and trained for the project using the instructions included in this Appendix as *Procedures, Crew Assignments, Duties, Mechanics*. The author acted as crew chief and the driving assignment was handled by a professional truck driver who was experienced in operating a combination vehicle in all of the areas visited. The driver's special skill in being capable of duplicating virtually the same average speed over a given highway section added greatly to the accuracy of the data. This was important since, in most instances, most highways or street sections were actually traversed four separate times — once each for familiarization, for a pedestrian exposure count, for a vehicle occupant exposure count, and finally for a following time test.

The other three members of the research crew, all students or graduate students of transportation, showed a remarkably high degree of skill and accuracy in their work. Some concern was expressed over the ability of this staff to count pedestrians or vehicles in very high volumes under certain traffic conditions. A set of stopwatch-controlled tests showed that a person can, with a hand click counter, accurately count 200 persons or vehicles per minute over a sustained period — and up to 250 for short periods of time. This maximum limit was approached only a very few times during the study, and then only briefly.

Since it was not practical to operate a truck combination as a test vehicle — due to its lack of seating capacity and visibility for the crew members — observations were made utilizing either a nine passenger station wagon or a twelve passenger van. To compensate for the smaller size of these vehicles, compared to a combination truck, the professional driver started, accelerated, slowed and stopped in a manner — and at the speeds — consistant with the performance of a combination. In each area, and with each vehicle used, an effort was made to check the accuracy of the vehicle odometer against posted highway test sections. In all instances, these were found to be well within the limits of acceptable accuracy for the test operations.

It will be noted on the "Computations" section of the *MASTER WORKSHEET* that mileage and average speed are shown. The mileage was computed as the odometer end reading less the odometer start reading — expressed in miles and tenths of a mile. "Average speed" was computed by converting the "elapsed time" into a percentage of 60 minutes (times were posted first in minutes and seconds and then converted into minutes and hundreths of a minute) and then dividing this number into the "mileage."

On the "Following time runs," the "average time per observation" on the master worksheet was computed for each test run by dividing the total number of seconds shown for all observations on that run by the number of individual observations. "Vehicle Count Runs" were converted into person observations on the basis of Federal data on average vehicle occupancy. For rural highways, this is 2.3 persons per vehicle, while suburban and urban highway occupancy rates are 1.8 and 1.5 persons respectively. In all instances, buses (and surface rail transit cars) were converted at 15 passengers per vehicle — also based on Federal data.

Finally, it is obviously impossible to tabulate each and every person or vehicle that sees a truck in traffic. It is inevitable that some will be overlooked — patrons of a restaurant facing a window which overlooks the road, cars pulling from a parking lot, and the like. Thus it is estimated that the tabulated results represent an understatement of actual total visual impressions in the magnitude of about five percent. On this basis, the data may be considered to be conservative as to the total impressions produced.

PROCEDURES

On each test run:

- — vehicle reaches traffic speed prior to initial point.
- — at initial point, odometer reading is taken, stop watch is actuated, and chief announces "count."
- — simultaneously, pedestrian or vehicle counts are commenced.
- — at end of run, chief announces "stop", and stop watch is stopped, while simultaneous odometer reading is taken.
- — Procedure is different for vehicle following runs and will consist of a simple calling of "start" and "stop" by observer to timer/recorder.
- — Separate runs are made for pedestrian and vehicle counts — on each road.

Observation Criteria (see attached sketch)

- — pedestrians are considered to have seen front and/or side of vehicle if they are either facing the street (on either side) or are facing the vehicle. Pedestrians are considered to have seen the rear of the vehicle only if they are facing in the direction of travel of the vehicle.
- — other vehicles (and their occupants) are considered to have seen the front and/or sides of the vehicle (test) if they are (1) approaching from the opposite direction, (2) waiting at an intersection which has an included angle of at least 90 degrees to the traveled way, or (3) are on an overpass crossing the traveled way. Other vehicles (and their occupants) are considered to have seen the back of the test vehicle if they are (1) following the test vehicle, (2) overtaking and passing the test vehicle on either side, or (3) are waiting at an intersection which has an included angle of less than 90 degrees with the traveled way.

CREW ASSIGNMENTS

Project Director
- Position — front seat
- — coordinate and direct project crew

Driver
- Position — in driver's seat
- — drive test vehicle under instructions of project director

Observer — Rear #1
- Position — in back facing rearward
- — Observe and count pedestrians and vehicles who see rear of test vehicle.
- — participate in time followed observations
- NOTE — due to uncomfortable position and added responsibility of this observer, duties will be rotated among observers.

Observer — Front Right (or curb) #2
- Position — in middle seat facing forward and to the right.
- — observe and count pedestrians and vehicles that see test vehicle on right side (see above and sketch)
- — participate in time followed observations.

Observer — Front Left (or traffic) #3
- Position — in middle seat facing forward and to the left.
- — observe and count pedestrians and vehicles that see test vehicle on the left side and from the front (see above and sketch).

DUTIES

Project Director
- — handle stopwatch, note odometer readings, determine run limits, navigate

Driver
- — drive at or below posted speed never exceeding 55 mph unless all traffic exceeds such limit.
- — start, accelerate, turn and stop vehicle in manner, and at rate, which simulate tractor semitrailer.
- — when being followed by an auto, stay close to left edge of lane and slow slightly (or "tap" brakes) to encourage following motorist to pass test vehicle as they would if it were a combination.

Observer #1
- — using a click counter, count pedestrians or vehicles which see rear of test vehicle on observation runs. Record data on worksheets.
- — give audible signal when auto pulls in behind test vehicle on time followed runs, and another audible signal when said auto commences to overtake test vehicle.

Observer #2
- — using a click counter, count pedestrians or vehicles which see right side of test vehicle on observation runs. Record data on worksheets.
- — using a stopwatch, record on worksheet time test vehicle is followed in time followed runs, taking time cue from observer #1.

Observer #3
- — using 2 click counters, count pedestrians or vehicles which see (1) left side and (2) front of test vehicle on observation runs. Record data on worksheets.

MECHANICS

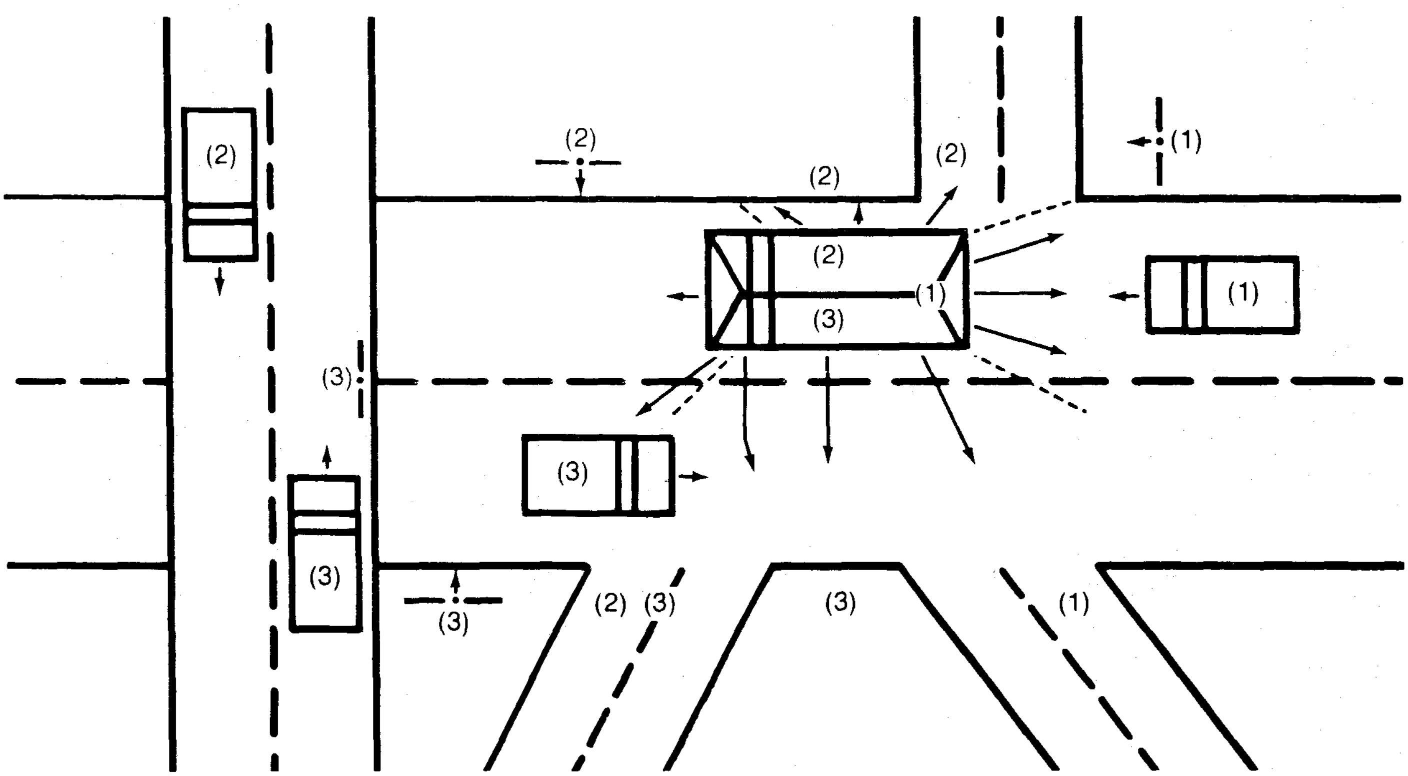
- — Equipment
  - — 2 stopwatches (one a "back-up" unit)
  - — 5 click counters (one a "back-up unit)
  - — clipboards
  - — route maps
  - — test vehicle
- — Usage
  - — Stopwatches to measure elapsed time of observation and time followed runs. Watch should be read in minutes and seconds and should be reset after each run.
  - — Click counters to be used to count pedestrians and vehicles on observation runs, and should be reset to zero after each run is recorded.

— clipboards to hold worksheets.
— route maps will be marked with routes to be followed.
— An attempt will be made with each test vehicle to check accuracy of odometer during the course of pre-observation practice runs (see below).

— Routes
— Prior to actual test runs, each route will be run for practice to observe any special conditions (road work, detours, etc.) and to familiarize driver and observers with route.
— For the most part, individual route sections will be limited to 10 miles each or less.
— Routes will include all types of highways; urban, suburban and rural.
— All runs will be made in the daylight, off-peak, mid-week hours.

— Worksheets
Each city, route and run will have separate worksheet sets which will be coded for identification.
— City Codes (director will keep "master" sheet)
I – Philadelphia/Camden
II – Houston
III – Chicago
IV – California Bay Area
— Type of Run codes (director will keep "master" sheet)
P – Pedestrian counts
V – Vehicle counts
F – Following time counts
— Route destination codes (director will keep "master" sheet with route #)
ISR – Interstate Rural
ISS – Interstate suburban
T – Toll Road
RPM – Rural primary multi-lane
RPT – Rural primary two-lane
SAM – Suburban arterial multi-lane
SL – Suburban local
CA – City arterial
CS – City street
— Observer codes
— Each observer will code and mark each worksheet used with observer number (#1, #2, #3) *corresponding to task performed on the run involved* — and will initial sheet.

— General
— Worksheets will be used only once each, and will contain no extraneous marks or comments. All special notes to be entered on "master" sheet.
— Worksheets for each run will be collected at the end of the run to avoid re-use.



RUN NUMBER **MASTER WORKSHEET**

City — I — Philadelphia/Camden
— II — Houston
— III — Chicago
— IV — Cal. Bay Area

Date ______________________

Time ______________________

Conditions
Weather ______________________

Traffic ______________________

Roadway ______________________
Speed Limit ______________________

Type of Run
— F — Following Time
— P — Pedestrian Count
— V — Vehicle Count

Route Description

Number ______________ Name ______________ Direction — E — W — N — S

No. of Lanes ______________ Access Control — Y — N Surface ______________

Start Point ______________ End Point ______________

Route Designation
— ISR ____ (interstate rural)
— ISS ____ (interstate suburban)
— T ____ (toll)
— RPM ____ (rural primary multi-lane)
— RPT ____ (rural primary two-lane)
— SAM ____ (suburban arterial multi-lane)
— SL ____ (suburban local)
— CA ____ (city arterial)
— CA ____ (city street)

Timing
Elapsed Time ______________ Time-Of-Day (end) ______________

Mileage
Odometer — Start ______________ End ______________

COMMENTS AND NOTES

____

COMPUTATIONS

Mileage ________ Ave. speed ________

"F" Runs
No. of Observations ________ Ave. time per observation ________

"P" Runs
#1 ________ Per Mile ________ Per Hour ________
#2 ________ Per Mile ________ Per Hour ________
#3F ________ Per Mile ________ Per Hour ________
#3S ________ Per Mile ________ Per Hour ________

"V" Runs
#1 ________ Per Mile ________ Per Hour ________
#2 ________ Per Mile ________ Per Hour ________
#3F ________ Per Mile ________ Per Hour ________
#3S ________ Per Mile ________ Per Hour ________

RUN NUMBER________ **WORKSHEET**

Observer — #1________ #2________ #3F________ #3S________
(F = front, S = side)

Name________ Date________ Time________

City

— I — Philadelphia/Camden
— II — Houston
— III — Chicago
— IV — Cal. Bay Area

Type of Run

— F — Following Time
— P — Pedestrian Count
— V — Vehicle Count

FOLLOWING TIME RUNS (list time in seconds for each observation)

1. ____ 2. ____ 3. ____ 4. ____ 5. ____ 6. ____ 7. ____

8. ____ 9. ____ 10. ____ 11. ____ 12. ____ 13. ____ 14. ____

15. ____ 16. ____ 17. ____ 18. ____ 19. ____ 20. ____ 21. ____

22. ____ 23. ____ 24. ____ 25. ____ 26. ____ 27. ____ 28. ____

PEDESTRIAN COUNT RUNS (use click counter and enter totals)

Number counted________

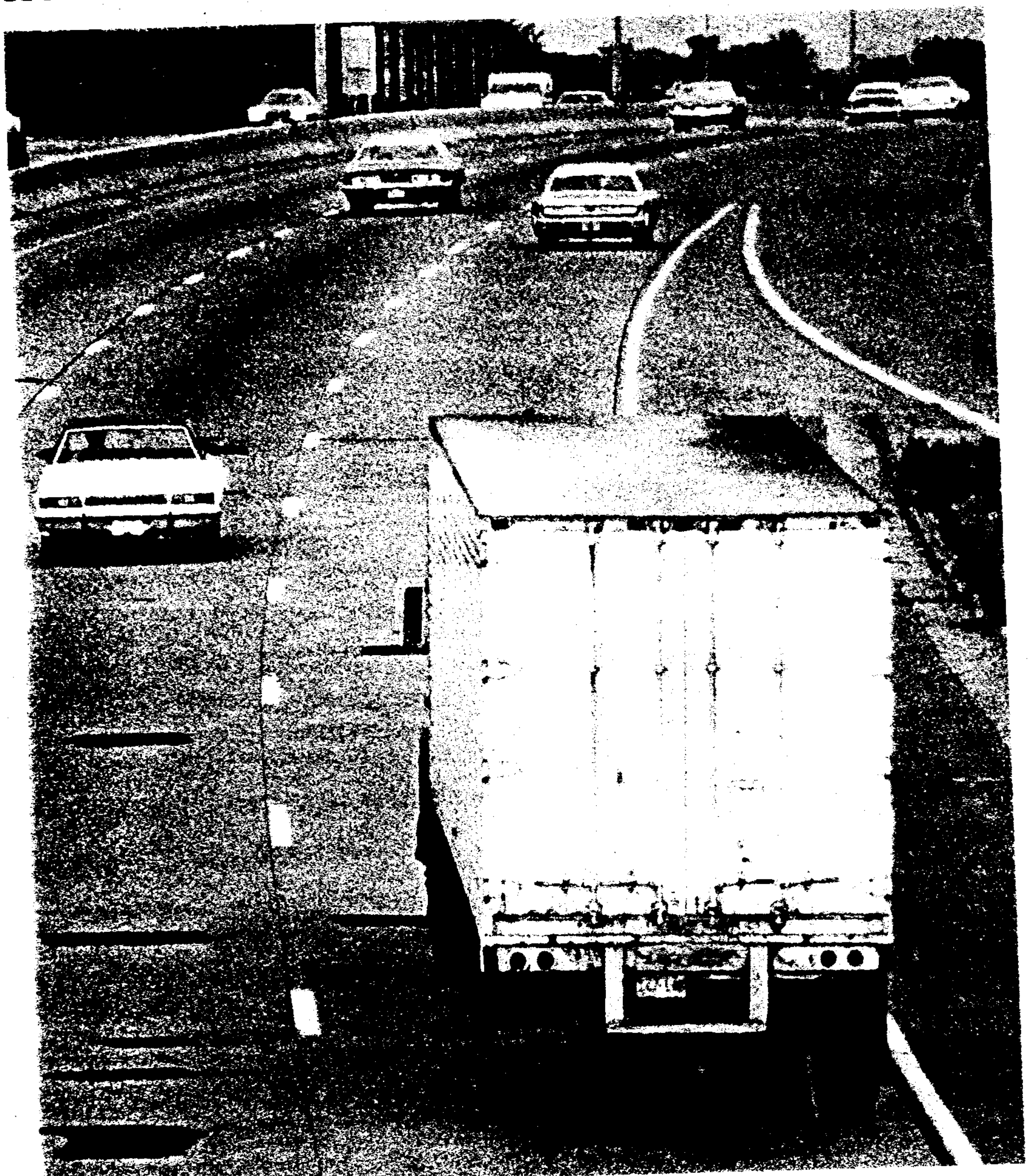
VEHICLE COUNT RUNS (count **all** vehicles only. Conversion to persons will be made later at 1.5 persons per vehicle on urban sections, 1.8 on suburban, and 2.3 on rural)

Number counted________ **NOTE:** Mark any buses seen and included in count________

COMMENTS ________

FOR WORKING NOTES AND SCRIBBLES

The Visual Impact of Trucks in Traffic



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