DIAGRAMMATIC SIGN STUDY

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Diagrammatic signs offer inherent improvements in road sign communication. Motorists are provided with more complete information on exits without additional words. The findings of this study show an improvement in exiting maneuvers after diagrammatic signs were installed and after lane lines were added to the diagrams on northbound I-287 at the left exit to westbound US-22. It is recommended that further evaluation of diagrammatic signing be carried out for a variety of exit configurations and for a whole series of interchanges. Serious consideration should be given to including the diagrammatic concept in new standards.

•THE USE of diagrammatic signs has been suggested as a method to reduce confusion at exits on the Interstate highway system. In 1968, the Special Subcommittee on the Federal-Aid Highway Program of the Committee on Public Works of the U.S. House of Representatives, known as the Blatnik Committee, took 16-mm movies and 35-mm stills of traffic approaching various exits at the interchange of I-95 and I-495 in Washington, D.C. The films show that a large number of vehicles swerve, stop, and back in the exit gore areas. The committee members generally assumed that the erratic behavior found was a result of confusion and that inadequate signing or road geometry or both were part of the problem. The erratic or unusual maneuvers shown in the films were considered to be symptomatic of both a hazardous situation and an annoyance to many motorists. The frequency of these maneuvers, it was felt, might be reduced by the installation of signs that will more adequately serve the needs of unfamiliar as well as familiar motorists.

The concept of using diagrams in signs is not new. The British have installed several signs of this type with apparent success. Symbolic warning signs have been used extensively in the United States and other countries.

The Federal Highway Administration's Office of Traffic Engineering had diagrammatic signs installed at the I-95 and I-495 interchange in Washington, D.C., and the engineers compared before-and-after frequencies of unusual maneuvers. They concluded that the comparison was not valid because of a difference in the proportion of "unfamiliar" motorists between the 2 study periods.

The FHWA requested that states carry out similar projects for a more thorough evaluation of freeway diagrammatics. In cooperation with the FHWA, the Division of Research and Development of New Jersey's Department of Transportation designed and had installed a system of these signs on northbound I-287 at US-22 in northcentral New Jersey.

SITE SELECTION

The interchange of northbound I-287 with US-22 was chosen from a careful investigation of 6 interchanges on the Interstate highway system in New Jersey. Aerial and on-ground photographs, as well as construction plans, were used in the investigation. Two interchanges were chosen for more detailed investigation. They were unique in that they both involved a left exit. The interchange of northbound I-287 with US-22

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was chosen because its geometric design was more conventional. At this site the drivers exiting to westbound US-22 are provided with 2 added, extra-long, high-speed deceleration lanes.

Interstate 287 is a particularly important location for study. When it is completed, it will connect with an Interstate system encircling New York City as I-495 encircles Washington, D.C.

STUDY SITE LOCATION AND DESCRIPTION

The chosen site is located in Bridgewater Township, Somerset County, approximately 10 miles northwest of New Brunswick. There are 4 interchanges in the 4 miles that precede the study site, the last of which is less than ½ mile away. On the northbound roadway, 3 lanes continue through. One lane is added on the right for the eastbound exit. Two lanes are added on the left for the westbound exit. These and other study site characteristics are shown in Figure 1. The approach to the first overhead sign (sign 2) is on a 1½-deg right curve. From that point to the last sign (sign 5), the road is tangent with a 2½ percent positive grade. The road then curves to the left on a 1½-deg curve beyond the last sign and maintains a slight positive grade.

PROCEDURE

Study and Sign Revision Sequence

The signs for the interchange of northbound I-287 at US-22 were altered or changed on 3 separate occasions (Figs. 2, 3, 4, and 5). The changes were made as follows:

1. Modification to a more standard form that was both in conformance with the Interstate sign manual (2) and compatible with the diagrammatic sign plans,
2. Replacement with new diagrammatic signs, and
3. Addition of lane lines within the diagrams.

The timing of sign changes and before-and-after studies was a major consideration in planning. The span of time between studies should not be so long that the proportion of unfamiliar drivers would be likely to change because of unknown causes. The span of time should not be so short between the sign change and the after study that familiar drivers would not have an adequate chance to get used to the new signs. It was decided that at least a week should be planned between the change and the after study, and no more than 2 months should be allowed between the before and the after studies.

Five separate studies were made of the sign changes. All the conditions of signing were studied, and each was compared with the previous condition. Studies were made in the following sequence, as shown in Figure 6.

1. Original signs versus modified signs—The original signs were studied in July and August 1969; the signs were modified in September and then studied in October. The comparison made was not a main objective but was included for informational purposes.
2. Modified signs versus diagrammatic signs—Diagrammatic signs were installed in late October 1969, and the data taken of modified signs in early October were compared with data from a study of diagrammatic signs made in November.
3. Diagrammatic signs in 2 seasons—Diagrammatic signs were studied in early May 1970 and in November 1969. The data were compared to measure the difference in the rate of unusual maneuvers with no changes in signing.
4. Diagrammatic signs versus diagrammatic signs with lane lines—Lane lines were added to the diagrams in late May 1970. The data from a study made in late June were compared with the data taken in May.

Study Procedure

In all studies, the number of unusual maneuvers at the exit gore from northbound I-287 to westbound US-22 were counted. The behavior of the traffic at the exit to eastbound US-22 was not studied because the volume of traffic using the eastbound exit was too small.

Figure 1. Study site.

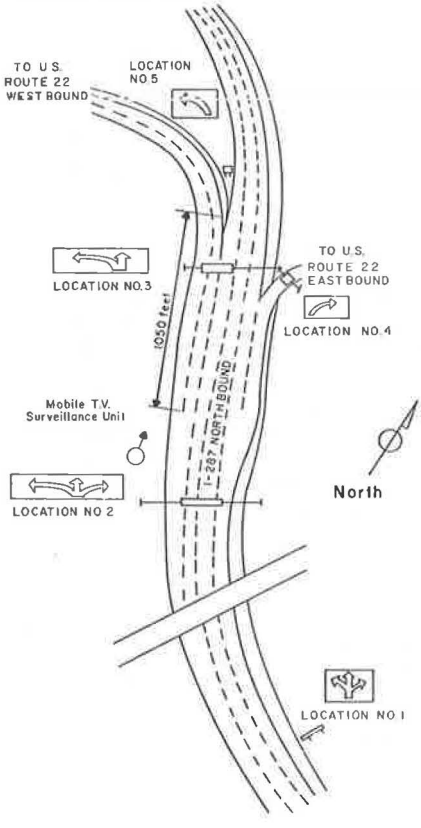


Figure 2. Sign 1.

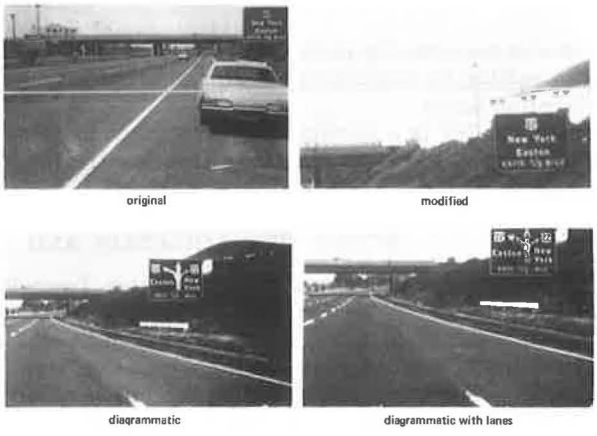


Figure 3. Sign 2.

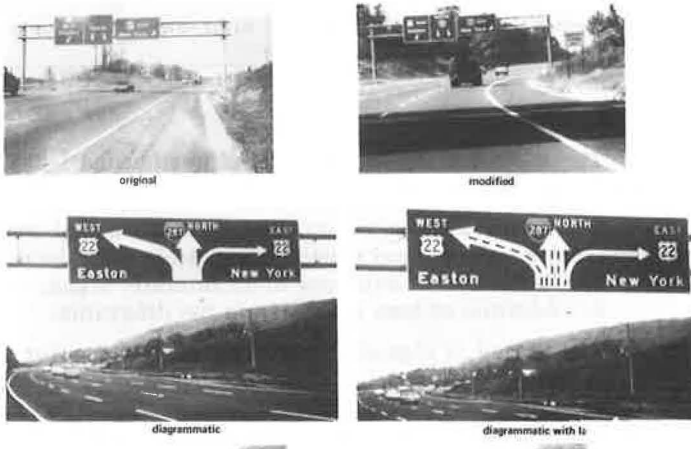


Figure 4. Signs 3 and 4.

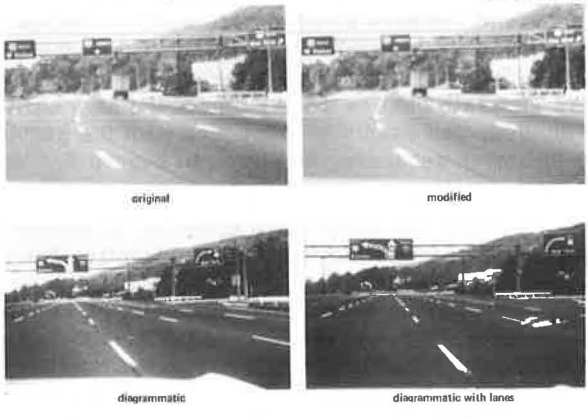
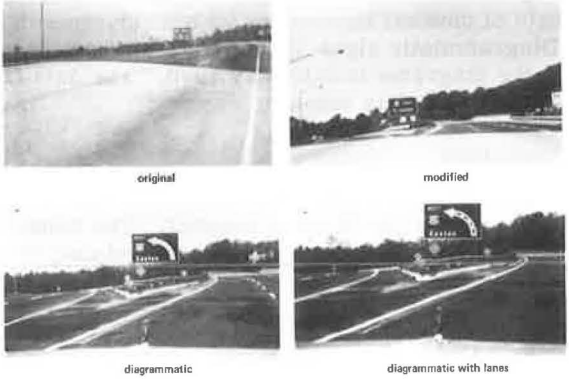


Figure 5. Sign 5.



Automatic traffic counters and TV recorders were used to record the data. Streeter-Amet hourly counters were placed to record the through volume and the left exit volume. The counters were placed at considerable distances past the exit gore so that they were not readily noticed by approaching drivers. The traffic approaching the exit gore was recorded on video tapes by means of a mobile TV surveillance unit (Fig. 7). The camera was adjusted to record all lanes from 400 ft upstream of the physical gore to the points beyond it. An audio band on the tapes recorded the time as announced every 5 min. Separate tapes recorded each hour of traffic. The study was limited to afternoon traffic.

The tapes were played back in the office under well-supervised conditions. A 15-min count of vehicles by number of axles was made for each hour. All unusual maneuvers that took place were noted and counted by hour (2 to 3 p.m., 3 to 4 p.m., and so on), movement (exit or through), number of axles (2 or more than 2), and initial and final lanes used. A summary of the unusual maneuver rates for 1 day (Monday) is given in Table 1.

Unusual Maneuvers Defined

An unusual maneuver, as defined for this study, includes any stopping, backing, or crossing the gore line in the section of northbound I-287 between the physical gore and a point 200 ft upstream of it (Fig. 8). The gore line in this case includes both the solid striped gore that is placed in front of the physical gore and the dashed line that continues upstream from the solid stripe. No more than 1 unusual maneuver was counted for any 1 vehicle. Some examples of unusual maneuvers are shown in Figure 8.

Data Correction

Several corrections to hourly data were necessary. Corrections for counter clock errors were made to the nearest 60th of a unit on a linear basis. Some missing through volumes were estimated on the basis of a linear regression analysis. The data for the regression were obtained from a study of volumes from prior weeks that were equivalent in day of week and time of day. The equation, $V = C/(X + 1.56y)$, was used to estimate the number of vehicles, given the machine counts, C, and the sample proportions of 2-axle, X, and 3- or more axle, y, vehicles in each hour. The constant 1.56 is based on a study of axle distributions made from earlier TV recordings from the same location. In cases where the television apparatus failed to yield a recording for short periods of time, the periods of failure were totaled for a given hour, and a linear correction was made to the unusual maneuver frequency totals.

Data Analysis

Comparisons were made by hour of exit. Two-axle rates were the only ones made because these categories consistently represented the vast majority of unusual maneuvers that occurred at the gore.

The Wilcoxon matched-pairs, signed-ranks method was used to test the significance of differences found in the comparisons (1, p. 361). The pairs were matched by hour, day, and number of axles. The following formula was used:

$$Z = \{T - [N(N + 1)]/4\}/\sqrt{[N(N + 1)\ (2N + 1)]/24}$$

where

T = smallest sum of ranks having similar signs;
N = number of qualified ranks; and
Z = normal standard deviation.

RESULTS

Original Signs Versus Modified Signs

No significant difference in the rates of unusual maneuvers was found at the 95 percent level of confidence after the signs were modified.

Figure 6. Time sequence of studies.

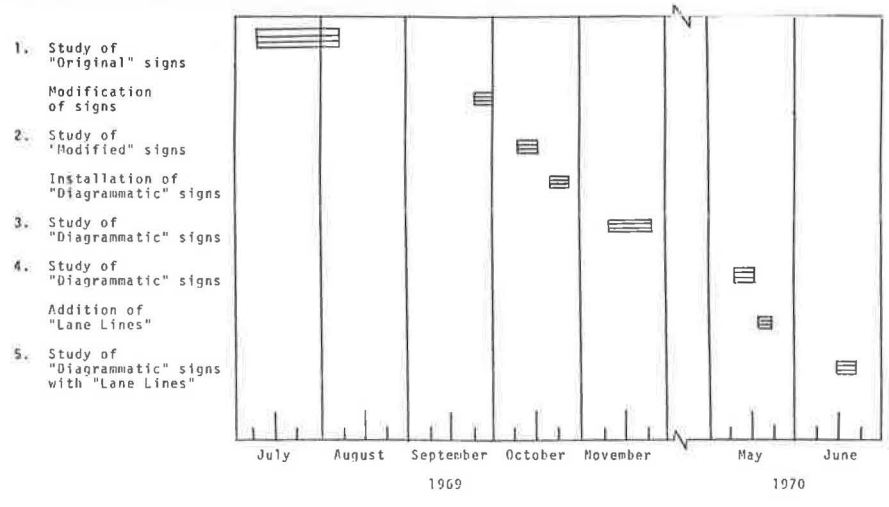


Table 1. Summary of unusual maneuvers on Mondays of 5 time periods.

Sign	Date	Hour (p.m.)	Axles	Lanes Used in Unusual Maneuver[a] E 3-2	E 4-2	E 5-2	E 2-2	T 2-3	T 3-3	Total[b] E	Total[b] T	Volume E	Volume T[c]	Rate E	Rate T
Original	7-7-69	2-3	2	11	2			1		13	1	395		0.033	
			3+	0	0			0		0	1	25		0.000	
		3-4	2	11	1					12	0	476		0.025	
			3+	2	0					2	0	25		0.080	
		4-5	2	10	2	2		1		14	2	662		0.021	
			3+	0	0	0		0		0	0	50		0.000	
		5-6	2	16	1			2	1	17	3	772		0.022	
			3+	2	0			0	0	2	0	16		0.125	
		6-7	2	5	1				1	6	1	452		0.013	
			3+	1	1				0	2	0	56		0.036	
Modified	10-13-69	2-3	2	11		1		1		12	1	390	256	0.031	0.00
			3+	2		0		0		2	0	34	132	0.059	0.00
		3-4	2	12			1	1		13	1	555	343	0.023	0.00
			3+	1			0	0		1	0	48	86	0.021	0.00
		4-5	2	27	2			1		29	1	713	578	0.041	0.00
			3+	1	0			0		1	0	54	86	0.019	0.00
		5-6	2	16						16	0	725	657	0.022	0.00
			3+	0						0	0	15	42	0.000	0.00
Diagrammatic	11-24-69	2-3	2	15						15	0	383	297	0.039	0.00
			3+	1						1	0	20	147	0.050	0.00
		3-4	2	12	2			1		14	1	482	325	0.029	0.00
			3+	2	0			0		2	0	85	168	0.024	0.00
		4-5	2	10.3						10.3	0	605	584	0.017	0.00
			3+	1.7						1.7	0	115	174	0.015	0.00
Diagrammatic	5-11-70	2-3	2	15	1					16		274	207	0.058	0.0
			3+	5						5		87	111	0.057	0.0
		3-4	2	25				1		25	1	373	230	0.067	0.0
			3+	7						7		111	76	0.063	
		4-5	2	36	2			1		38	1	464	460	0.082	0.0
			3+	1						1		52	108	0.019	
Diagrammatic with lines	6-29-70	2-3	2	17	1			3		18	3	317	214	0.057	0.0
			3+	2	1			0		3	0	56	83	0.054	0.0
		3-4	2	13	0			5		13	5	396	236	0.033	0.0
			3+	5	1			0		6	0	75	117	0.080	0.0
		4-5	2	32	1			1		33	1	626	319	0.053	0.0
			3+	3	0			1		3	1	62	90	0.048	0.0

Note: E = exiting vehicles, and T = through vehicles.

[a]See Figure 8. [b]May reflect miscellaneous categories not shown. [c]Not available for July 7, 1969.

Figure 7. Mobile TV surveillance unit.

Figure 8. Identification of unusual maneuvers.

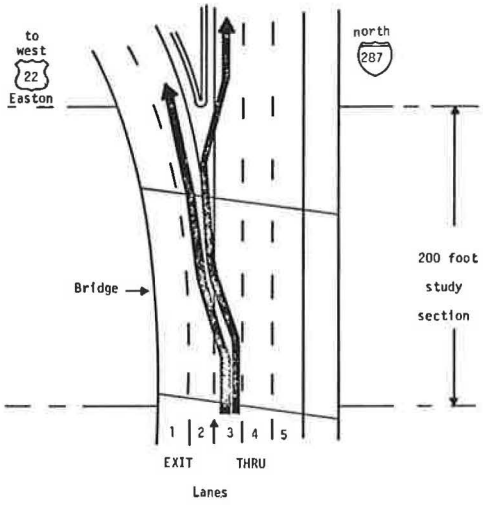
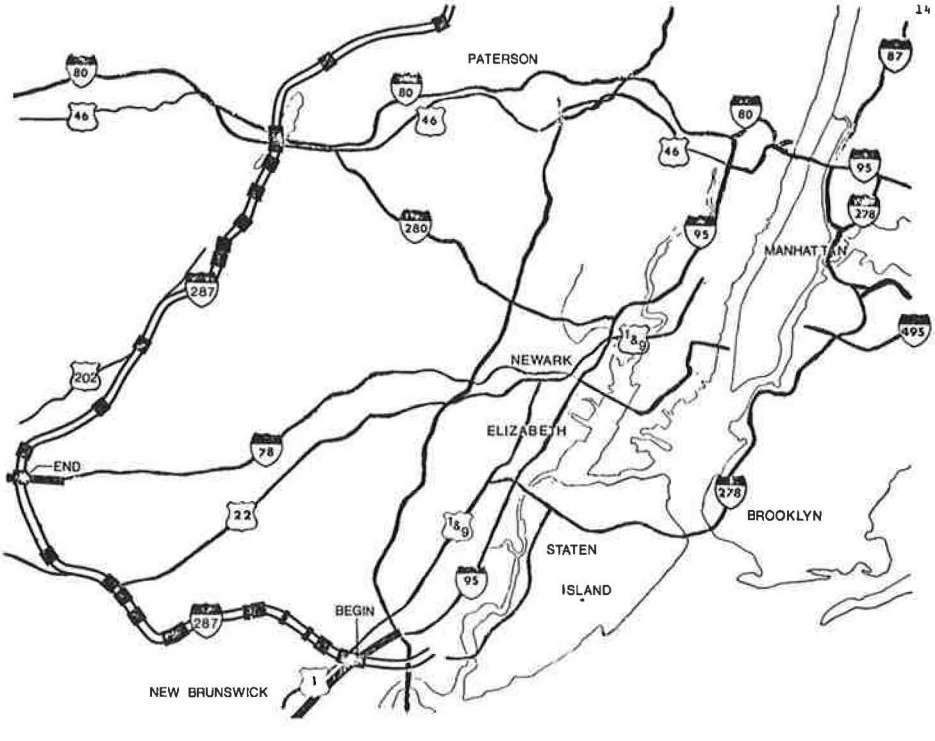


Figure 9. Area of proposed sign changes.



A significantly lower rate could have been expected with the modified signs if it can be accepted that October will have a lower proportion of unfamiliar motorists than July or August.

Modified Signs Versus Diagrammatic Signs

A significant reduction at the 95 percent level of confidence in the rates of unusual maneuvers was found after diagrammatic signs were installed.

The specific changes made on the signs were (a) the exchange of diagrammatic with conventional arrows and subsequent repositioning of messages and (b) the addition of one US-22 shield on the first sign.

The reduction in the rates may be partially attributed to these changes, but they may also be partially attributed to (a) the greater attention value from the uniqueness of the signs within the I-287 system and (b) the motorist's feeling that greater importance has been put on his needs at this particular location.

Diagrammatic Signs in Two Seasons

A significant increase at the 95 percent level of confidence was found in the rates of unusual maneuvers after no changes were made to the diagrammatic signs.

The higher rate may be partially attributed to the fact that the 2 sets of data compared were collected in unlike seasons and partially attributed to effects on the comparison brought about by other causes allowed to operate during the relatively long span of time (6 months) between collection periods.

Diagrammatic Signs Versus Diagrammatic Signs With Lane Lines

A significant reduction at the 95 percent level of confidence in the rates of unusual maneuvers was found after lane lines were added to the diagrammatic signs.

A higher rate could have been expected, assuming that June has a higher proportion of unfamiliar drivers than May.

DISCUSSION AND OBSERVATIONS

Observation of the diagrammatic signs points out some apparent improvements over standard signing.

1. The exit directions are more clearly communicated at more advanced locations as well as at the most advanced location, which is at the first sign.
2. The number of lanes for a movement can be communicated at the most advanced point. This may be done by a display of different arrow stem thicknesses and lane lines.
3. The destination and route number information is more meaningful because it is matched with the major diagrammatic components of the interchange on all signs. The motorist does not, therefore, have to infer the match in advance because this is done for him.
4. The driver's position relative to the exits within the interchange is more adequately communicated. Arrow stem connections and lengths show the choices left to the motorist at the sign locations.
5. The attention value of the diagrammatic signs in this study seems greater than that of the conventional signs, perhaps because the arrows add more white area.

Although a statistically significant reduction in the rate of unusual maneuvers was found after the diagrammatic signs were installed, an "ideal" application had not been made. Because of the restriction on the study that the present structures be used, the following observations were made.

1. The sign at location 3 was not referenced on the lane line that divides exit from through movements. A more ideal placement—8 ft to the left and at a more advanced point—was not possible because of the overhead structure's wind-load capacity and its constructed position.
2. In the mind of the motorist, the possibility that the exit ramp referred to on the sign at location 5 may be farther down the highway is not entirely eliminated. The sign

may have been better placed over the exit ramp on a cantilever structure with its support on the outside of the ramp.

RECOMMENDATIONS

It is recommended that further evaluation of diagrammatic signing under basic conditions be carried out for cloverleaf geometry, diamond geometry, and an entire series of interchanges. Serious consideration should be made that new standards include the diagrammatic concept.

Additional studies at US-22 should be made to learn more about the variable of unusual maneuvers as a sign-value parameter and the factors that affect it.

FUTURE PLANS

The Bureau of Operations Research has proposed a more extensive study. The proposal includes the replacing of all the signs on I-287 from the New Jersey Turnpike through the interchange at I-78 (Fig. 9). The proposed studies of 10 ramps within this section would add more data on the diagrammatic concept and also answer the question of "uniqueness" of these signs within a standard system because all the interchanges would have diagrammatic signs. This means that by the time the unfamiliar northbound driver would arrive at US-22 and other interchanges, the novelty of seeing diagrammatic signs would have worn off.

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