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# AN INVESTIGATION OF
# SIGNS FOR MEDIAN CROSSOVERS

BY

GILLIAN MARY WORSEY, 1957-

A DISSERTATION

Presented to the Faculty of the Graduate School of the

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# ABSTRACT

This paper describes a study of advance warning signs for median crossovers on divided highways. Candidate crossover signs were identified from a literature review, survey of current State practices and discussions with FHWA personnel. Seven of these signs were selected for further testing in a laboratory study for legibility, understanding and driver preference. Sixty subjects representing a cross-section of drivers took part in the study, thirty at the Turner-Fairbanks Highway Research Center in McLean, Virginia and thirty at the Unversity of Missouri-Rolla in Rolla, Missouri.

Two of the seven signs were word messages and five were symbolic signs. The results from both groups of subjects showed that the most appropriate word message sign would appear to be "Median Crossover". This sign was understood the best by the subjects to whom it was shown and "Crossover" was the word the majority of subjects thought best conveyed the intended meaning.

The symbolic sign found to be the best out of those tested was one showing two median noses. This did well in legibility and understanding tests and was least confused with other signs. It was also the symbolic sign most preferred by the subjects and was the simplest of the symbolic designs. Legibility of the symbolic signs was much greater than that of the word messages and this symbolic design is the sign recommended to identify median crossovers.

# ACKNOWLEDGEMENTS

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# TABLE OF CONTENTS

# LIST OF ILLUSTRATIONS

# LIST OF TABLES

# I. INTRODUCTION

## A. UNIFORM SIGNING

The need for a uniform system of traffic signs was recognized in this country as early as 1923 when the Mississippi Valley Association of State Highway Departments adopted recommendations that formed the basis for national standards published by the American Association of State Highway Officials (now the American Association of State Highway and Transportation Officials, AASHTO) in the 1927 "Manual and Specification for U.S. Road Markers and Signs". This manual, which was for rural use only, included an octagonal STOP sign with black letters on a yellow background. According to Rosenbaum (1983) a red background would have been used but no durable red paint or baked enamel was available.

An urban "Manual for Street Traffic Signs, Signals and Markings" was developed in 1927 and published by the National Conference on Street and Highway Safety in 1929. In this manual, the octagonal STOP sign had red letters on a yellow background.

The necessity for unification of standards for all roads and streets was therefore obvious and to meet this need, a joint committee of AASHTO and the National Conference on Street and Highway Safety was formed which led to the original edition of the "Manual of Uniform Traffic Control Devices" which was published in 1935. In this edition the STOP sign was permitted to have black or red letters.

The Manual on Uniform Traffic Control Devices (MUTCD) has since been through a number of editions and revisions, ending with the present 1978 edition. The committee, although changed from time to time in organization and personnel, has been in continuous existence since the first edition and since 1972 it has been known as the National Advisory Committee (NAC) on Uniform Traffic Control Devices. In making the 1946 revisions the committee expressed concern about the need for uniformity through State legislation and training (Neal, 1946).

The present STOP sign with white letters on a red background was included in the 1954 edition of the MUTCD and had been in general use since 1951. This edition also included a triangular YIELD sign with a black "YIELD RIGHT OF WAY" on a yellow background. In the 1961 edition of the Manual this was reduced to "YIELD" and it was not until the 1971 edition that the present design was adopted which was adapted from the international sign for "give way".

According to Elliot (1960), sign standardization began in Europe even earlier, in 1909, when four symbol signs were adopted by the Convention on the International Circulation of Motor Vehicles held in Paris. This was followed in 1926 by the adoption of a triangular shape for danger or warning signs by the Convention Relative to Motor Traffic and in 1931 by circular regulatory and rectangular information signs by the Convention for the Unification of Road Signs. In 1939 a committee of the League of Nations recommended an international road sign system but World War II prevented its implementation. In 1949 the idea of a uniform sign system world wide was discussed by the United Nations and a protocol of road signs and signals was proposed by the U.N. Conference on Road and Motor Transport held in Geneva. In the early 1950's a U.N. group of experts was formed to study the problem further and recommended an international system in 1953 but this was not widely adopted. The

1949 Protocol still forms the basis of the sign system now generally used throughout Europe and it makes great use of symbols.

The adoption of the U.N. Protocol has been somewhat gradual however. For example, according to Duff and Greig (1972), by 1949 the United Kingdom was already committed to a system with signs based on the recommendations of a Government Departmental Committee on Traffic Signs made in 1944 which used both words and symbols. However in the 1960's, in response to public and Parliamentary pressure, the British Ministry of Transport set up a committee which recommended adopting the U.N. Protocol signs. The changeover began in 1965 and nearly all traffic signs in Great Britain now conform to this system.

According to Kikura and Matsushita (1972), in 1950 an effort was made in Japan to conform to the U.N. signs but not all of the proposed modifications were adopted. The U.N. signs were adopted for prohibitory, mandatory and guide signs but American style diamond warning signs were adopted. Words in Japanese and English were added to symbolic signs for educational purposes. It was not until 1963 that the U.N. signs were extensively adopted and the word indications were eliminated, thereby increasing the number of signs with symbols only.

According to Sharp and Jardine (1970), Canada's Constitution assigns the responsibility for public roads to individual provincial governments and so a similar situation exists to that in the United States. As urbanization proceeded, local governments who had been delegated authority for street networks by the provinces became concened with the question of uniform traffic control and as no one government level was in a position to legislate uniformity for all of Canada, a

Joint Committee on Uniform Control Devices was formed by the Canadian Section of the Institute of Traffic Engineers (now the Institute of Transportation Engineers, ITE) and the Canadian Good Roads Association. After five years of work the first edition of the Canadian Manual of Uniform Traffic Control Devices was published in 1960.

The American Manual had been used by most traffic engineers in Canada for 25 years but the bilingual culture of Quebec did not lend itself to this Manual, especially worded sign messages which were cumbersome. In the Canadian Manual, shape and colour were largely retained from the American system but symbols were increasingly used, based on those already in use in Quebec and European and South American signs.

One difference, according to McLean (1972), is the use of positive signs instead of negative or prohibitory signs. Turn control signs indicate the movement allowed at an intersection rather than those prohibited. The resulting signs which have a green circle containing arrows to indicate the allowed movements have been in use in some places for ten years.

There has therefore been an increasing trend towards uniformity of traffic signs over the years and particularly toward the use of symbolic signs.

## B. MEDIAN CROSSOVER SIGNS

The 1978 MUTCD provides for the marking of official or emergency use median crossovers on divided highways with a double delineator on the left side of the through roadway on the far side of the crossover (page 3D-2). However no way of marking public use crossovers was included in the Manual until the third revision of September 1984.

From a survey of the States' practices of signing median crossovers on divided highways, the question of special signing for crossovers seems to have first been addressed in Virginia where a special green and white crossover sign was developed and installed in the Salem and Suffolk Districts as a means of enhancing motorists' awareness of the presence of a crossover in the early 1960's (see Figure 1). This was done particularly for the benefit of the State Police in that area who felt that the standard edge delineator used in Virginia to mark crossovers on non-limited access divided highways did not allow crossovers to be readily seen when they needed to reverse direction on a divided highway in a hurry. The standard edge delineators were also used to mark objects adjacent to the roadway.

These special signs were installed on three crossovers on Route 60 in Chesterfield County, Virginia in 1975 with the intention of evaluating them under different atmospheric ocnditions for approximately six months but the evaluation was never completed.

In 1983 a task force on crossover markers was established on the recommendation of the Virginia Traffic Research Advisory Committee which in turn recommended performing an evaluation of crossover markers, including the MUTCD double yellow delineator, the Virginia standard edge delineator and the special crossover sign. They also recommended using object markers instead of edge delineators to mark objects adjacent to the roadway to conform to Section 3C of the MUTCD.

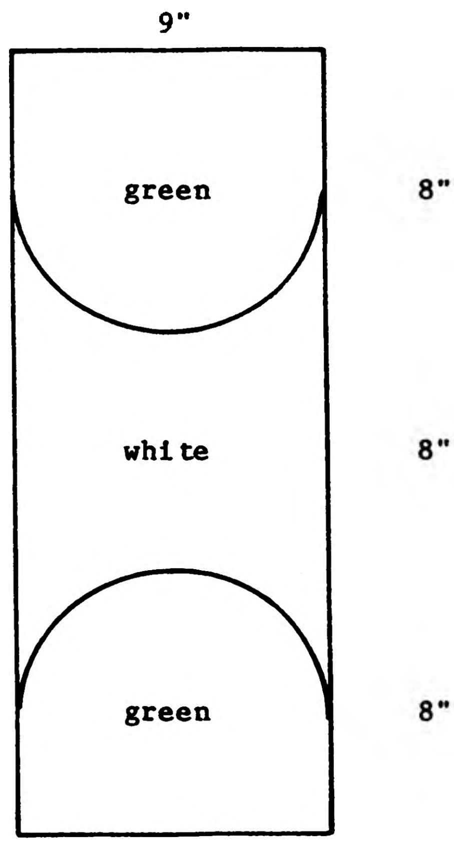



Figure 1. Virginia Crossover Sign

The evaluation of crossover markers was carried out by the Virginia Highway and Transportation Research Council at the end of 1983 and consisted of a brakelight survey, a study of detection and legibility distances and understanding and preferences and a survey of emergency service personnel, (Virginia Highway and Transportation Research Council, 1984).

Part I, the brakelight survey, was carried out on Route 29, north of Charlottesville, Virginia at two sites where each of three crossover treatments (no delineator or sign, standard edge delineator and crossover sign) was observed for three hours, between the hours of 6.00 and 9.00 p.m. The location of the initial brakelight application relative to the crossover was noted. The results did not reveal any significant differences between the three crossover treatments.

Part II of the evaluation involved a test section in which standard edge delineators were installed at one crossover and crossover signs were installed at another. Distance markers were placed in the median at 50 feet intervals for 1200 feet in advance of each crossover. Ten test drivers from the Council staff drove one of two identical test vehicles over the test section at night and were asked questions about when they saw the signs (detection distance), saw the pattern on them (legibility distance) and what they meant to them. They were also asked what cues they used to identify a crossover and which of the two signs they preferred.

The results showed that the crossover signs had a significantly greater detection distance than the standard edge delineators due to their larger size but there was no significant difference in the legibility distances. The standard delineator was concluded to be understood better and the symbol of the crossover on the crossover sign was found to be not understood at all well. The standard edge delineator was found to be the most frequently used cue to identify crossovers at night. No significant difference in the subject's preferences for the two markers was found.

Results of the survey of Rescue Squad, Fire Department, Sheriff's Department and State Police personnel were mostly favourable. The consensus was basically that the median crossover signs were useful and should be adopted as a standard in the areas where the signs were in use and that they would be helpful in those areas where they were not already in use.

These results were reported to the Virginia Traffic Research Advisory Committee in early 1984 who decided that they did not justify an attempt to have the crossover sign accepted as an official traffic control device in the MUTCD or even add it to the Virginia Supplement to the MUTCD. At the same time the amendment to the MUTCD containing the officially recommended crossover signs became effective and the State Attorney General's Office recommended following the MUTCD recommendations.

At this point in time it was pointed out that the discussion at the Traffic Research Advisory Committee resulted in the feeling that additional investigations were needed before a decision was made and this could best be done through the research programmes at the Federal Highway Administration (FHWA). A problem statement was therefore prepared and submitted for consideration by the FHWA which resulted in the study reported here and it was agreed in Virginia to defer a decision on the use of crossover signs until this study was complete.

The subject of median crossover signs was first addressed by the FHWA in the Federal Register in 1980 (80-10, 45 FR 41600) when they originated Request II-7-Signing Public Median Crossovers and suggested that highway safety could be improved by providing signing for public median crossovers that are inconspicuous to the motorist. On the basis of the 32 responses to this request (of which the majority agreed there was a need for signing of public crossovers), the FHWA published a notice of proposed amendment in the Federal Register in January 1983 (82-15, 48 FR 1075).

The National Committee on Uniform Traffic Control Devices gave consideration to a request for the adoption of the Virginia crossover sign as a standard traffic control device from a private individual in 1983 but recommended in favour of the sign proposed by the State of Texas which had been suggested by the FHWA in their proposed amendment at the beginning of the year.

Of the 26 responses to the proposed amendment, 20 endorsed the FHWA proposal and the final rule on the amendment was published in the Federal Register in December 1983 (82-15, 48 FR 54336). The amendment became effective in March 1984 and was included in the September 1984 revision of the MUTCD as sign D13-1 (see Figure 2). The feeling in Virginia however is that the Texas sign incorporated into the MUTCD which measures 6 feet by 3 feet is too big to be used in many situations.

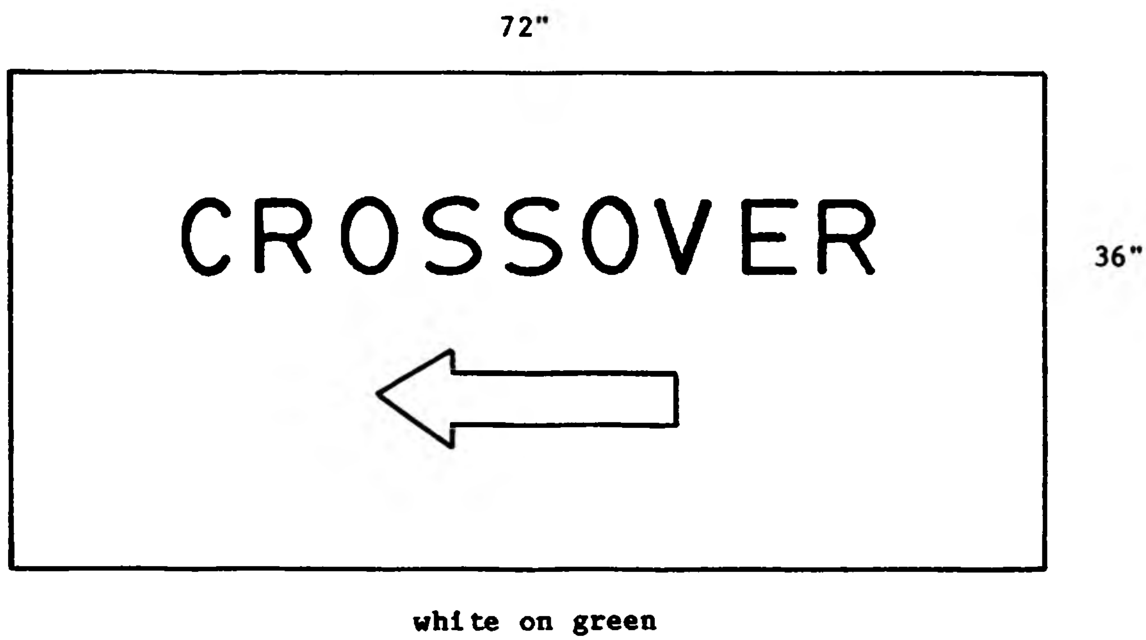



Figure 2. MUTCD Crossover Sign (D13-1)

This study has therefore set out to identify alternative designs for median crossover signs from a survey of States practices of signing median crossovers and a review of the literature on traffic signs and to test a number of these signs in a laboratory situation for legibility, recognition, meaning and preference.

# II. REVIEW OF LITERATURE

There have been numerous studies of various different aspects of highway signs and the terms used for the different aspects are confusing. This review has been divided into two major sections on the recognition and understanding of highway signs. The recognition section relates to the ability to identify a sign and has been divided into legibility which relates to the clarity of the sign and visibility which relates to its capacity to be seen. The understanding section relates to the ability to understand the meaning of a sign. These terms are somewhat confused in the literature however and one paper may belong in more than one section.

## A. RECOGNITION OF HIGHWAY SIGNS

A literature search by Forbes, Snyder and Pain (1965) of work on highway signs over the previous ten years showed that the recognition of signs had been investigated in many ways. The investigations included both laboratory and field studies and could be classified under two major headings - legibility and visibility. Legibility included the measurement of pure and glance legibility and involved such factors as letter size, width and spacing, colour of letters and contrast. Distance was usually used to measure legibility although reaction time was occasionally used. Visibility involved such facors as sign locations, background colours, visual dectectability, attention gaining characteristics and considerations such as the advantage of familiar legend and symbols.

<u>1. Legibility</u>: An early study by Forbes (1939) indicated that two

types of legibility could be measured, pure legibility and glance legibility. In this study both pure and glance legibility were tested in an outdoor study using a sign board with a shutter in front of it. When the shutter was opened, observers walked towards the sign board until they were able to read the 6-letter nonsense test words. They then recorded the distance which was marked out on the ground at 25 feet intervals and the letters they saw. For pure legibility the shutter was opened and left open. For glance legibility one second exposures were used. Wider letters with the greater spacing of the two used were found to have consistently greater legibility. The effect of reducing seeing time was to reduce the legibility distance slightly (10 - 16%). A further reduction of the exposure to 0.2 - 0.3 seconds did not consistently reduce the legibility distance.

a. Early Studies: These were mainly concerned with the legibility of letters. Forbes and Holmes (1939) studied the pure legibility of standard destination signs outdoors under both day and night conditions with reflectorized and unreflectorized letters. Reflectors were found to reduce the daytime legibility of letters less then 18 inches high only very little and the night legibility of reflectorized signs was found to be approximately the same as that of floodlit signs. Night legibility was found to be less than day legibility for all letters. A non-linear relationship was found between letter size and legibility distance and narrow letters were found to be less legible than wide ones under both day and night conditions.

Lauer (1947) attempted to develop a better stop sign with letter combinations which would best fit on an octagonal background by testing the legibility of letters in a laboratory study under low light levels. Black letters on a white background were found to be superior to the reverse arrangement and rounded letters with wide spacing were found to give the best legibility. A proposed new design was then tested outdoors and the rounded letters with wider spacing were found to increase legibility by up to 50% over the standard signs then in use.

Forbes, Moscowitz and Morgan (1950) compared the legibility of lower and upper case letters on highway signs as lower case words had been found to give more rapid reading on printed pages than all capitals. They used white letters on black backgounds in familiar and unfamiliar place names and in scrambled words. Observers walked towards a sign outdoors until they could read it. Familiar place names were found to be read at the longest distances, followed by unfamiliar names, followed by the scrambled words and these advantages were greater during the day than at night. Lower case observation distances were found to be consistently longer than those for capital letters.

Case et. al. (1952) asked subjects to read combinations of 8 letters in an outdoor experiment at different distances. Black letters on a white background were found to be more legible when the letters were closely spaced but that white letters on a black backgound were more legible when the letters were widely spaced. They attributed these results to the phenomenon of irradiation where bright objects on dark backgrounds appear to be wider than dark objects of the same size on bright backgrounds.

Solomon (1957) looked at the effect of letter width and spacing on the night legibility of highway signs using observers who drove at about

30 mph in a large parking lot. White letters on a black background were used. Improvements in legibility were found with moderate increases in the spacing of letters above that normally used and letters with reflector buttons had slightly superior legibility to similar letters made of reflective sheeting.

b. Other Studies: A variety of methods have been used to study sign legibility in both the field and laboratory. Allen and Straub (1955) studied the relationship between legibility and sign reflectance using a method where observers travelling in a car read numerals. Laboratory experiments were then undertaken where subjects viewed slides of signs of different brightness. White letters on a black background were found to be more legible than vice versa in the middle brightness range but not at extremes of brightness. When glare was introduced, legibility distance was increased at high brightness suggesting bright signs should be used where there is glare. Legibility distances were found to be less in the field by about one third.

Allen (1958) used observers sitting in the front passenger seat of a car driven at 15 mph on a flat rural highway to study night legibility distances of highway signs. An optimum level of illumination at which the night legibility of 4-letter words was greatest was found but even with this, night legibility distances were 15% less than daytime ones. Flat reflective sheeting was found to give the best legibility distances out of the reflective materials used.

Hulbert and Burg (1957) studied the overall legibility of experimental highway destination signs with different types of lines separating different directions and with two, three or four destinations per sign, different arrow configurations and different lengths of place names. Films were taken of signs placed in a standard location and, as each sign was passed on the film, as it was shown to subjects the name of a city was called out. Subjects had to mark its direction. The results showed a reduction in misreading when lines were used on signs with places of unequal length but not for place names of equal length. Errors increased as the number of destinations on the signs increased. Relative word length was found to be an important aid to reading signs.

In a study of highway signs in Virginia in 1960 (Decker, 1961) two proposed information sign colour combinations were compared using observers who read 2-word messages of familiar 4-letter words from a moving vehicle. During daylight no significant difference was found in the legibility distances of the two types of sign but at night under both high and low headlights, white on blue signs were legible at a significantly greater distance than green on white signs.

Desrosiers (1965) used a 16mm colour film of signs that had been used in a field experiment and compared the results of the two experiments. Observers drove a test car in the field experiment. Two, four and 6-word destination signs comprised of 6-letter nonsense words were used. The same results were basically found in the field and laboratory tests but legibility distances in the field were approximately five times as great as those in the laboratory. For both the field and laboratory tests a decrease in legibility distance occurred when the number of words on the sign increased from four to six and the number of errors increased as the number of words increased.

In a series of studies, Dewar, Ells and others used both field and laboratory methods to evaluate sign legibility. The first study (Dewar and Ells, 1974) compared three techniques using the same signs. In the first, subjects drove on a stretch of 2-lane undivided highway and the distance at which they could first classify signs and then identify them was measured. Both symbol and verbal signs were used. This experiment was then repeated on an unused roadway in the same vehicle using one third size signs and driving at one third of the speed. A laboratory study was also undertaken where subjects were shown slides of signs in a dark vision tunnel and asked to classify and identify them. The symbol signs were found to be identified better than the laboratory study. The results obtained from the modified road experiment correlated well with the full scale experiment.

In the second study (Dewar, Ells and Mundy, 1976) the laboratory reaction time to signs was compared to their perception in actual driving. Slides of signs were shown to subjects in a dark vision tunnel and they again had to classify and then identify them. Reaction times were found to be the same for verbal and symbol signs in classification but less for verbal signs in identification. The experiment was also repeated with an auxilliary task and reaction times were again less for verbal signs. The slides were then projected onto a colour film of a 2-lane rural highway and the subjects were required to maintain the speed on a speedometer. In this experiment the superiority of verbal signs disappeared. The reaction times were correlated with the previous on-the-road distance measures. They were found to predict the legibility of verbal signs but only those with visual distraction (shown with the film) predicted the legibility of symbol signs.

In the third study (Ells and Dewar, 1979) they had subjects listen to a traffic sign message and answer yes or no if the sign had the same meaning when a slide of a sign was shown in a dark vision tunnel. The response time under bright glare was compared to that under normal vision. The response time was found to be shorter for symbolic signs than for verbal ones and when vision was restricted the average decrement in efficiency was greater for verbal signs than for symbolic ones.

Gordon and Boyle (1978) undertook a laboratory study of the legibility of symbolic parking signs proposed for use in Dallas. The legibility distances found in the laboratory were multiplied by scale factors to obtain the legibility distances of full-size signs. Subjects moved closer to the signs until they could judge whether parking was permitted or not. The experiment was then repeated to test the legibiltiy of the word messages. On the average the symbols were identified at over five times the distance of the word messages. An experimental symbol with a large slash extending beyond the circle gave double the legibility distance of the conventional symbol. Messages with large lettering were identified at longer distances than messages with small lettering.

Avant et. al. (1984) tested drivers' recognition of word and symbol versions of eight signs by showing subjects the signs tachistoscopically. The subjects then had to decide which of the possible 16 signs which were shown outside the tachistoscope in clear vision had just been shown to them on the tachistoscope. The subjects had been shown all 16 signs used in the experiment beforehand. The correctness of each response was recorded. As expected, the number of recognition errors decreased as exposure duration increased and most of the reduction in errors occurred as exposure duration increased from 32 to 41 ms. Fewer recognition errors were made for signs requiring a slow down or lateral move. Some signs were found to produce many recognition errors with other sign messages whereas other signs produced very infrequent recognition errors.

c. Glance Legibility: This has been studied by very few authors. A study reported by Hurd (1946) undertaken by students of the Yale Bureau of Highway Traffic compared the rapid reading of the then new rounded letters and the old standard letters. A shutter arrangement was used to control the length of time observers were permitted to look at the black on white background letters. Scrambled letters and familiar words were observed on their own in 7-letter words and in groups of four 4-letter words. 0.4 second exposures were used for the single words and letter recognition for the rounded letters was found to be 8% better than for the old block type lettters. Familiar words were recognized more easily than the scrambled letters. One second exposures were also used for the groups of words which greatly increased the percentage of words recognized.

More recently Ellis King and Tierney (1970) compared the glance legibility of symbol and verbal signs. They used colour films to present subjects signs, one at a time, for exposure durations of 1/3, 1/6, 1/9 and 1/18 seconds. After each exposure subjects were asked to match the test sign with one of nine possible signs. The percentage of correct matches was found to be greater for symbol than for verbal signs. For verbal signs the percentage of correct matches increased as exposure time increased but no relationship between the percentage of correct answers and exposure time was found for symbol signs. 65% of the subjects expressed a preference for symbol signs.

In a second study, Ellis King and George (1971) extended this work using a 35 mm slide tachistoscope projector to present subjects with both symbol and word traffic signs for an exposure duration of either 1/3 or 1/18 second. Each presentation was followed by either a 5 or 10 second delay period or a 10 second interference period after which the subjects were asked to match the test sign to one of 10 shown on a following slide. During the interference period subjects were asked to read random letters. The results showed that for the 1/3 second viewing time there was no difference in the percentage of correct responses betweeen symbol and word signs for any of the three test conditions but for the 1/18 second viewing time the percentage of correct responses was higher for symbol signs than for word signs. The amount of delay or interference did not make any significant difference to the percentage of correct responses.

2. Visibility: Most studies of sign visibility have been done in the laboratory. An early study by Forbes (1939) involved taking drivers around a test route in a moderate hurry and asking them to call out all the signs they saw on the way whilst they were also engaged in conversation. He found that multiple signs tended to be read from left to right and top to bottom and that the top position showed priority in four out of five cases. Forbes defined two types of sign visibility - target value which makes a sign stand out from its background and

priority value which results in it being read first among others of the same type.

A series of studies of sign visibility was carried out in the 1960s by Forbes and his associates. The method used is described by Forbes (1964) and a summary of the results is given in Forbes (1969). Slides of highway scenes with constant illumination were displayed while subjects responded to an auxiliary task of 12 small red light stimulii located directly ahead at a point representing the view of the road. One to four of the lights were extinguished randomly and had to be relit. At varying intervals, triggered by a response to the light task, signs were superimposed on the scene and the subjects had to indicate which of the group of four they saw first and best.

In the preliminary series of five experiments it was found that signs positioned over the road were seen before others beside the road in the same slide so in the remaining experiments all four signs were positioned over the road. The second series of experiments used Interstate green signs with two white nonsense letters of four different brightnesses and four different sizes. Each subject saw the signs against a day and a night background. Overlays were used to reduce letter-to-sign contrast.

These experiments showed that signs with the greatest brightness contrast against the background were seen best, i.e. brighter signs were seen better against a night backgound and darker signs were seen better against a day background. Brighter signs were also seen better against a dark daytime backgound (Forbes et. al., 1967). The larger signs were seen best when brightness was held constant (Forbes et. al., 1968a).

Greater letter-to-sign contrast gave an advantage in visibility which enhanced sign visibility if the sign-background contrast was low but if the sign-background contrast was high, greater letter-to-sign contrast did not add to the sign's visibility. The four different brightnesses were tested against two backgrounds of competing signs and the darkest signs were then seen best against a dark background with competing advertising signs (Forbes et. al., 1968a).

The signs of different brightness were then seen against coloured backgrounds. The brightest sign was seen best against dark green trees, the darkest sign was seen best against a hill and neither was seen best against a cliff (Forbes et. al.,1968b). Black, green, blue, dark green, red, yellow and white signs were then tested against different coloured backgrounds in pairs. The brighter colours (white, yellow, red and light green) as measured by a Pritchard photometer were seen best more frequently.

Lastly, field experiments were then conducted where subjects rode in the front passenger seat of a car driven around a 40 mile route consisting of approximately half rural freeway and half urban driving and called out signs as sooon as they noticed them, giving the colour and position (Forbes et. al, 1968b). The results of the distances at which the signs were first seen were compared to estimates calculated by a mathematical model based on the laboratory experiments and quite good correspondance was obtained.

An early laboratory study by Janda and Volk (1934) measured the time required for subjects to identify signs placed 75 feet away as well as the correctness of the reponse. They found that arrow symbols for turn or curve were better than verbal signs or symbols with words. Shape was found to make no difference to reaction times unless the subject had taken the test several times.

Mills (1933) conducted experiments outdoors using a tachistoscope to compare the visibility of signs of different shapes and colours. For non-luminous signs, black on yellow was found to be more visible than black on white or white on black during the day. At night the yellow background contrasted more with the surroundings but the legend was more easily identified on the black and white signs. Different types of reflector buttons were also tested at night. It was found that signs outlined with reflector buttons were more visible but buttons were found to reduce the daytime legibility of signs.

A recent study by Lum et. al. (1983) used the highway simulator at the FHWA Highway Research Station (HYSIM) to compare the effectiveness of orange and yellow backgrounds for STOP and Yield AHEAD signs by measuring recognition distances. The signs were presented at speeds of 35, 45 and 55 mph. Age, speed and sign colour were all found to have a significant effect on recognition distance, age being the most important with younger drivers having longer recognition distances. For both signs and for good and bad visibility conditions signs with yellow backgrounds were recongnized earlier vhan those with orange backgrounds, probably due to the greater contrast between the background and the red symbol.

Mace and Pollack (1983) measured changes in the speed of speeding vehicles in response to a warning SPEED TRAP sign. The results showed that at locations with complex visual scenes, measures of the scene and the sign's surround predicted visual performance better than sign brightness and contrast. Twenty two variables measuring uniformity and brightness of the scene and scene illuminance measured photometrically at an observer's eye were used to measure the complexity of the visual scene and thirteen varibles measuring the uniformity and brightness of the sign surround were used.

Howard (1962) studied motorists' reaction to a SOUND HORN sign in both sensible situations where line of sight was limited and ridiculous situations where line of sight was not restricted. He observed compliance with the sign as well as speed, sex of driver and number of passengers. He found that observance of the signs increased sharply as the reasonableness of the sign increased, response increased when passengers were present, women tended to observe the signs better than men and when an advance sign was present observance was greater. There was no significant difference between the speed of those who observed the signs and those who did not.v

Two studies in Sweden (Johansson and Rumar, 1966 and Johansson and Backlund, 1970) looked at the visibility of different traffic signs in the field. One of the six signs was placed on a main highway so that drivers had a clear view of it. Beyond the sign, around a slight rise and a curve so that it was out of sight was a police barrier where all drivers were stopped and asked questions about the last sign they saw. The second study involved a far larger sample and more variables were studied but the results were basically the same, i.e. the percentage of drivers who gave the correct answer for the sign varied according to the type of sign in place although all the signs were chosen to have similar "perceptual impressiveness". The percentage of correct responses ranged from 78% for a speed limit sign to 17% for a warning sign in the first study and the same ranking of correct responses was found in the second study.

## B. UNDERSTANDING OF HIGHWAY SIGNS

Apart from the legibility and visibility of highway signs there have been many studies on the understanding of signs. These have included both field and laboratory studies.

1. Speed Related Signs: During the 1970s a number of studies investigated drivers' understanding of various types of signs concerned with speed. Ritchie (1972) used subjects who drove over a 110 mile course on rural highways in Ohio on dry days. The course contained 227 identifiable curves, of which 73 had advisory speed limits. From these 162 curves on which speed was not influenced by anything else were selected of which 79 had curve signs, 68 with advisory speed limits. He found that above 40 mph advisory speeds were closely followed but below 40 mph they were exceeded.

Koziol and Mengert (1977) evaluated motorists' understanding of 12 speed control sign configurations. They included passive signs, signs with flashing beacons, a symbolic advance warning sign, traffic activated warning signs, rumble strips and pavement markings. Traffic activated warning signs were the most effective and reduced speeds by 3-4 mph more than passive signs. Signs with flashing beacons were the next effective during daylight but pavement markings and rumble strips were the next effective at night. Very few differences were found between the various passive signs tested and no sign achieved as much as

30% compliance to the existing 35 mph speed limit. They suggested that 40 mph would be a more realistic speed limit for small towns located on a high-speed road.

Lyles (1982) studied the use of advisory and regulatory speed signs for curves by measuring motorists' speeds as they drove round two curves when five different sign configurations were in place. No one configuration was found to be superior to the others although reasonable speed changes were measured in most cases consistent with the advisory or regulatory speeds displayed. The speed reductions may not have been due to the signs however but because the curve conditions required them.

Reiss and Robertson (1976) studied driver perception of school signs by measuring their speeds before, entering and in a school zone. The drivers were then interviewed and asked if they had seen any school-related signs and if they had altered their behaviour. Activated flashing lights were found to dramatically increase driver recognition of signs but increased awareness of the school zone did not cause drivers to go significantly slower.

Lanman, Lum and Lyles (1979) evaluated techniques for warning of slow-moving vehicles ahead using vehicle-mounted and roadside warning devices. A slow-moving vehicle was driven over an instrumented roadway and other vehicles tracked by computer as they passed it. Roadside signs with the message SLOW-MOVING VEHICLES AHEAD were used with and without flashing lights. The signs with flashing lights had more effect and speeds were reduced when the sign was encountered. Highspeed drivers tended to take less notice of the signs.

Coleman, Koziol, and Mengert evaluated the effectiveness of railway crossing signing schemes. In Phase 1 (Coleman et. al., 1977), they evaluated seven new signing systems to determine if any were more effective than existing signs by observing head movements and measuring speeds at field sites where they had been installed. Three systems were selected for further study in Phase 2 (Coleman et. al., 1979) and were installed at 18 sites in 14 states. Head movements and speed reduction were used as measures of effectiveness in lieu of accidents and the Texas System showed a significant improvement over standard signs in terms of head movements but not speed reduction as changes in speed were small for all systems and no significant speed profile effect was found for any of the new systems.

Hanscom studied motorists' understanding of types of warning signs concerned with speed reduction. In his first study (Hanscom, 1975), he looked at eight sign schemes warning of an icy bridge hazard on the basis of signs used by highway departments. Vehicle speeds were measured and motorists interviewed and asked about their familiarity with the road and the potential icing hazard. Activated signing was found to produce greater speed reduction than non-activated signing and activated signing both before and at the bridge produced the maximum speed reduction. At the bridge activated signs produced larger speed reductions than before the bridge ones. Activated signing was also seen by drivers more than non-activated signs and those on the bridge were seen more than those ahead of it.

In the second study (Hanscom, 1976), he tested six sign conditions at three field sites with potential skidding hazard as determined by accident history and site geometry. Vehicle speeds and interviews were again used and testing was carried out under wet and dry road conditions. Significant speed reductions were again found to occur only with signs that had flashing beacons and higher speed reductions resulted with the use of advisory speed limits. Motorists who saw signing slowed down more than those who didn′t. The signs used were not permanent but were installed just before testing during rain so the use of activated flashing beacons on wet weather skidding signs was suggested.

2. Guide Signs: Another area of investigation during the 1970s was concerned with Guide Signs and particularly diagrammatic signing on Interstate Highways. Hanscom (1972) evaluated motorists′ understanding of diagrammatic signing at the Capital Beltway Exit 1 in Virginia wwhich had been shown to be a problem interchange because of unusual geometrics, heavy traffic and confusion. The effects of installing diagrammatic signing (which is commonly used in Europe) were investigated by observing erratic vehicle movements and taking traffic counts. A significant reduction in weaves over the gore area was found after their installation and drivers tended to weave before the gore area. Informal interviews suggested drivers preferred the diagrammatic signs.

Roberts (1972) conducted a study on diagrammatic signs in New Jersey at an intersection on I-287 using a similar method. No significant difference was seen after standard signs from the Interstate Sign Manual were introduced but a significant reduction in unusual manoeuvres occurred when diagrammatic signs were introduced. Another significant reduction occurred when lane lines were added to the diagrammatic signs.

An expanded study in New Jersey (Roberts, Reilly and Jagannath, 1975) was later made over a continuous 22 mile section of I-287 involving 30 signs at 10 sites. A similar method was again used. Diagrammatic signs were again found to be more effective in reducing unusual manoeuvres such as stopping and backing.

Diagrammatic signs have also been studied in the laboratory. Eberhard (1972) used a two projector system, one to display slides of road scenes and the other with a tachistoscopic shuttter to project conventional and diagrammatic Guide Signs on to the road scenes. Subjects were asked to identify the proper lane and indicate their degree of confidence to a destination. Several different types of Guide Signs were tested and no one was found to be better than the others. The two projectors were also used to show a map of an intersection with different signing schemes. Subjects were asked to select the scheme they liked best. Diagrammatic signs were found to be preferred in all cases.

Gordon (1972) used black and white slides of sign locations on which coloured drawings of signs were superimposed to study understanding of diagrammatic Guide Signs in the laboratory. Subjects were asked to select a lane for a given destination. He found that diagrammatic signs were not better than conventional ones but thought this was because they were too cluttered. Subjects said they preferred the diagrammatic signs.

Gordon´s results were somewhat different from other studies so

Zajkowski and Nees (1976) used the slides previously used by Gordon as well an colour prints made from them to replicate previous experiments. They found that depending on the method used, the results could be made to match the previous investigations, giving conflicting conclusions so they suggested a standardized method for the evaluation of diagrammatic Guide Signs.

Dewar, Ells and Cooper (1977) evaluated understanding of Guide Signs at four problem areas at Toronto airport using videotape field observations of traffic flow and interviews with drivers. They then showed black and white slides of signs and asked undergraduate subjects to indicate as quickly and accurately as possible which lane they should be in for a certain destination. On the basis of these experiments, the existing signs were then modified and the experiments repeated. Further modifications were then made to some signs and the experiments repeated. Videotape observations showed no improvement but fewer interviewed drivers said they had difficulty finding their way after the modifications were made.

McNees (1985) conducted a study to determine the most appropiate terminology to use to guide motorists to the CBD of metropolitan areas and their suburbs. He used 35mm slides to present various messages to subjects which showed a number of Guide Signs in locations entering the city limits, approaching a beltway, near the centre of the city and near the given destination. The subjects were asked which sign they would expect at the location, which sign they preferred and also had to choose a lane for their destination. Their response time was also measured. A wide disparity was found between the messages they expected and prefered in many locations. The use of the word DOWNTOWN and the name of a different city to the one the road was in was found to be very confusing and the author suggested downtown should only be used with the name of the city the driver is in at the present time.

3. Symbol Versus Verbal Signs: There has long been concern about the use of symbolic signs and drivers´ understanding of them. Forbes (1960) investigated the use of symbols for lane control signals. Slides of the signals superimposed on the nearby Mackinac bridge were shown to student subjects. A red X was found to be the most understood symbol to mean lane closed in the laboratory tests so a signal was installed on the bridge and driver behaviour was observed in field tests. The red X was found to produce earlier movement out of a lane with a hazard ahead so signal combinations of red Xs and green arrows were installed permanently on the bridge.

Burg and Hulbert (1962) evaluated lane ending signs with words and symbols by filming the signs from the driver´s position in a moving vehicle and showing the film to subjects, after which they answered questions. All the subjects shown the symbolic sign preferred it the least. The sign preferred was a rectangular worded sign which also seemed to convey meaning best.

Gordon (1979) did a laboratory study in which symbols such as those evaluated by Forbes on the bridge were compared to worded message signs for lane occupance. Lane occupancy problems were given to subjects on ringed cards and when the subject said, "Ready", a road sign was projected onto a screen infront of them. Twenty two questions were asked on each of the four types of signs. The results showed that changeable message signs gave more accurate responses, were more quickly interpreted and were preferred by divers and that the symbolic signs were more effective than worded messages.

The understanding of symbolic parking signs has also been evaluated. Hanson, Bennett and Radelat (1966) tested this because of complaints received about the complexity of Washington D.C. parking signs. Five designs were selected for testing on the basis of signs used in other areas and comments received by various organizations. These designs were put on papers which subjects looked at and then answered questions about whether they could park at certain times in certain places. This was done before and after the signs were explained to the subject and the time taken to answer the questions and the correctness of the answer were recorded. The distance at which the signs vould be understood was also measured in another part of the experiment. Symbols were found to be understood from a considerable distance and from the results of the experiment recommendations were made for the parking signs in Washington, especially with regard to simplification.

Gordon (1980) also studied parking signs. He compared conventional (MUTCD) parking signs as used in Washington D.C. with time-referenced signs and changeable message signs. Subjects were asked questions about whether they vould park at certain times in certain places. Eighteen questions were asked on each of the sign types. The time-referenced signs were found to give an average of three-quarters the number of errors with equivalent conventional signs. On the basis of the results of the study he recommended that parking signs should be simplified and that unusual additional information should be avoided. The use of the word "standing" was found to cause alot of confusion.

Early studies on symbolic signs were concerned with the ability of Americans to understand European symbol signs. Brainard, Campbell and Elkin (1961) showed 30 European symbolic signs, reproduced on display cards to students who were asked to write down their meanings. The experiment was then repeated with different students who were asked to choose a meaning from a list of nine for each sign. The same subjects were then asked to write down the meanings of the signs after the signs had been shown to them and the meanings given verbally. Different subjects were also asked to draw a symbolic sign for meanings read aloud to them. The results showed that the most readily identified signs were those with direct pictorial representations and those with direct American counterparts. The use of additional symbolic codes such as slashes was found to be confusing. When subjects were told the meaning of the signs only once, interpretability of most of the signs was found to be nearly 100%.

Walker, Nicolay and Stearns (1965) showed European symbol signs and American word signs for NO RIGHT TURN, NO LEFT TURN and DO NO ENTER to undergraduate students on a tachistoscope in a completely darkened room. The subjects had studied the signs for five minutes beforehand and were shown the actual drawings used. The symbols were found to be correctly identified significantly more frequently than the word signs. Just over a third of the subjects were asked to recall the meaning of the symbols 24 hours later and all did so perfectly. Colour was removed from the symbol signs so that it did not aid in identification.

In Great Britain several studies on the understanding of symbol signs were done at the Transport and Road Research Laboratory when a nationwide changeover was made to mostly symbolic signs in the mid 1960s. In the first study (Mackie, 1966) a national survey of 2,000 people was made in which subjects were interviewed and asked to identify seven signs shown to them on cards. A generally low level of understanding of what were intended to be fairly self-explanatory signs was found, with drivers having a better understanding then non-motorists (an average of about 50% of the drivers knew the signs compared to an average of about 30% of non-drivers). A tendancy towards better understanding in the higher social classes was found and men had better understanding than women. Knowledge was lower among older people with the 25-34 age group having the best understanding of the signs.

In the second study (Mackie, 1967), 75 names were chosen at random from local driving licence records around three cities in Britain and a similar interview was conducted. This procedure was done in 1965 and again in 1966. An appreciable increase in knowledge over the one-year period was found, even for the more difficult signs. However, although a high level of knowledge was found for some of the signs, others were understood by only a small percent of motorists questioned. The higher social classes were again found to have a better knowledge of the signs but there was no significant difference between the sexes. Those over 60 were found to have a very poor knowlege of the signs. Knowledge of the meaning of sign shapes and colours was not good but those who did know this gave more correct answers to the meanings of the individual signs.

In the third study (Mackie, 1972), the same procedure was used in

1966 and again in 1967 in a trial area in Hampshire where new symbolic signs were erected before they were generally in use in the rest of the country and a comparable control area also in Hampshire. The new signs were erected in 1967 so that the surveys represented knowledge before and after the signs were put in place. Knowledge of the symbol signs was found to increase after the signs had been erected in the trial area but not in the control area. Knowledge was also found to increase with miles driven per year. The meanings of the shapes and colours of the signs were again poorly understood. Some specific signs were well understood, but others were not, particularly those with abstract symbols.

Dewar and Swanson (1972) showed coloured signs of symbol and word signs on a tachistoscope for 1/25 second and asked subjects to write down what they meant. They had been shown all the signs and their meaning had been explained previously. Volunteer city employees and driver trainees before and after training were used as subjects. Generally symbols were understood better than words and older subjects especiallly were found to have more difficulty with words than symbols. The driver training enhanced the understanding of only three signs. NO LEFT TURN signs were also tested in the field over a two year period by counting illegal turns but no significant difference was found between different versions of the sign.

Dietrich and Markowitz (1972) evaluated 20 newly proposed symbol signs and their equivalent currently used verbal signs. Additional signs from the MUTCD were also used in the experiment as control signs. The signs were presented tachistoscopically to subjects at four different exposure durations. The shorter the exposure the more poorly all the signs were recognized as would be expected. Two groups of subjects were used and for one the symbol signs were recognized more readily whereas for the other the verbal signs were more recognizable. A field test was also carried out on a private test road with an experimental apparatus which allowed the subject drivers to view the road only at periodic intervals. The regulatory signs used in the laboratory experiment were observed by the drivers who then called out the name of the sign they had just seen. Some drivers were given extra training on the meaning of the signs and these drivers did better than the average group. For the latter group the symbol signs were understood more easily than the verbal signs.

Two studies made by the AAA Foundation for Traffic Safety, (Hulbert, Beers and Fowler, 1979 and Hulbert and Fowler, 1980) used a film of traffic control devices at various locations throughout the U.S. from the driver's seat of a moving car which they showed to groups of subjects at different locations in the U.S. The subjects answered a multiple choice questionnaire with special marker pens which enabled the correctness of their answer to be shown to them. The questions were in the soundtrack of the film. About one third of the traffic control devices were symbol signs. In both studies they found that even the best understood signs were not well understood by 5-10% of the drivers tested, drivers understood symbol signs better than either signals or pavement markings, the orange background of construction zone signs was not fully undserstood, older drivers (>49) generally showed the least understanding of traffic controls and drivers aged 24-49 the best.

Allen, Parseghian and Valkenburgh (1980) studied the effects of symbol sign recognition using a highway simulator to dynamically present 72 symbol signs to subjects of four age groups. The subjects "drove" the test course three times including a second time after training on the signs' meanings and a third time approximately one week later. Older drivers were found to have less current symbol sign knowledge than younger drivers but did not have problems in learning and retaining knowledge of symbol signs. However the distances at which they recognized the signs were shorter, i.e. they required more time to process information from symbol signs than younger drivers.

Cairney and Sless (1982) studied 12 symbolic roadside information signs. Subjects were shown slides of the signs and asked to indicate their meaning, a confidence rating from 1-4 and whether they had seen the sign before in a response booklet. Five different groups of subjects were tested and the testing was repeated a week later. Some signs showed high idenfication rates on the first testing and most of the signs did on the retest. Very few opposite meanings to those intended were given.

Williams, Wilson and Dale (1985) used a VCR technique to present signs in their respective environments to groups of subjects and compared the results obtained using that technique with those obtained from a technique with signs not in their usual environments for six symbol warning signs. Subjects for both techniques were asked the meaning of the signs and what they would do and responses were classified as correct, close or wrong. Three of the signs were already in use and three were experimental. Those in use were shown to be significantly more effective than the experimental signs. Responses for the sign plus environment technique were significantly more correct than those for the sign only technique. A positive relationship between the definition and behavioural responses was found to exist suggesting the same information can be obtained by using either technique

4. Other Studies: In an early study, Jackman (1957) observed drivers' behaviour at two locations where there were several different types of stop sign erected at different times but found that no one sign was any more effective in terms of driver obedience than any other.

Powers (1962) studied the effect of advance route turn markers on city streets using subjects who drove over a four mile test route in Washington D.C. and followed special signs. By using in car observers to estimate the distances at which drivers moved into the proper lane and used turn signals, with different combinations of advance turn signals he found that there was benefit in using advance turn markers. The number of errors that occurred were lower than expected but almost all occurrred where there were no advance signals.

Huchingson and Dudek (1983) carried out a study to determine abbreviations that could be used on highway signs and be understood by > 85% of drivers. They asked subjects to abbreviate 80 words found on highway signs. The most common abbreviations were then shown to different subjects who were asked what the words were when on their own and combined with a commonly used prompt word. > 40% of the subjects gave the same abbreviation for 27 words, 26-29% for 31 words and < 25% for 22 words. 21 abbreviations were understood by > 88% of the subjects and 28 were understood by 55-84%. With prompting, 18 abbreviations were understood by 100% of the subjects, 15 were understood by 96% and 13 by 88-92%.

Bates (1985) looked at sophisticated aspects of Interstate signing such as the significance of Interstate numbering, mileposts and interchange identification using a multiple choice questionnaire given to groups of subjects. The results showed that much of the sophistication of Interstate signing was not understood by many of the drivers who participated.

## C. WORK ON MEDIAN CROSSOVERS

Very little work appears to hve been done on median crossovers themselves. Cribbins et. al. (1967) looked at the effect of median crossovers on accident rates and found nine multiple regression equations to predict accidents at different types of median crossovers. They attempted to determine the optimum median opening spacing but were unable to do so. In another study of accidents on multilane highways, Cribbins, Arey and Donaldson (1967) found that about 35% of accidents occurring between intersections involve median openings.

Garner (1970) investigated U-turn accicents at median crossovers in Kentucky. He found that the numbers of such accidents were affected by the volume and composition of traffic, the proximity to urban areas, the presence of major interchanges and the nearness of crossovers to interchanges, interchange spacing, the number of crossovers and the width and type of median. Stover, Adkins and Goodknight (1970), in recommending guidelines for medial access control on major roadways, thought that median openings should only be provided at public street intersections and access points to large traffic generators.

# III. SURVEY OF STATES PRACTICES OF SIGNING AND DELINEATING MEDIAN CROSSOVERS

After consultation with several traffic engineers, a questionnaire on standard signing and delineation practice at Rural Median Crossovers was prepared and sent to each State in April 1985, addressed to the State Traffic Engineer. Those States that had not replied by September were contacted by phone and several more copies of the questionnaire were then sent out. Thirty three States replied to the questionnaire.

Questions were asked about the signing, marking, delineation and geometric design of median crossovers for minor roads, authorized vehicles and commercial development and on the D13-1 sign in the MUTCD (see Figure 2). Respondents were also asked if they knew of any studies of median crossovers. The questionnaire is included as Appendix A.

From the replies received it was found that the questionnaire had caused some confusion concerning the meaning of the word "crossover". Several States were found to use the word with a different meaning to that intended in the survey. In eight States the word "crossover" appeared to be used for facilities accommodating minor turning movements into driveways and U-turns by emergency vehicles only whereas in 11 States "crossover" appeared to mean any opening in the median, including major intersections. Eleven States appeared to use the definition intended in the survey, using "crossover" to mean any minor unsignalized intersection, driveway or emergency U-turn facility.

The replies to the survey therefore varied somewhat but were analyzed so that the following discussion is based on the intended definition of a crossover, i.e. "any paved or gravel crossing across a median section for a minor cross street, commercial or residential development or authorized vehicles". The numbers in the following discussion will not always total 33 as not all the States that replied to the survey provided all the information requested.

## A. SIGNING OF MEDIAN CROSSOVERS

1. Minor Road Crossovers: These are most commonly signed on the divided highway approaches by green guide signs of varying sizes (eight States) and route number signs are also used (three States). A yellow diamond Cross Road or Side Road sign is used by six States, varying in size from 48x48 inches (two States) through 36x36 inches to 30x30 inches (one State each). This is usually supplemented by a sign with the street name on it. One State uses No U Turn signs on all crossovers and Vermont uses 48x48 inches Right Lane for Right Turn, Left Lane for Left Turn and Left Lane Must Turn Left signs. Figure 3 summarizes this discussion.

On the minor approach, Stop signs are used by 29 States. In seven States these are 30x30 inches but 36x36 inches and 42x42 inches signs are used by one State each. Yield signs are used by three States. One Way signs are also used by 23 States. Eight States use 36x12 inches signs and one State uses 48x24 inches signs. Divided Highway signs are used by 15 States, eight States using 24x18 inches signs. A Stop Ahead sign is used by six States, a 36x36 inches sign being used by two States. Six States use a No Left Turn sign; two States use a 24x24 inches sign. Green guide signs are used by two States and route numbers by three States. Figure 4 summarizes this discussion.

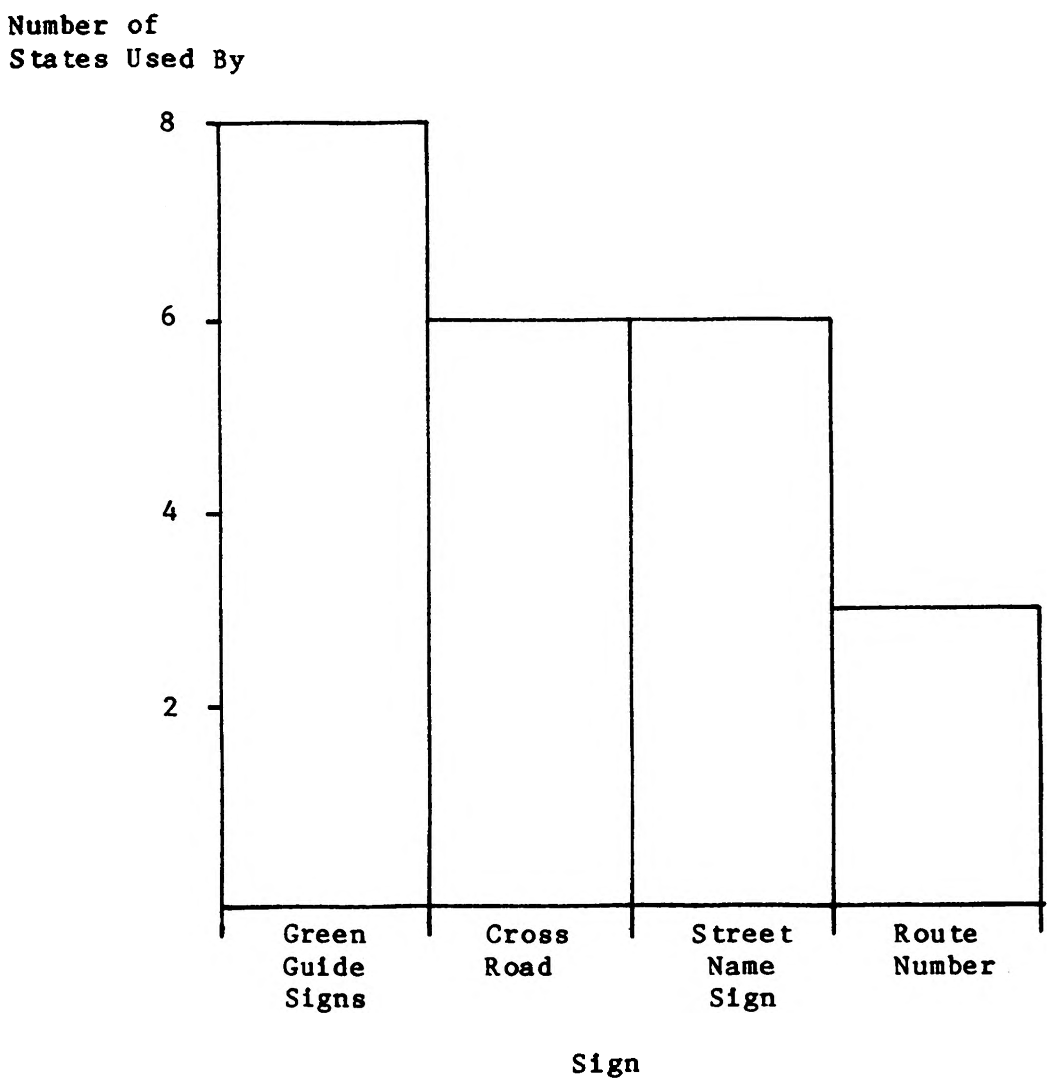



Figure 3. Most Common Signs Used on Divided Highway Approaches to Minor Road Crossovers

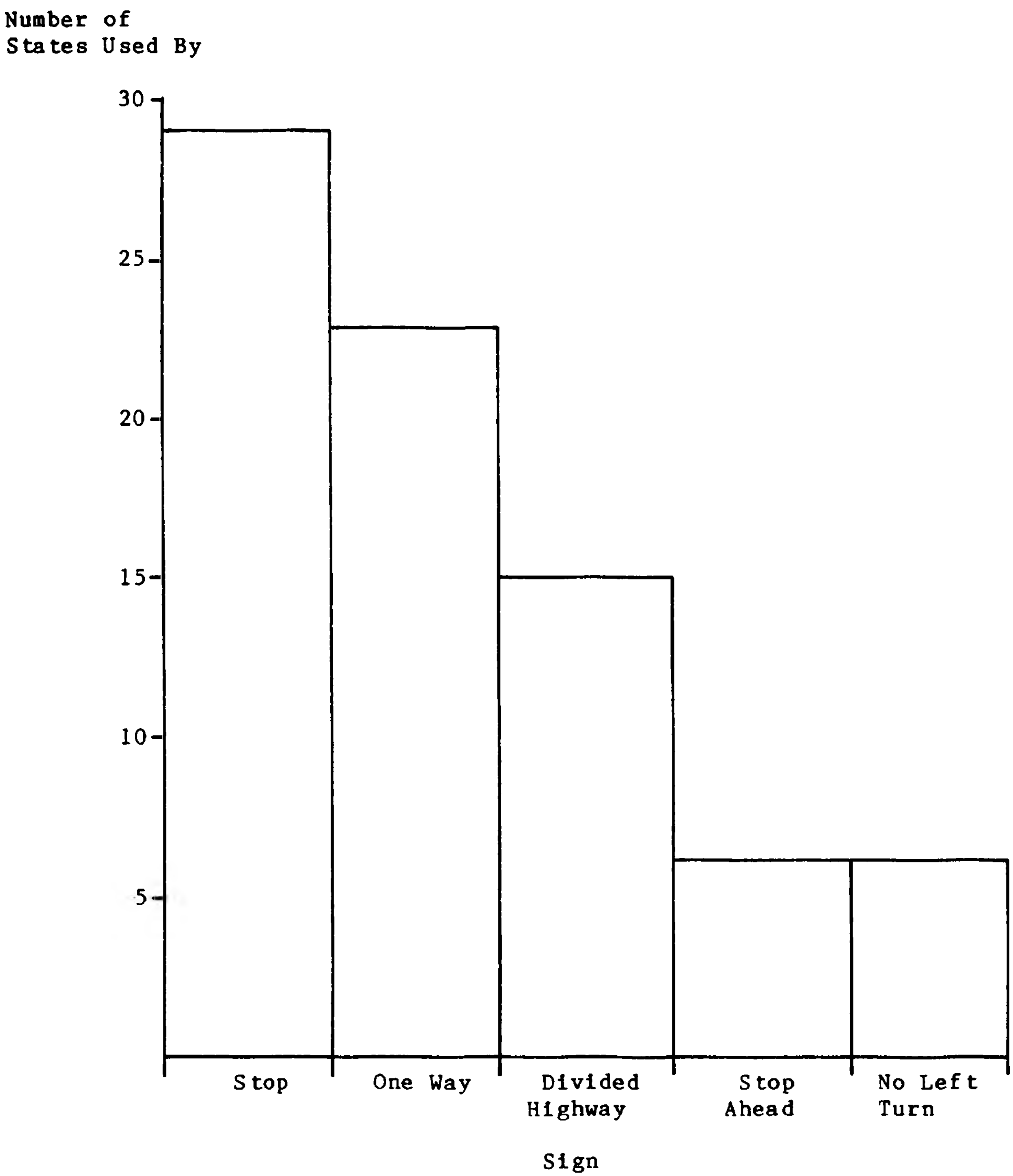



Figure 4. Most Common Signs Used on Minor Approaches to Minor Road Crossovers.

For traffic crossing the median, 15 States use Yield signs; three States use 36x36x36 inches signs and one State uses 48x48x48 inches signs. Seven States use Stop signs; two states use 30x30 inches signs and one uses 42x42 inches signs. Twenty two States use One Way signs; seven States use 36x12 inches signs and one State uses 48x24 inches signs. No Right Turn signs are used by six States and Keep Right signs are used by five States. Figure 5 summarizes this discussion.

To help prevent wrong way movements, 22 States use Do Not Enter signs in the median or on both sides of the roadway. Four States use 30x30 inches signs and one State uses 36x36 inches signs. Sixteen States use Wrong Way signs which in three States are 36x24 inches in size.

Delineators on each roadway are also used by some States to mark minor road crossovers. Two States use two Type 1 Object Markers while another two States use one Type 1 Object Marker. Mississippi uses two yellow Type 1 Object Markers on the far side of the crossover and two green Type 1 Object Markers on the near side of the crossover. Oklahoma uses a Type 1 Object Marker in the centre of the crossover with a double yellow delineator and double yellow delineators in the corners of the crossover with red delineators on the reverse in the near corner.

Two States use three yellow delineators mounted horizontally and Florida uses one yellow delineator with a green delineator on the reverse. North Carolina uses four single yellow delineators in front of the crossover, yellow and clear delineators in the near corners and the centre of the crossover and an yellow delineator in the far corners. South Carolina uses a double yellow delineator in all four corners or a bidirectional double yellow delineator in the centre of the crossover

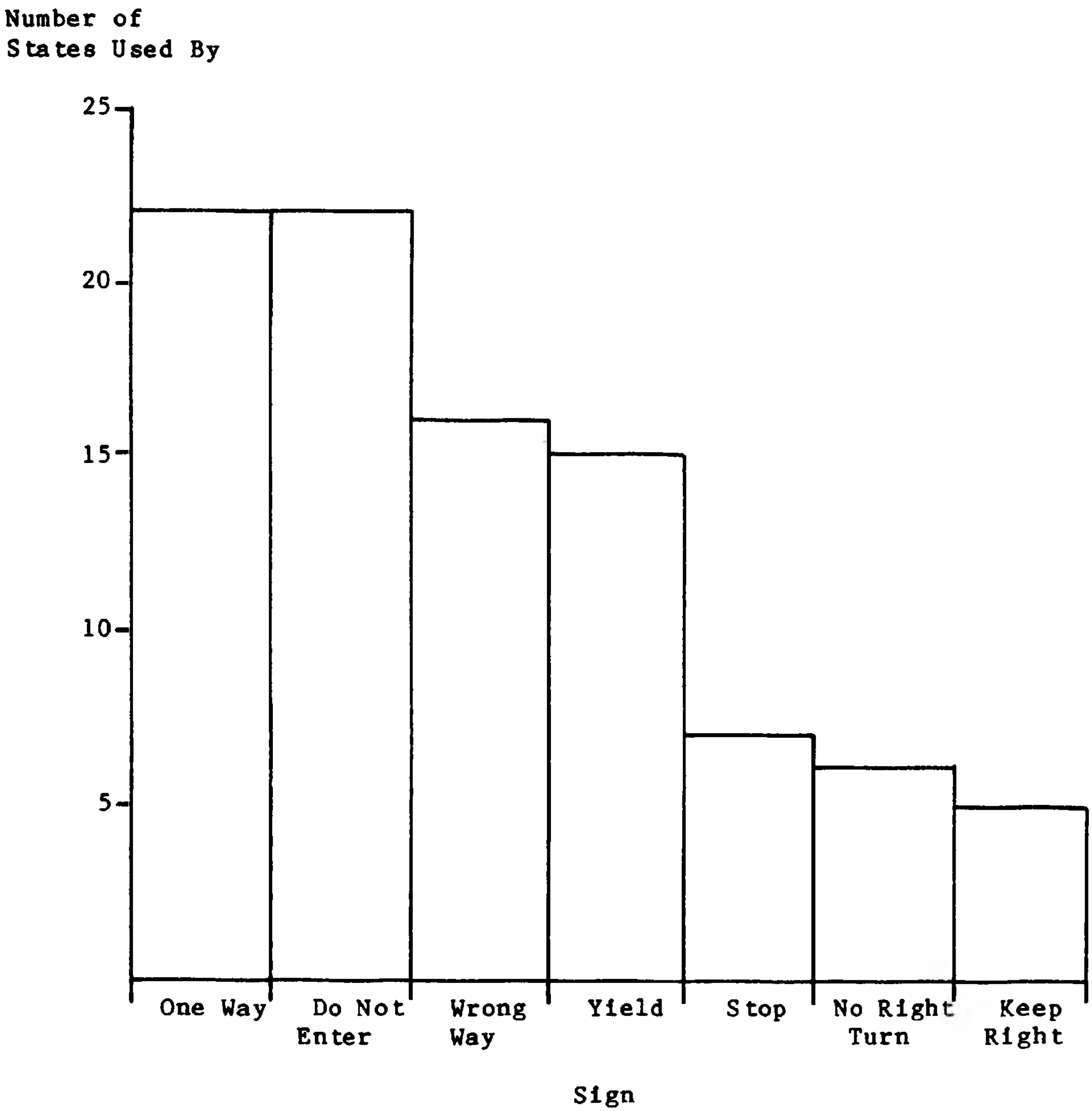



Figure 5. Most Common Signs Used in Median at Minor Road Crossovers

depending on the width of the median. Washington uses two double yellow delineators with red reflective sheeting on the reverse infront of and in the centre of the crossover and a double yellow delineator on the far side.

Many States use different sign configurations for different median widths. Thirteen States have different configurations for medians over 30 feet. Tennessee has different practices for medians less than 30 feet, 30-42 feet and over 42 feet, South Carolina for medians less than 20 feet, 20-39 feet, 30-49 feet and 50 feet or more and Illinois for medians less than 10 feet, 10-30 feet, 31-49 feet and 50 feet or more.

2. Authorized Vehicle Crossovers: These are signed in a variety of ways, most commonly using some variation of the "Emergency and Authorized Vehicles Only" sign mentioned on page 2B-26 of the 1978 MUTCD. The most common variation is "Authorized Vehicles Only" which is used by five States. The MUTCD wording is used by two States and "Official Use Only", "Official Use Only Crossover", "For Use By Emergency Vehicles Only", "For Use of Authorized and Emergency Vehicles Only" and "Maintenance and Authorized Vehicle Only" are used by one State each. The No U Turn sign is used by five States and one State uses this sign with an "Except Authorized Vehicles" plate.

Delineators are also used to mark authorized vehicle crossovers, both with and without signs. The most common configuration is a double yellow delineator at the left side of the through roadway on the far side of the crossover for each roadway as specified on page 3D-2 of the 1978 MUTCD. This configuration is used by seven States but other positions of a double yellow delineator are also used. Three States place them in the centre of the median at the crossover. Pennsylvania uses two double yellow delineators spaced at intervals both in front of and beyond the crossover on each roadway as well as a double yellow delineator at the far corner of the crosover.

Other configurations are also used. Oklahoma uses a Type 1 Object Marker in the centre of the median at the crossover and Montana uses a single yellow delineator at all four corners of the crossover. Delineators are also usesd in advance of a crossover. Illinois uses a triple yellow delineator 800 feet in advance of a crossover and Washington uses three single yellow delineators at 100 feet intervals in advance.

Two States do not mark authorized vehicle crossovers at all and two States do not provide for crossovers. Sign sizes tend to vary according to the message on them but vary from 12x18 inches to 36x48 inches for the "Authorized Vehicles Only" sign.

3. Commercial Development Crossovers: These are not provided by ten States. Twelve States use the same signing as for minor road crossovers with no separate standard practice for commercial development crossovers. These crossovers are not signed in two States while others use double yellow delineators either on the far side of the crossover, in the centre of the median at the crossover or at all four corners of the crossover.

Only six States have developed special treatments for median crossovers of this type. Texas has used the D13-1 sign included in revision three of the 1978 MUTCD (see Figure 2) for a number of years.

Vermont provides "jug-handle" facilities with diagrammatic signs and a Type 1 Object Marker in the gore of the "jug-handle". Washington uses a "U-Turn Route 1/4 Mile" sign where a crossover is provided for U-Turns. Michigan has developed a directional crossover sign symbolizing the roadway and Minnesota uses a rectangular median opening marker with a black X crossover symbol on a yellow background. Virginia has used a green and white delineator symbolizing a crossover since the early 1960s and this sign is also used in Delaware as well as a variation in black and yellow. These different treatments were considered as alternatives to test in the experimental part of this study.

4. Comments: In reply to whether the D13-1 sign contained in Revision 3 (9/84) to the MUTCD was considered to be meaningful and helpful to motorists, comments were varied. Four replies were negative in that they did not consider the sign to be helpful and five replies were positive in that they thought the sign would be helpful. Other replies indicated the sign would be helpful in special cases such as where crossovers are few or several miles apart or where unauthorized median crossing is occuring and a crossover is located further on.

Fifteen of the replies contained comments that the signs would probably not be used, as present signing was considered adequate or such facilities were not provided and two said they would probably be used to a limited extent. Where there are very few crossovers one comment was that a crossover sign would have very little value as motorists would not have sufficient exposure to the sign to learn its meaning.

Two replies thought that the word "Crossover" would cause confusion and suggest to motorists that they had to cross over the median. Another suggested using the name of the cross road on a similar sign. Another reply suggested that a crossover sign should not be a green guide sign as D13-1 but a yellow warning sign and suggested using a symbolic sign.

The only State that had performed any studies of median crossovers was Arizona where the use of double amber reflectorized raised pavement markers for freeway emergency median crossovers was tested but no conclusions were made.

## B. PAVEMENT MARKINGS AT MEDIAN CROSSOVERS

Pavement markings at median crossovers mainly followed MUTCD guidelines as in Figure 3-6 of the MUTCD. Three States replied that their pavement markings are as per the MUTCD. The following discussion is summarized in Figure 6.

Solid yellow centre lines are used by 18 States and in 11 States these are four inches wide. In 14 States the yellow markings stop at the median nose whereas in four States they continue all the way around the median nose. Several States use dashed yellow lines across the crossover itself. In two States these are four inches wide and two feet long with four feet skip or six feet long with ten feet skip.

Solid white edge lines are used by 17 States. In 10 States these are four inches wide and in one State they are four and a half inches wide. In two States the edge line is extended across the cross road. Eleven States use white Stop lines on the cross road, ranging from 12 inches in width through 16 and 18 inches to 24 inches. Nine States use solid yellow centre lines on the cross road extending for at least 50 feet from the stop line. In four States these are four inches wide.

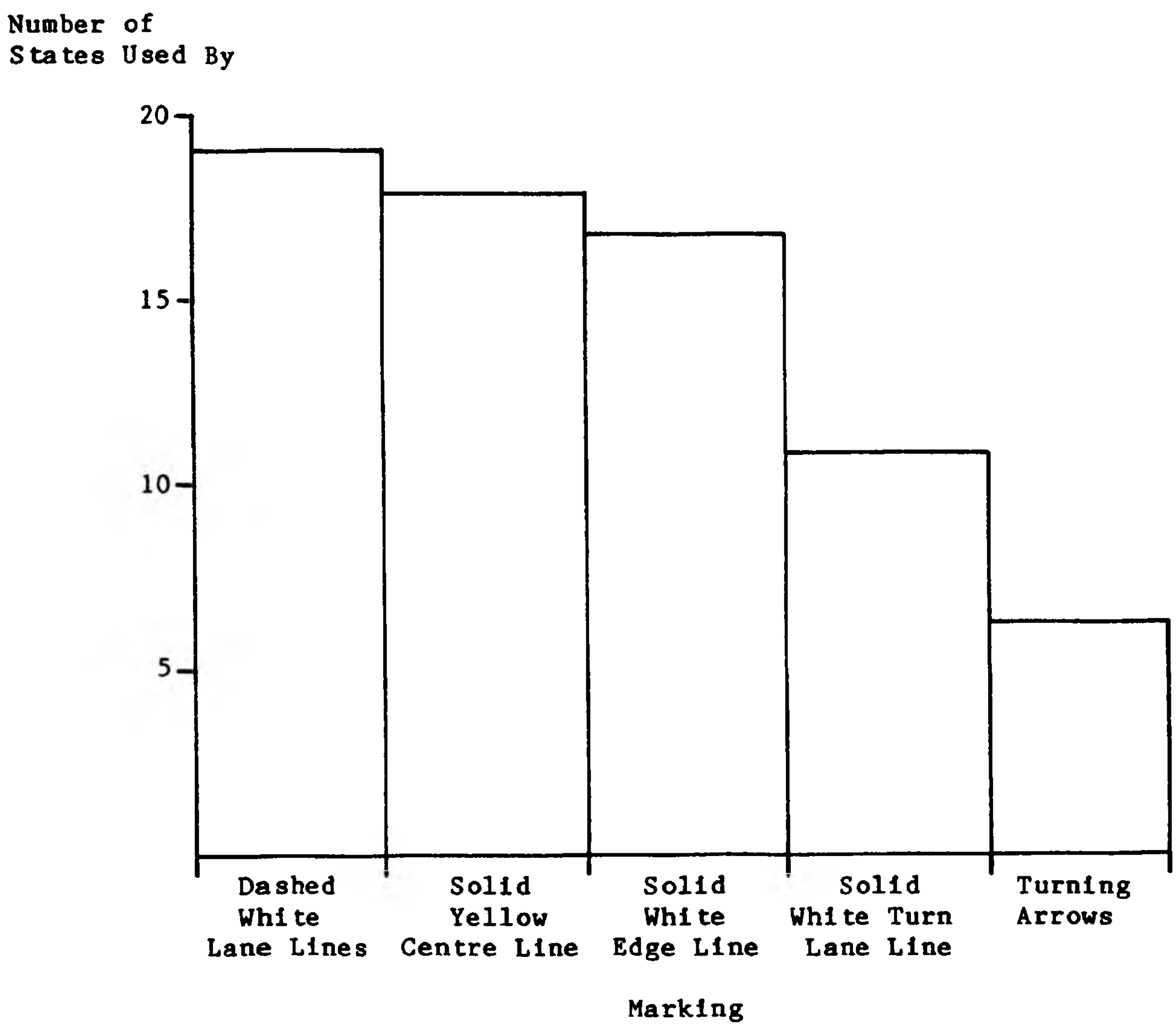



Figure 6. Most Common Pavement Markings Used on Divided Highway Approaches at Crossovers

Nineteen States use dashed white lane lines which in six States are four inches wide and ten feet long with a thirty feet skip. In one State they are four and a half inches wide and in another they are 12 1/2 feet long with a 37 1/2 feet skip. White through arrow markings are used by two States which are 24 feet long and North Carolina uses white through plus turning arrow markings before the crossover and through arrow markings after the crossover.

If a turn lane is present a solid white line is used to delineate the turn lane by 11 States. In nine States this is a straight line but in two States the line curves following the median nose to the centre of the median. In four States the line is four inches wide and in one State it is eight inches wide. In one State a dashed white line is used to delineate the turn lane and in another a dashed white line is used across the turn lane taper with two feet long lines and four feet skips.

Pavement arrows are also used in turn lanes. Four States uses white arrows plus ONLY and two States use turning arrows by themselves. Three States use white through arrows in the through lanes and North Carolina adds the word ONLY to these. Georgia uses white painted islands to separate turning traffic.

Within the crossover itself three States use double solid yellow centre lines which are four inches wide in one State. Two States use two sets of through plus turning arrows, Mississippi uses a sixteen inch white Stop line and North Dakota uses four inch white edge lines.

Reflective markers are also used by some States at crossovers.

California uses one-way clear reflective markers spaced at 48 feet intervals with four non-reflective white markers spaced at four feet intervals centred between the reflective markers on the lane lines and one-way yellow reflective markers, spaced at 48 feet intervals on the centre lines. A similar system is used in Arizona with one-way clear reflective markers spaced at 40 feet intervals with five non-reflective white markers spaced at two and a half feet intervals centred between the reflective markers on the lane lines and two-way yellow reflective markers at narrowing intervals on the centre lines as the crossover is approached. Georgia uases raised pavement markers on the lane lines and turning lane lines. Mississsippi uses red-clear reflective markers between skips on the lane lines and turning lane lines. Ilinois uses two-way yellow reflective markers on the centre lines and one-way white reflective markers on turning lane lines spaced at 40 feet intervals.

## C. GEOMETRIC DESIGN OF MEDIAN CROSSOVERS

A large amount of material was received concerning the geometric design of median crossovers but this discussion will be confined to the questions asked on page two of the questionnaire and will be concerned firstly with the design of the deceleration side of a crossover and secondly with the design of the acceleration side of a crossover. It does not include the five States who replied that they followed AASHTO standards without submitting further details.

1. Designs for Deceleration: These included both those with and without deceleration lanes and are summarized in Table I. Nine designs without a deceleration lane were submitted with radii varying throughout

TABLE I

SUMMARY OF DIMENSIONS OF DESIGNS FOR DECELERATION AT MEDIAN CROSSOVERS

Deceleration Lane Absent

| | Minimum (feet) | Maximum (feet) | Mode (feet) |
|---|---|---|---|
| Radius | 19.5 | 150 | 40 |
| Nose Radius | 2 | 8 | 2 |
| Minimum Median Width | 4 | 40 | 20 |
| Minimum Width Within Crossover | 12 | 40 | 40 |

Deceleration Lane Present

| | Minimum (feet) | Maximum (feet) | Mode (feet) |
|---|---|---|---|
| Radius | 40 | 150 | 50&75 |
| Nose Radius | 2 | 20 | 2 |
| Taper Length | 18 | 600 | none |
| Lane Length | 0 | 380 | 75&100 |
| Lane Width | 12 | 12 | 12 |
| Minimum Median Width | 13 | 100 | 40 |
| Minimum Width Within Crossover | 28 | 60 | 40 |

a range from 19.5 feet to 150 feet. The majority of the designs had bullet noses with radii varying from 2 feet to 8 feet but two designs had semi-circular noses. The minimum median width at the site of a median crossover without a deceleration lane ranged from 4 feet to 40 feet with three States using a value of 4 feet and four States using a value of 20 feet. The minimum width within the crossover ranged from 12 feet to 40 feet with five States using a value of 40 feet.

Eighteen designs with a deceleration lane were submitted, with radii varying from 40 feet to 150 feet. The most popular radii were 50 feet and 75 feet which are used by three States each. All of the designs had bullet noses with radii varying from 2 feet to 20 feet; a 2 feet radius being used by three States.

The length of the taper used for the deceleration lane varied from 18 feet to 600 feet with no particular length being favoured. The length of storage lane provided varied from 0 feet where only a taper is provided (four States) to 380 feet. The width of the deceleration lane was 12 feet in all cases.

The minimum median width at the site of a median crossover with a deceleration lane ranged from 13 feet to 100 feet with three States using a value of 40 feet. The minimum width within the crossover ranged from 28 feet to 60 feet with eleven States using the AASHTO recommended value of 40 feet.

A number of States use designs with distinctive features which makes them worth mentioning. New York uses a 25 feet to 100 feet colour contrasted pavement or jiggle bar divider to separate left turning traffic from through traffic on the divided highway and Illinois uses a large curbed island to separate left turning traffic. Missouri uses a triangular island 4 feet from the edge of the through lane and 18 feet from the curved end of the median level with the bullet nose to direct left turning traffic from the divided highway.

Mississippi uses pavement markings to separate opposing directions of traffic within the crossover and Michigan uses two separate roadways in some cases to separate opposing traffic. California uses a design with acceleration and deceleration tapers and a bullet nose end for crossovers where no acceleration and deceleration lanes are provided.

2. Designs for Acceleration: These included mainly designs without acceleration lanes. However five designs with acceleration lanes were submitted although in only one case was an actual lane provided, the others just being tapers which varied in length from 18 feet to 200 feet. A 12 feet width was provided at the beginning of the taper in all cases. All of the designs had bullet noses with nose radii varying from 2 feet to 5 feet and main radii ranging from 40 feet to 150 feet.

Fifteen designs without acceleration lanes were submitted which had radii varying throughout a range from 19.5 feet to 150 feet. The most popular radius was 50 feet which is used by five States. The majority of the designs had bullet noses with radii varying from 2 feet to 8 feet but two designs had semi-circular noses.

# IV. METHODOLOGY

As can be seen from the literature review, the effectiveness of highway signs has been evaluated using a great variety of methods both in the field and in the laboratory. Dewar (1972) evaluated a number of methods used to study signs and found that the number of subjects was frequently small and did not constitute a representative sample of the driving population, especially if they were university students.

He pointed out that in laboratory studies there is a lack of the normal visual cues and distractions of attention that are part of the driving task and that even driving simulators do not duplicate the task perfectly. Forbes (1964) used slides of highway scenes on which signs were superimposed plus an auxiliary task of relighting 1-4 of 12 small red light stimulii, located directly ahead at a point representing the view of the road to simulate the driving task. Other investigators have used other tasks but Dewar pointed out that they do not really duplicate the distraction involved in driving.

Another problem with laboratory studies is that they involve static rather than dynamic peVception of the signs according to Dewar. Williams, Wilson and Dale (1985) compared two laboratory methods. A videotape was used to record signs in their respective environments and was then presented to groups of subjects and this method was compared to one in which subjects saw the signs only. They found that the meaning and behavioural responses for the sign plus environment technique were significantly more correct than those from the sign only technique.

Other problems with laboratory studies, according to Dewar, include the fact that signs are not always presented in random order and that most experiments only examine one factor in the complex process of detecting, recognizing and understanding a sign message.

Dewar stated that field studies had generally been less adequately designed and conducted than laboratory studies as they tend to involve more uncontrollable variables and assumptions tend to be made about the variables measured.

According to Roberts, Lareau and Welch (1977), when the purpose of a study is to assess the relative effectiveness of various signs for a particular message, then a laboratory study represents the logical first step and field studies can then be used to test the best signs from the laboratory experiment. (In this case a field study was not feasible in the limited time available.) They also suggested that the sign effectiveness reduction due to attention distraction and dynamic factors would be the same for all the signs if they were viewed in the same environment in field tests.

In this study an attempt has been made to show the signs in their appropriate environment by locating the signs on slides showing a median crossover. In this way some of the visual cues associated with the driving environment are present although the signs are not seen in a dynamically changing environment as in the case of a movie or videotape presentation.

The signs were first shown to subjects in Virginia in June 1985 and then to subjects in Missouri in November and December 1985. The experiment was designed at the Turner-Fairbanks Highway Research Center in McLean, Virginia and will be described for the Virginia subjects in detail. It was adapted for the Missouri subjects but was basically the same. The differences will be noted.

The slides were presented in random order to each subject and the order of presentation was different in the second presentation for each subject. An attempt has been made to measure the visibility of each feature of the signs, the ability to recognize them before and after learning their meaning and the subjects' preferences for the signs.

## A. VIRGINIA EXPERIMENT

1. Subjects: The Virginia subjects were paid volunteers recruited from Research Fellowship Students and Computer Centre staff at the Turner-Fairbanks Highway Research Center in McLean, Virginia and from a list of subjects, most of whom had participated in previous experiments at the Research Center. All subjects also took part in an experiment being run at the same time on the Highway Simulator at the Center.

In the case of subjects from the subject list, nearly all took part in the experiment before or after driving the Highway Simulator. It was possible to schedule appointments so that only two subjects had to make two separate trips to the Research Center. Subjects were paid $10.00 for their participation.

Thirty subjects were tested in all, ten (five males and five females) in each age group, 17-29, 30-49 and 50 and over. The mean age of each group is shown in Table II. All subjects had their vision tested on an Ortho-Rater to ensure corrected visual acuity of 20/33 or better

TABLE II

MEAN AGES OF VIRGINIA SUBJECT GROUPS

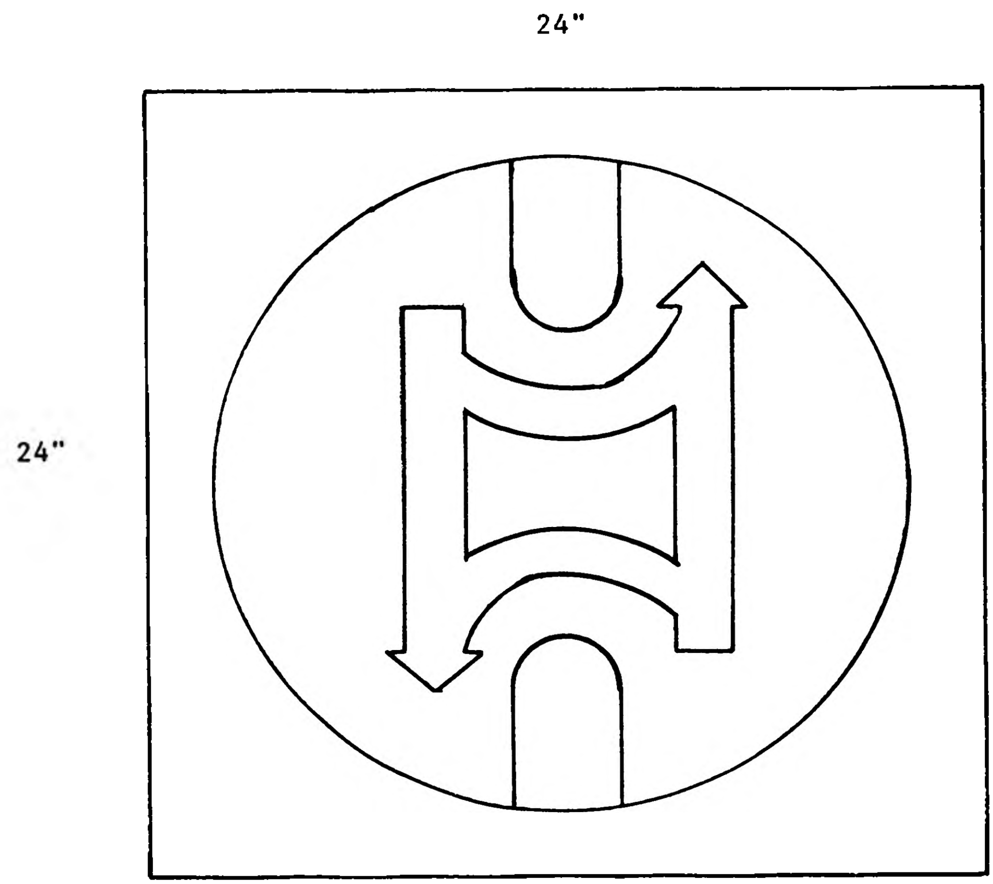
| | Age | | | |
|---|---|---|---|---|
| Sex | Under 30 | 30 - 49 | 50 & Over | Total |
| Male | 21.2 | 38.8 | 59.8 | 39.93 |
| Female | 24.0 | 42.0 | 57.4 | 41.13 |
| Total | 22.6 | 40.4 | 58.6 | 40.5 |

and normal colour vision. The mean visual acuity was 20/20. Those subjects who wore corrective lenses for driving also wore them for the experiment.

The sample was slightly biased towards older subjects by design. In 1983, approximately one third of licensed drivers were under 30 (Highway Statistics, 1983), 36.7% were between 30 and 49 and only 30% were 50 or over.

2. Apparatus: Seven candidate signs for median crossovers were studied in the experiment. These included five symbolic designs and two word signs. The design of the signs came from several sources, including the survey of State Highway Departments (two signs), the literature review (one sign), Federal Highway Administration personnel (two signs) and the Virginia crossover sign. The word signs included "Crossover" as this is the wording on the Texas sign included in Revision 3 of the 1978 Manual on Uniform Traffic Control Devices and "Median Opening" which includes the word "Median". Questions about wording were included in the last part of the experiment. The seven signs are shown in Figures 1 and 7-12. Nine other sign designs (from the same sources) were considered but in order to keep testing time to approximately one hour only a limited number of signs could be tested. The other designs considered can be seen in Appendix B.

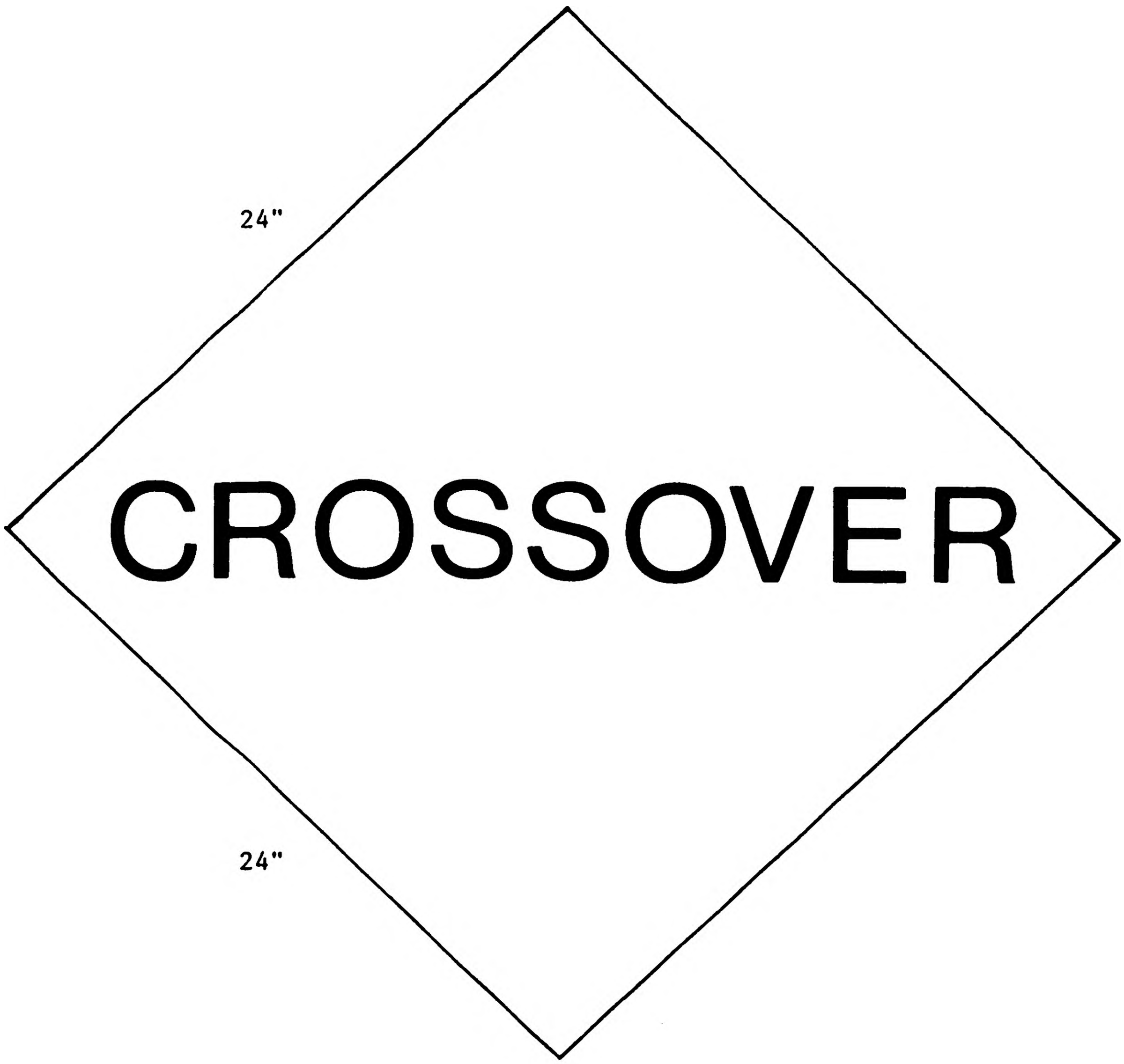
All the signs tested were yellow diamond warning signs at the suggestion of the Federal Highway Administration Office of Traffic Operations, with the exception of the Virginia crossover sign and the




black on white

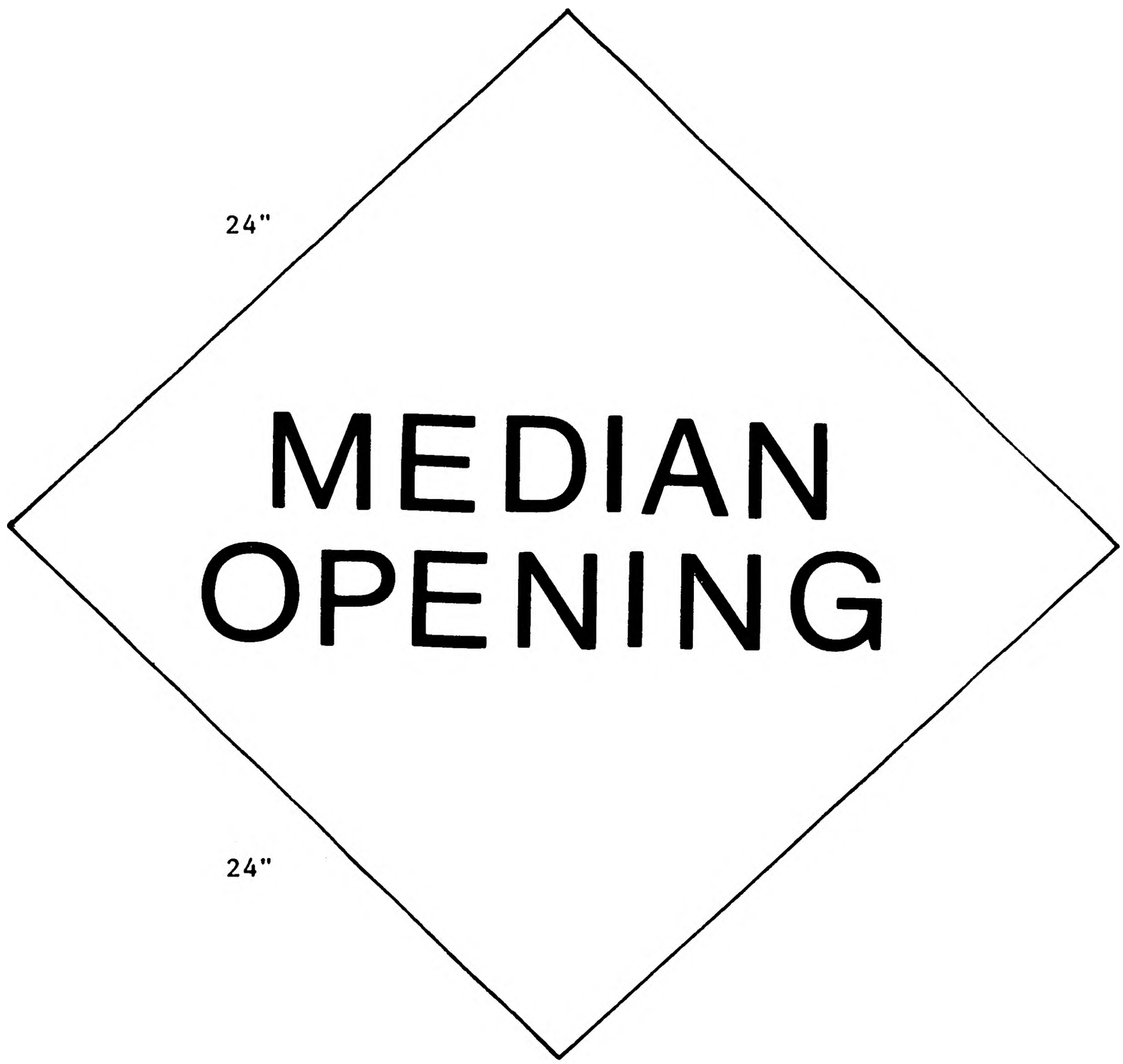
with green periphery

Figure 7. Permissive U Turn Sign Suggested by FHWA Office of Traffic Operations



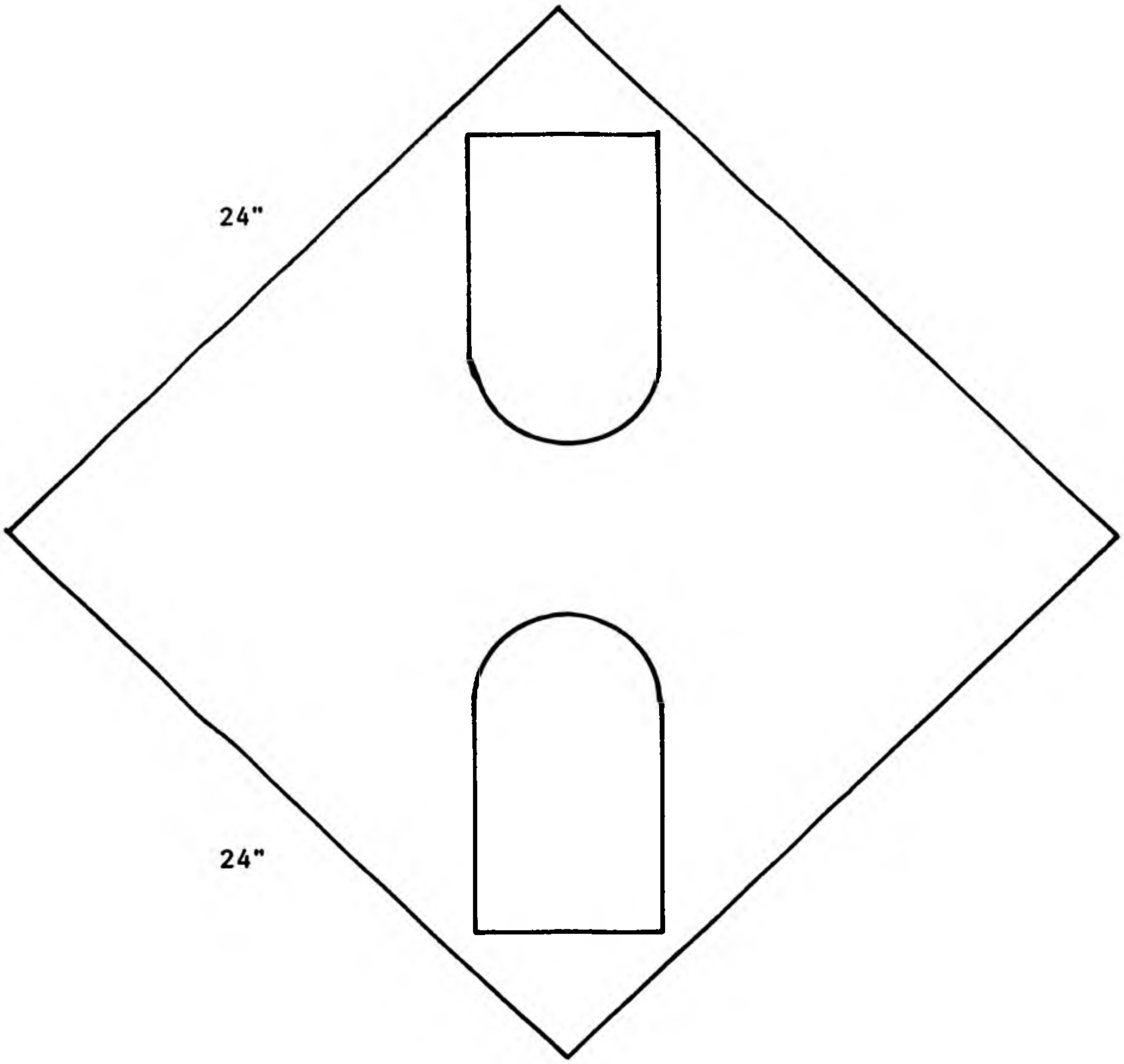

black on yellow

Figure 8. "Crossover" Sign Suggested by South Carolina



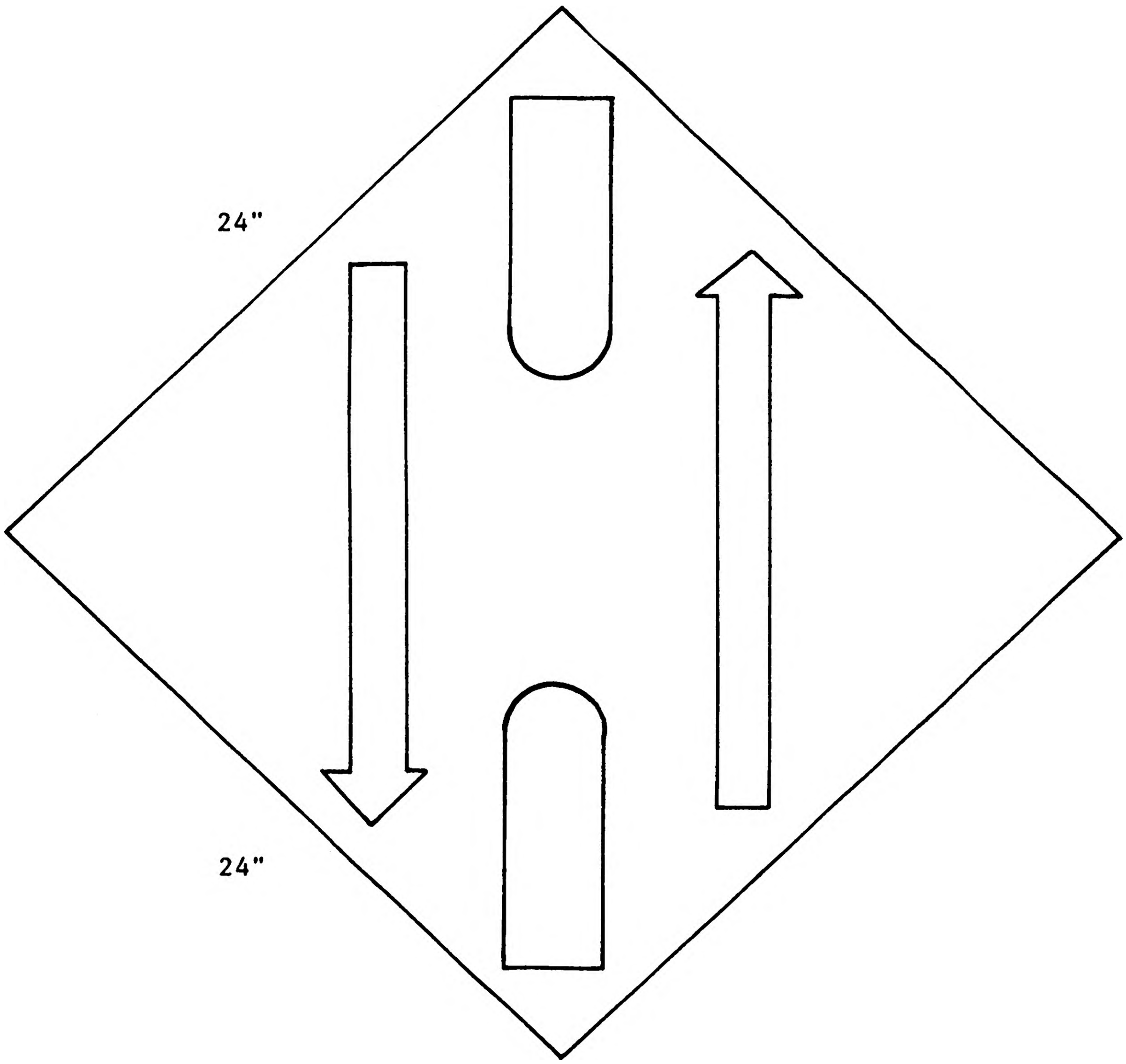

black on yellow

Figure 9. "Median Opening" Sign Suggested by FHWA Personnel



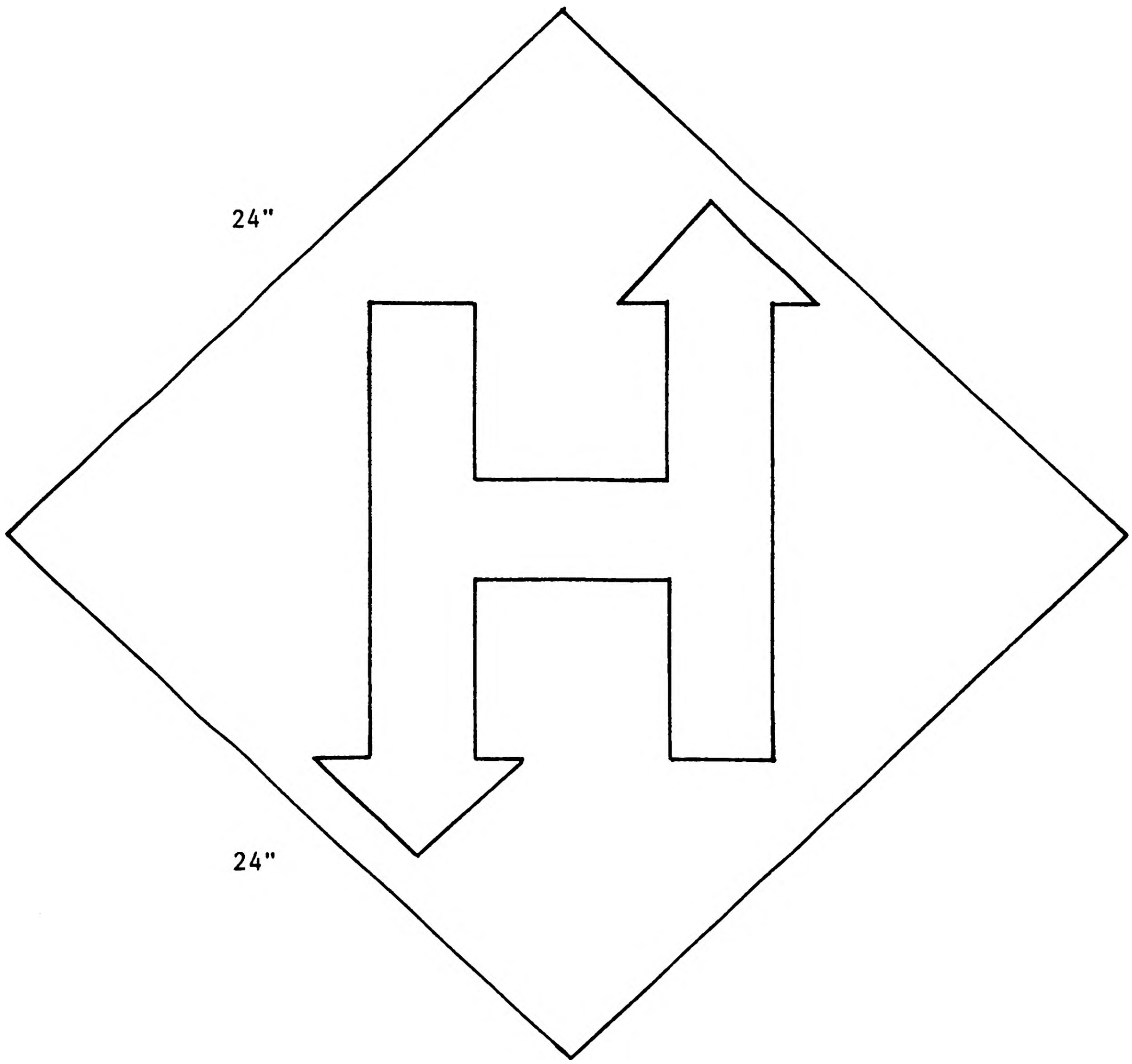

black on yellow

Figure 10. Crossover Nose Sign Suggested by FHWA Personnel




black on yellow

Figure 11. Nose Plus Arrows Sign Adapted from a Canadian Sign




black on yellow

Figure 12. Arrows Sign Suggested by South Carolina

Permissive U Turn sign suggested by the Office of Traffic Operations. Instead of a green ring to denote a permissive sign as has been tested in previous sign studies (eg. Walker, Alicandri and Roberts, 1985) they suggested using a green periphery (see Figure 7).

The signs were composed on a Tech Graphics II computer graphics system which is based on an IBM PC computer. The user communicates with the computer via a keyboard and a graphics tablet while the computer communicates with the user via a standard monitor and a high-resolution Intelligent Graphics Terminal (IGT) which displays images on an IGT monitor. Programs and data to operate the system are stored on a Corvus Hard Disk and pictures can be stored on the hard disk or on floppy disks. The IGT can display 256 different colours on the monitor at one time so any picture can contain 256 colours. A set of 256 representative colours is usually set up for each picture and is stored in a "colour map".

The system can also digitize images onto the IGT monitor through the use of a video camera and a digitizer. In the case of colour images, three images, one each through red, green and blue filters, are overlayed to produce the final colour image. After the signs had been composed on the graphics system they were superimposed onto a photograph of a median crossover which had been digitized into the system.

A red-green-blue camera can then be used to photographically record the images on the IGT monitor. Red, green and blue separations are made by photographing a black and white high-resolution, flat screen monitor through coloured filters. A standard Konica FS1 camera back is used to take slides on 35 mm film. The superimposed signs were photographed for

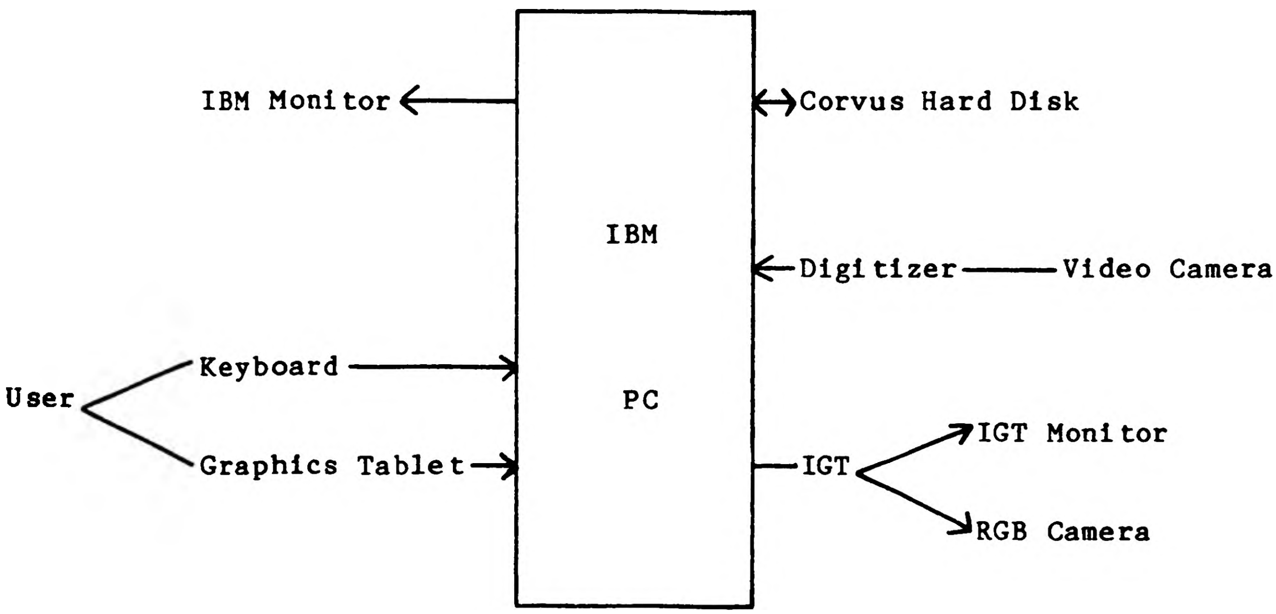



Figure 13. Components of the Tech Graphics II Computer Graphics System.

slides and the original sign designs were photographed for prints. Figure 13 shows a diagrammatic representation of the Tech Graphics II system.

Thirteen other signs were used as distractors. These included a Permissive Right Turn Sign similar to the Permissive U Turn and a railroad crossbuck outlined in red which was part of another Federal Highway Administration study. The other eleven signs were MUTCD signs, ten of which were chosen because they had already been drawn on the computer graphics system as they had been used in previous studies and were stored on computer disks. A type 3L object marker was also used as the Virginia crossover sign was similar in size to an object marker. The MUTCD signs used are shown in Table III.

The slides were rear-projected onto a translucent screen hanging from the ceiling by a Kodak Ektagraphic II slide projector, Model AT. The size of the projected image of the signs was 2 and 3/8 inches from point to point of the yellow diamond. This size was chosen so that the subjects with the best eye sight could not recognize familiar signs at the furthest distance away from the image (110 feet). Figure 14 shows a crossover sign superimposed onto a median crossover scene as seen by the subjects. A long advance lead allowed the slides to be advanced from the 110 feet distance.

The testing took place in a concrete tunnel approximately 12x12x120 feet underneath the structures laboratory at the Turner Fairbanks Highway Research Center in McLean, Virginia. The slide projector and screen were set up at one end of the tunnels as illustrated in Figure 15. Subjects viewed 5 x 3 1/2 inch prints of the seven crossover signs


Figure 14. Crossover Sign Superimposed Onto a Digitized Photograph of a Median Crossover

TABLE III

MUTCD SIGNS USED AS DISTRACTOR SIGNS

| Sign | MUTCD Code |
| --- | --- |
| No Right Turn | R3-1 |
| No U Turn | R3-4 |
| Type 3L Object Marker | OM-3L |
| Reverse Curve | W1-2R |
| Curve Right | W1-4R |
| Winding Road | W1-5 |
| Merge | W2-1 |
| Cross Road | W2-2 |
| Side Road Left | W4-1 |
| Two Way Traffic | W6-2 |
| Divided Highway Ends | W6-3 |

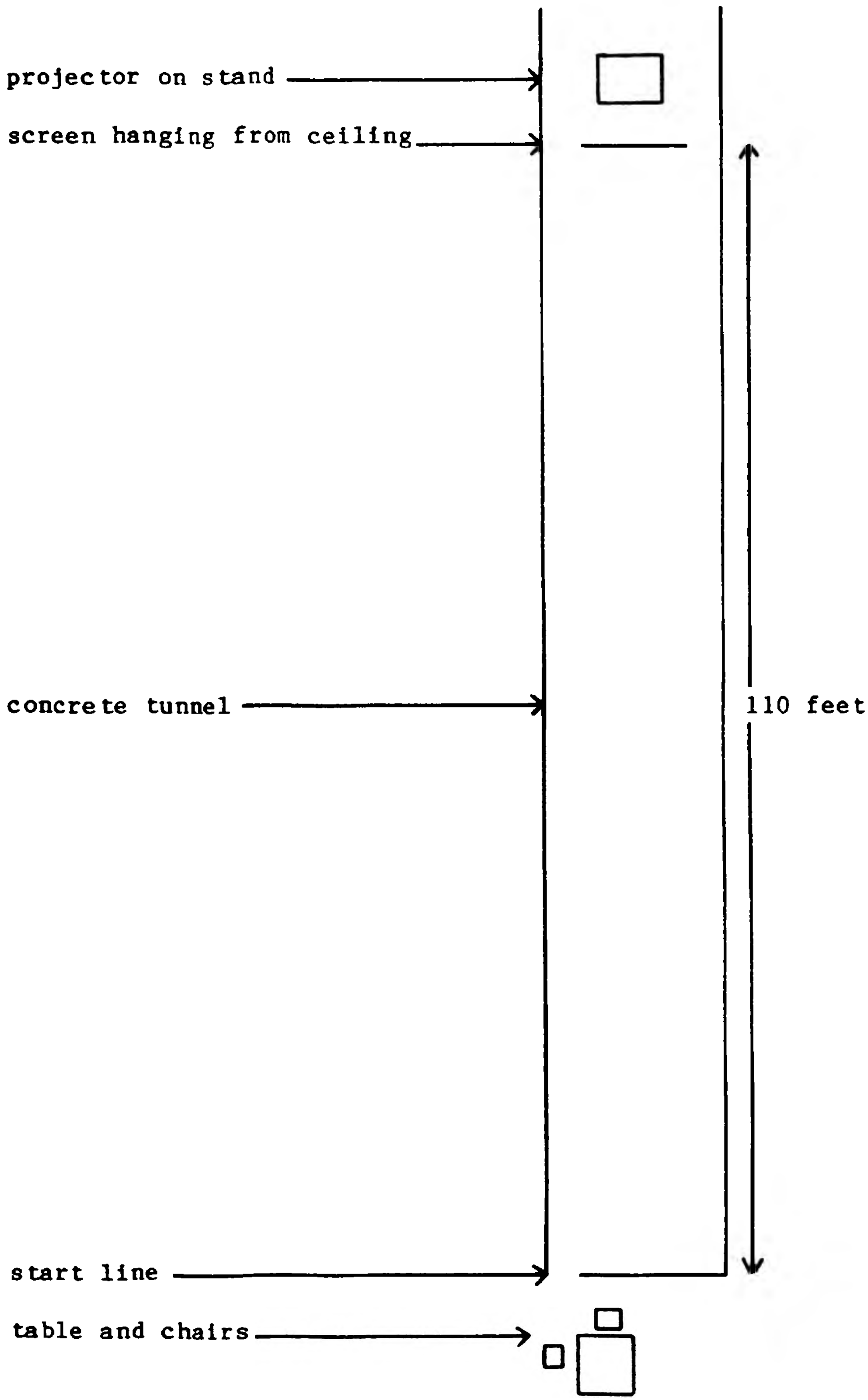



Figure 15. Apparatus Used for the Virginia Experiment

while listening to the intended meaning of the signs before part III of the experiment and while ranking the signs during part IV.

3. Procedure: The subjects were taken to the tunnel and first filled in a biographical data and consent form which can be seen in Appendix C. If they wore corrective lenses for driving they also wore them during the experiment.

a. Legibility and Meaning: The instructions for parts I and II were read to the subjects (see Appendix C) and after answering any questions they might have, the first slide was presented on the screen and the subject walked towards the projected sign until they could identify any feature on the sign. The feature and the distance at which it was identified were recorded. This procedure was repeated until all the major features of each sign had been identified. See Appendix C for the data collection sheet used for legibility.

The subjects were also instructed to give the meaning of the sign as soon as they thought they knew what it meant. If the meaning they gave was wrong they were instructed to try again. See Appendix C for the data collection sheet used for meaning.

When all of the features of the sign had been identified the subject walked back to the end of the tunnel, the next slide was presented and the procedure was repeated. This process was repeated until the subject had seen all 20 slides. The slides were presented in random order (which was different for each subject) with the proviso that the first two signs were not crossover signs. In this way the subject had some practice in the procedure before seeing a candidate sign, although they were not told this.

b. Recognition: After the subjects had completed the legibility and meaning section the intended meaning of the crossover signs was explained to them and they were given prints of the seven signs to become familiar with them.

The instructions for part III were read to the subject (see Appendix C) and they were then shown the 20 slides again, this time in a different random order. The subject walked towards the projected sign until they could identify it. The subjects were encouraged to guess the signs' meanings as far as possible from the screen so as to maximize confusions. All confusions and the distance at which they occurred and the distance at which each sign was correctly identified were recorded. The subjects were also asked to guess the meaning of the signs as soon as possible in part II and the data collection sheet used for recognition can be seen in Appendix C.

When each sign had been correctly identified the subject walked back to the end of the tunnel, the next slide was presented and the procedure was repeated. This process was repeated until the subject had seen all 20 slides.

c. Preference: The last part of the experiment was a preference test. The subjects were instructed to arrange prints of the seven crossover signs in order from the one they liked the best to the one they liked the least. The rank of each sign was then recorded (see Appendix C for the data collection sheet used for preference). The subjects were then asked seven questions about crossovers in general and were paid $10.00 for their participation.

## B. DIFFERENCES IN MISSOURI EXPERIMENT

1. Subjects: The Missouri subjects were unpaid volunteers recruited from Psychology and Civil Engineering students, staff, faculty and faculty wives at the University of Missouri-Rolla. Thirty subjects in the same age groups were again tested. The mean age of each group is shown in Table IV. There were some differences in the mean ages of each group from the Virginia subjects but these differences were fairly small.

The only method available for testing to ensure corrected visual acuity of 20/30 or better was a Snellen Eye Chart and this only allowed visual acuity to be classified as 20/20 or 20/30. Unfortunately colour vision could not be tested but their colour vision was correct according to each subject and no subject had problems with colours during the experiment.

2. Apparatus: The same set of slides were shown to the Missouri subjects with the addition of a "Median Crossover" sign which was shown to those subjects for which there was time to do so.

The slides were again rear-projected using exactly the same type of slide projector but the only method available to do this was using a smaller screen than that used in Virginia, standing on a table. The projector was also placed on the table, to the side of the screen and the slides were rear-projected using a mirror behind the screen. The

TABLE IV

MEAN AGES OF MISSOURI SUBJECT GROUPS

| Sex | Age: Under 30 | 30 - 49 | 50 & Over | Total |
|---|---|---|---|---|
| Male | 20.8 | 40.4 | 57.8 | 39.67 |
| Female | 20.6 | 42.0 | 58.8 | 40.47 |
| Total | 20.7 | 41.2 | 58.3 | 40.07 |

same size of projected image was used and the subjects again started viewing the slides from a distance of 110 feet. As only 60 feet of advance lead was available, the slides were advanced from the 60 feet distance.

A facility equivalent fo the tunnel in Virginia was not available so the testing took place in the third floor corridor of the Butler-Carlton Civil Engineering building at the University of Missouri-Rolla. Illumination in the corridor was 2-16 footcandles at floor level whereas that in the tunnel was 10-40 footcandles at floor level. The slide projector and screen were set up at one end of the corridor as illustrated in Figure 16.

3. Procedure: Exactly the same procedure was used as in Virginia with the exception that the subjects were not paid. The following discussion of the results will be concerned firstly with the Virginia results and secondly with the Missouri results. The results from both experiments will then be compared. Raw data will not be presented but is available in the Department of Civil Engineering at the University of Missouri-Rolla.

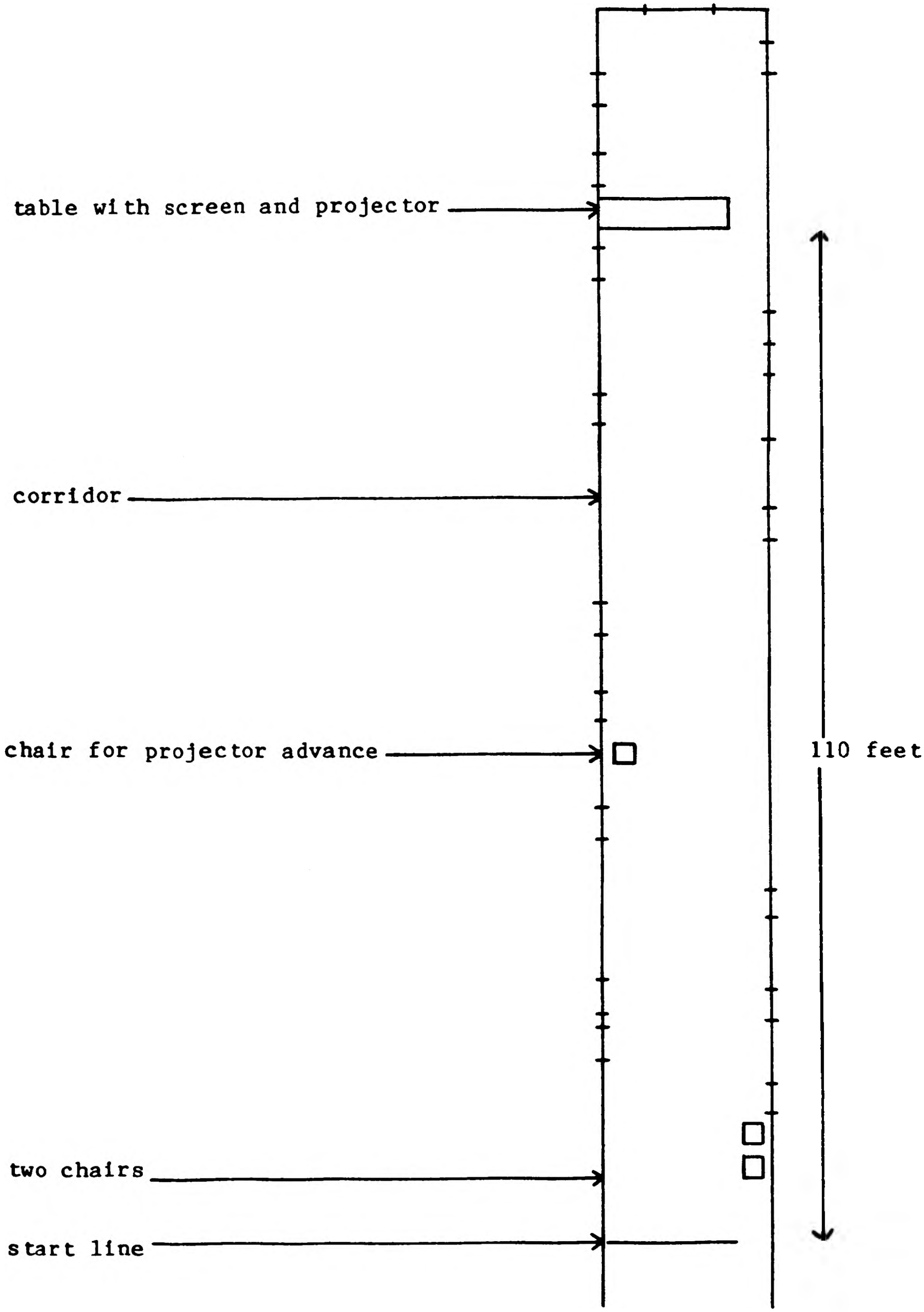



Figure 16. Apparatus Used for the Missouri Experiment

# V. RESULTS

## A. VIRGINIA

1. Legibility: Summary statistics for the identification of features data are given in Table V. The average distances reported here in feet are a relative measure of legibility from this laboratory situation and not the distances at which drivers would be able to read the signs in a real driving situation. In a similar study, Walker et. al. (1985) found a statistical relationship between their data and distances measured in a study involving real driving but this would not necessarily hold for the data from this study.

Sign shape was identified at a mean distance of approximately 100 feet or more except for the Virginia sign, the shape of which could not be identified until a mean distance of 63 feet. As can be seen from Table VI, an analysis of variance gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different. Sign colour could be identified at a mean distance of approximately 100 feet or more for all the signs and did not give a significant F value, indicating no mean distance was significantly different from the others.

The mean distance at which the colour of the symbol or letters could be seen was between 70 and 90 feet with the exception of the Virginia sign and the Permissive U Turn sign which had colour identification distances of 57 and 55 feet respectively. An analysis of variance gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table VII).

TABLE V: MEANS & STANDARD DEVIATIONS OF VIRGINIA LEGIBILITY DISTANCES

| Feature | | Crossover | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
|---|---|---|---|---|---|---|---|---|
| | | **Type of Sign** | | | | | | |
| Sign Shape | M | 99.90 | 106.67 | 62.77 | 101.96 | 103.63 | 108.20 | 100.64 |
| | SD | 15.35 | 10.18 | 29.38 | 12.91 | 12.50 | 5.64 | 19.73 |
| | N | 30 | 30 | 26 | 28 | 30 | 30 | 28 |
| Sign Colour | M | 106.30 | 107.87 | 99.03 | 105.67 | 107.40 | 107.80 | 100.27 |
| | SD | 7.47 | 7.01 | 20.85 | 9.91 | 6.99 | 5.93 | 19.75 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Colour of Symbol or Letters | M | 74.96 | 70.95 | 57.48 | 78.82 | 84.04 | 89.16 | 54.92 |
| | SD | 26.29 | 25.20 | 27.54 | 24.84 | 22.15 | 22.09 | 31.58 |
| | N | 23 | 22 | 29 | 28 | 27 | 25 | 26 |
| Presence of Symbol or Letters | M | 48.10 | 53.93 | 51.75 | 82.54 | 84.86 | 89.56 | 65.88 |
| | SD | 24.59 | 19.42 | 20.24 | 21.53 | 21.65 | 20.97 | 28.22 |
| | N | 29 | 30 | 8 | 26 | 29 | 25 | 25 |
| Presence of Median Nose | M | | | 34.03 | 36.20 | 34.60 | | 26.43 |
| | SD | | | 12.61 | 10.88 | 13.42 | | 11.98 |
| | N | | | 30 | 30 | 30 | | 30 |
| Road Pattern | M | | | | | 34.43 | 52.23 | 24.97 |
| | SD | | | | | 11.71 | 16.59 | 6.69 |
| | N | | | | | 30 | 30 | 30 |
| Crossover Movement | M | | | | | | 48.37 | 24.73 |
| | SD | | | | | | 11.77 | 7.08 |
| | N | | | | | | 30 | 30 |
| Read Legend | M | 12.27 | 11.40 | | | | | |
| | SD | 3.50 | 3.41 | | | | | |
| | N | 30 | 30 | | | | | |

All means and SDs are in feet

Sample sizes (N) differ because not all subjects mentioned all features

TABLE VI

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR VIRGINIA SIGN SHAPE IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 39323 | 6554 | 24.63 | <.01 |
| Within Groups | 195 | 51891 | 266 | | |
| Total | 201 | 91214 | | | |

df = degrees of freedom

SS = sum of squares

MS = mean square

TABLE VII

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR VIRGINIA SYMBOL COLOUR IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 26409 | 4401 | 6.57 | <.01 |
| Within Groups | 173 | 115825 | 670 | | |
| Total | 179 | 142234 | | | |

The presence of a symbol could be seen at an mean distance of 80-90 feet for the Median Nose, Nose Plus Arrows and Arrow signs but not until an average 66 feet for the Permissive U Turn sign and an average 52 feet for the Virginia sign. The presence of letters on the worded signs could not be seen until somewhat closer. The letters on the Median Opening sign could be seen at a mean distance of 54 feet whereas those on the Crossover sign could only be seen at an mean distance of 48 feet. An analysis of variance again gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table VIII).

The individual pictographic elements on each sign were identified at varying distances. The most obvious result was that the worded signs could be read only at very short distances, a mean distance of 12 feet for the Crossover sign and a mean distance of 11 feet for the Median Opening sign. An analysis of variance of the distance at which the smallest pictographic element could be identified produced a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table IX). Out of the symbol signs, the symbol on the Arrows sign could be seen at a mean distance of approximately 50 feet compared to a mean distance of about 35 feet for the symbols on the Median Nose, Nose Plus Arrows and Virginia signs. The symbol on the Permissive U Turn sign was seen the least well, at a mean distance of about 25 feet.

No significant relationship was found between the identification distance and the size of the largest dimension of each symbol or the largest dimension of individual pictographic elements. No significant

TABLE VIII

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR VIRGINIA SYMBOL PRESENCE IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 44711 | 7452 | 14.44 | <.01 |
| Within Groups | 165 | 85121 | 516 | | |
| Total | 171 | 129832 | | | |

TABLE IX

ANALYSIS OF VARIANCE SUMMARY TABLE FOR

VIRGINIA SMALLEST PICTOGRAPHIC ELEMENT IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 37266 | 6211 | 48.29 | <.01 |
| Within Groups | 203 | 26109 | 129 | | |
| Total | 209 | 63375 | | | |

relationships were found between identification distances and biographic variables such as age, sex, weekly driving mileage, accidents and violations in the past five years and wearing corrective lenses. Correlation coefficients of $r = -0.34$ to $-0.80$ ($p<.10$) were obtained between visual acuity and nearly all the identification distances for all the signs except for the Permissive U Turn sign, indicating as might be expected that subjects with lower (better) visual acuity could identify features at longer distances.

A classification of the data according to sex showed that the females tended to identify the shape and colour of the signs and the presence and colour of the symbols at slightly longer distances whereas the males tended to identify the details on the signs at longer distances. However two-way analyses of variance did not show any significant effects of sex on the legibility distances. A classification of the data according to age did not show any consistent differences and two-way analyses of variance did not show any significant effects of age on the legibility distances.

2. Understanding: The subjects were encouraged to guess the meaning of the signs as soon as possible. Their answers were coded according to whether they made an incorrect guess before a correct one or could not guess the meaning. The results are shown in Table X. The Chi Square value for this contingency table was significant ($p<.01$), indicating that the frequency distributions of answers for each sign were different.

The sign that seemed to convey the meaning most successfully was the Median Opening sign for which all the subjects managed to give the

TABLE X

VIRGINIA FREQUENCIES OF CORRECTNESS OF ANSWER BY TYPE OF SIGN

| Type of Answer | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Correct Answer Straight Away (1) | 16 | 27 | 13 | 18 | 15 | 13 | 9 |
| Partially Correct Answer Before Correct Answer (2) | 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| (2) + (3) | 10 | 3 | 4 | 5 | 8 | 11 | 6 |
| Incorrect Guess Before Correct Answer (3) | 8 | 2 | 4 | 4 | 8 | 11 | 6 |
| Incorrect Guess and No Correct Answer (4) | 4 | 0 | 5 | 4 | 5 | 6 | 5 |
| (4) + (5) | 4 | 0 | 13 | 7 | 7 | 6 | 15 |
| Don´t Know (5) | 0 | 0 | 8 | 3 | 2 | 0 | 10 |

Because of cells with frequencies of less than 5, categories 2 and 3 and 4 and 5 were combined to give the frequencies shown between these pairs of categories and Chi Square analysis was performed using 3 categories.

Chi Square = 41.65, df = 12, $p < .01$

correct meaning, 27 without a wrong guess first. The least understandable sign was the Permissive U Turn sign for which only 15 subjects managed to give the correct meaning and only nine without a wrong guess first. The Virginia sign also caused problems with 17 subjects not knowing the meaning or giving a wrong meaning first.

A record was also kept of misinterpretations of the meaning of the signs by the uncued subjects, of which there were nearly 100. Table XI shows the frequency of misinterpretations for each sign. The Arrows sign was misinterpreted most often, mainly with "hospital" or "H". The Nose Plus Arrows sign was misinterpreted 18 times, mainly with "divided highway" or "two way traffic". The Crossover sign was also misinterpreted a number of times especially with "crossroads", "bridge or overpass" and "construction". The last of these misinterpretations was probably due to misreading rather than not understanding the meaning of the sign.

The most frequent misinterpretations of the signs are given in Table XII. Most of the misinterpretations with "hospital" were associated with the Arrows sign and most of those with "divided highway" were associated with the Nose Plus Arrows sign. Some of the more obsure misinterpretations included "mountains", "football", "tunnel", "jogging" and "use seatbelts".

Table XIII shows the frequency of misinterpretations for the six groups based on age and sex. The 30-49 age group misinterpreted the signs more often than the other age groups and females under 30 misinterpreted the signs more often than males of the same age group but this could be due to a greater willingness to guess rather than greater

TABLE XI

VIRGINIA FREQUENCIES OF MISINTERPRETATIONS BY TYPE OF SIGN

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Misinterpretations | 18 | 5 | 10 | 11 | 18 | 23 | 13 |
| Subjects who could not guess the meaning at all | 0 | 0 | 8 | 3 | 2 | 0 | 10 |

TABLE XII

VIRGINIA MOST FREQUENT MISINTERPRETATIONS OF MEANING OF THE SIGNS

| Misinterpretation | Frequency |
|---|---|
| Hospital | 15 |
| Divided Highway | 11 |
| Traffic Signal, Lights | 8 |
| Bridge, Overpass | 6 |
| Crossroads, Intersection | 5 |
| Road Narrows, Lane Drop | 5 |
| Two-Way Traffic | 4 |
| Stop | 4 |
| Head-On Traffic | 3 |
| H | 3 |

TABLE XIII

VIRGINIA FREQUENCIES OF MISINTERPRETATIONS BY AGE AND SEX

| | Age | | | |
|---|---|---|---|---|
| Sex | Under 30 | 30 - 49 | 50 & Over | Total |
| Male | 11 | 21 | 14 | 46 |
| Female | 19 | 19 | 14 | 52 |
| Total | 30 | 40 | 28 | 98 |

difficulty in understanding the signs. No pattern was found in the types of misinterpretations for each sign according to age or sex.

The mean distances at which subjects understood the meaning of the signs are given in Table XIV. The worded signs were understood at much shorter distances than the symbolic signs because the subjects had to be able to read the signs before they could understand them. Of the symbol signs, the Arrows sign was understood at the furthest distance and also by the most subjects. However, this sign also caused the most confusion before a correct answer was given. An analysis of variance of the distances at which subjects understood the signs gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XV).

No significant relationships were found between understanding distances and biographic variables such as age, sex, weekly mileage, accidents and violations in the past five years, visual acuity and wearing corrective lenses. A classification of the data according to age and sex did not show any consistent differences.

3. Recognition: In this part of the experiment the subjects knew the meaning of the signs. Table XVI shows the mean distances at which they recognized the signs. The Virginia crossover sign was recognized at by far the greatest average distance because of its distinctive colour and shape followed by the Permissive U Turn sign. The worded signs were again recognized at the closest mean distances. An analysis of variance of the mean recognition distances gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XVII).

TABLE XIV

MEANS AND STANDARD DEVIATIONS OF VIRGINIA UNDERSTANDING DISTANCES (FEET)

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Mean | 14.12 | 11.40 | 24.94 | 32.57 | 30.61 | 41.08 | 22.07 |
| SD | 8.58 | 3.41 | 7.55 | 11.56 | 8.83 | 13.54 | 9.02 |
| N | 26 | 30 | 17 | 23 | 23 | 24 | 15 |

Sample sizes (N) differ because not all subjects understood what all the signs meant.

TABLE XV

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR VIRGINIA UNDERSTANDING DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 16992 | 2832 | 32.64 | <.01 |
| Within Groups | 151 | 13101 | 87 | | |
| Total | 157 | 30093 | | | |

TABLE XVI

MEANS AND STANDARD DEVIATIONS OF VIRGINIA RECOGNITION DISTANCES (FEET)

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Mean | 39.30 | 41.87 | 82.37 | 48.48 | 47.13 | 56.53 | 60.53 |
| SD | 19.96 | 21.49 | 24.91 | 19.03 | 14.53 | 18.26 | 29.24 |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

TABLE XVII

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR VIRGINIA RECOGNITION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 38799 | 6466 | 13.95 | <.01 |
| Within Groups | 202 | 93650 | 464 | | |
| Total | 208 | 132449 | | | |

The Median Nose sign was the only sign not recognized by one person. The total number of confusions with other signs was only 20. Eight of these involved the Nose Plus Arrows sign and were mainly confusions with "divided highway". The Arrows sign was confused five times. Table XVIII shows the frequency of confusions for each sign.

No significant relationships were found between recognition distances and biographic variables such as sex, weekly driving mileage, accidents and violations in the past five years and wearing corrective lenses. However correlation coefficients of $r = -0.46$ to $-0.50$ ($p<.05$) were obtained between age and recognition distance for the Median Opening, Median Nose, Nose Plus Arrows and Arrows signs, indicating that younger subjects found these signs easier to recognize than older subjects. Acuity was also found to be negatively correlated to the recognition distances for all the symbol signs ($r = -0.44$ to $-0.60$, $p<.05$) but not the worded signs.

A classification of the data according to age showed that mean recognition distances tended to be longer for each younger age group. However a two-way analysis of variance did not show any significant effects of age on the recognition distances. A classification of the data according to sex did not show any consistent differences in the mean recognition distances and a two-way analysis of variance did not show any significant effects of sex on these distances. However females tended to confuse the signs with other meanings more than males.

4. Preference: Table XIX shows the mean preference ranks subjects gave to the signs. The sign they thought best conveyed the message of a median crossover was ranked as number 1 and the sign they thought least

TABLE XVIII

VIRGINIA FREQUENCIES OF CONFUSIONS BY TYPE OF SIGN

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Confusions | 2 | 2 | 0 | 2 | 8 | 5 | 1 |
| Subjects who did not know the meaning | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

TABLE XIX

MEANS AND STANDARD DEVIATIONS OF VIRGINIA PREFERENCE RANKINGS

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Mean | 3.47 | 3.37 | 4.57 | 3.07 | 3.23 | 4.30 | 6.00 |
| SD | 1.93 | 1.88 | 1.89 | 1.51 | 1.91 | 1.66 | 1.64 |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

conveyed the messsage as number 7.

The most obvious conclusion from Table XIX is that the Permissive U Turn sign was the least preferred, with an average rank of 6. The Median Nose and Nose Plus Arrows signs were the most preferred, followed by the two word message signs, followed by the Arrows sign and the Virginia sign. A coefficient of concordance, W = 0.2341 was obtained for the preference rank data, and a Friedman Chi Square value of 42.12 was highly significant ($p<.001$), indicating there was a significant difference between the mean preference ranks of the signs and some agreement between the subjects on the ranks they gave to the signs.

A classification of the preference rank data according to age and sex showed that there was most agreement within the under 30 group in the preference ranks they gave to the signs. A coefficient of concordance, W = 0.4214 was obtained for this group and a Friedman Chi Square value of 25.29 was the only significant value obtained ($p<.001$) for the subgroup data. Within this young group there was most agreement between the females. A coefficient of concordance, W = 0.6171 was obtained for young females and a Friedman Chi Square of 18.51 was significant, $p<.01$.

Subjects were also asked questions on median crossovers in general. From the replies in Table XX there appears to be a need that could be filled by the use of crossover signs. Twenty two of the subjects (73%) thought public use crossovers are a hazard on divided highways and 29 (97%) thought a sign would help them locate a crossover.

Table XXI shows the types of hazards the subjects associated with

TABLE XX

VIRGINIA SUBJECT OPINIONS ON MEDIAN CROSSOVERS

| | Yes | No |
|---|---|---|
| Do you think median crossovers constitute a hazard on a divided highway? | 22 | 8 |
| Do you think a sign would help identify a crossover if you wanted to use one? | 29 | 1 |
| Would the addition of a distance plate help you locate a crossover? | 28 | 2 |

TABLE XXI

TYPES OF HAZARDS ASSOCIATED WITH MEDIAN CROSSOVERS BY VIRGINIA SUBJECTS

| Hazard | Frequency |
|---|---|
| Traffic slowing in fast lane | 20 |
| Traffic accelerating into fast lane | 8 |
| Turning Traffic | 4 |
| Sudden lane changes | 3 |
| Drivng on wrong side of road | 1 |
| Rear end collisions | 7 |
| Broadside collisions | 4 |
| None | 2 |

crossovers. They were clearly aware of the problems that crossovers can produce. The most frequently mentioned hazard was slowing traffic in the fast lane, followed by traffic accelerating into the fast lane, turning traffic and lane changes. One subject thought a crossover might lead to someone driving on the wrong side. The possibility of rear end collisions was mentioned by seven subjects and broadside collisions by four subjects. Only two subjects did not associate any hazards with crossovers.

Subjects were also asked what effect a crossover sign would have on their driving. The replies are shown in Table XXII. Twelve subjects said they would look for the sign if they wanted to locate a crossover and two subjects said they would be able to change lane or signal when they saw the sign if they wanted to use a crossover. Half the subjects said they would look for slowing traffic if they saw a crossover sign, five said they would slow down and four said they would change lane. Only one subject said the sign would have no effect on their driving.

The replies to questions about worded signs are shown in Table XXIII. The subjects were asked which word out of "Crossover", "Crossing" and "Opening" conveyed the meaning to them the best. Twenty of the subjects chose "Crossover", seven chose "Opening" and three chose "Crossing". They were also asked if the addition of the word "Median" would help clarify the meaning and 24 (80%) said it would.

Questions were also asked about the appropriate distance for placing a crossover sign in front of it. Subjects did not necessarily have to reply in feet. The replies are shown in Table XXIV. Two thirds of the subjects gave distances of over four hundred feet in terms of

TABLE XXII

EFFECT VIRGINIA SUBJECTS SAID SIGN WOULD HAVE ON THEIR DRIVING

| Effect | Frequency |
|---|---|
| Would look for sign if wanted to use a crossover | 12 |
| Would change lane if wanted to use a crossover | 1 |
| Would signal if wanted to use a crossover | 1 |
| Would look for slowing traffic | 15 |
| Would slow down | 5 |
| Would change lane | 4 |
| None | 1 |

TABLE XXIII

VIRGINIA SUBJECT OPINIONS OF WORDED SIGNS

| | Crossover | Crossing | Opening |
|---|---|---|---|
| Which word best conveys the presence of such a facility to you? | 20 | 3 | 7 |

| | Yes | No |
|---|---|---|
| Would the addition of the word "median" help to clarify the meaning of the sign? | 24 | 6 |

TABLE XXIV

DISTANCE AT WHICH VIRGINIA SUBJECTS THOUGHT SIGN SHOULD BE PLACED IN FRONT OF A CROSSOVER

| Distance | Frequency |
|---|---|
| Less than 100 feet | 4 |
| 100-199 feet | 2 |
| 200-299 feet | 2 |
| 300-399 feet | 2 |
| 405 feet (5 seconds at 55 mph) | 1 |
| 500 feet (stopping distance at 55 mph) | 8 |
| 810 feet (10 seconds at 55 mph) | 3 |
| 1320 feet (1/4 mile) | 2 |
| 1620 feet (20 seconds at 55 mph) | 1 |
| 2640 feet (1/2 mile) | 5 |

travelling time at 55 mph, stopping distance or miles. The most common reply was time to slow down and stop before the crossover. AASHTO stopping sight distances are 450-550 feet at 55 mph on wet pavement so these replies were converted to 500 feet. Table XX shows that 28 (93%) of the subjects thought that the addition of a distance plate beneath the sign would help to locate the crosssover.

B. MISSOURI

1. Legibility: Summary statistics for the identification of features data are given in Table XXV. Sign shape was identified at a mean distance of over 100 feet except for the Virginia sign, the shape of which could not be identified until considerably closer again. As can be seen from Table XXVI, an analysis of variance gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different.

Sign colour could be identified at a mean distance of approximately 108 feet for the yellow diamond signs but at somewhat closer mean distances for the green Virginia and Permissive U Turn signs. An analysis of variance gave a significant F value ($p<.01$), indicating that at least one mean was significantly different (see Table XXVI).

The mean distance at which the colour of the symbol or letters could be seen was between approximately 76 and 100 feet with the exception of the Virginia sign which had a colour identification distance of 55 feet. An analysis of variance gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XXVII).

TABLE XXV: MEANS & STANDARD DEVIATIONS OF MISSOURI LEGIBILITY DISTANCES

| Feature | | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
|---|---|---|---|---|---|---|---|---|
| | | Type of Sign | | | | | | |
| Sign Shape | M | 103.83 | 106.03 | 65.43 | 102.00 | 102.77 | 109.23 | 102.28 |
| | SD | 11.94 | 8.00 | 30.16 | 15.78 | 16.25 | 2.34 | 18.29 |
| | N | 30 | 30 | 28 | 30 | 30 | 30 | 29 |
| Sign Colour | M | 108.67 | 107.63 | 96.37 | 107.77 | 108.00 | 105.50 | 85.55 |
| | SD | 4.74 | 7.09 | 23.14 | 6.62 | 7.28 | 6.23 | 29.61 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 29 |
| Colour of Symbol or Letters | M | 82.93 | 76.40 | 55.03 | 93.47 | 95.13 | 100.53 | 76.21 |
| | SD | 25.75 | 25.63 | 28.42 | 21.76 | 19.78 | 15.27 | 29.61 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 28 |
| Presence of Symbol or Letters | M | 41.47 | 50.33 | 69.05 | 92.60 | 95.27 | 100.53 | 84.54 |
| | SD | 22.18 | 21.24 | 26.48 | 23.50 | 19.68 | 15.27 | 27.53 |
| | N | 30 | 30 | 19 | 30 | 30 | 30 | 26 |
| Presence of Median Nose | M | | | 36.70 | 39.67 | 34.97 | | 29.33 |
| | SD | | | 12.24 | 10.98 | 13.29 | | 12.01 |
| | N | | | 30 | 30 | 30 | | 30 |
| Road Pattern | M | | | | | 37.83 | 59.03 | 27.63 |
| | SD | | | | | 14.22 | 19.24 | 9.13 |
| | N | | | | | 30 | 29 | 30 |
| Crossover Movement | M | | | | | | 50.28 | 27.13 |
| | SD | | | | | | 11.45 | 9.67 |
| | N | | | | | | 29 | 30 |
| Read Legend | M | 12.40 | 11.93 | | | | | |
| | SD | 3.15 | 3.76 | | | | | |
| | N | 30 | 30 | | | | | |

All means and SDs are in feet

Sample sizes (N) differ because not all subjects mentioned all features

TABLE XXVI

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR MISSOURI SIGN SHAPE AND COLOUR IDENTIFICATION DISTANCES

Sign Shape

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 37888 | 6315 | 22.98 | <.01 |
| Within Groups | 200 | 54963 | 275 | | |
| Total | 206 | 92851 | | | |

Sign Colour

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 14077 | 2346 | 10.27 | <.01 |
| Within Groups | 202 | 46125 | 228 | | |
| Total | 208 | 60202 | | | |

TABLE XXVII

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR MISSOURI SYMBOL COLOUR IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Sign Type | 6 | 42983 | 7164 | 12.46 | <.01 |
| Sex | 1 | 4859 | 4859 | 8.45 | <.01 |
| Sign Type x Sex | 6 | 784 | 131 | 0.23 | n.s. |
| Error | 194 | 111562 | 575 | | |
| Total | 207 | 160188 | | | |

The presence of a symbol could be detected at an mean distance of approximately 90-100 feet for the Median Nose, Nose Plus Arrows and Arrow signs but not until an average 85 feet for the Permissive U Turn sign and an average 69 feet for the Virginia sign. The presence of letters on the worded signs could not be seen until somewhat closer. The letters on the Median Opening sign could be seen at a mean distance of 50 feet whereas those on the Crossover sign could only be seen at an mean distance of 41 feet. An analysis of variance again gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XXVIII).

The individual pictographic elements on each sign were again identified at varying distances. The worded signs could again be read only at very short distances, a mean distance of 12 feet for both the Crossover sign and the Median Opening sign. An analysis of variance of the distance at which the smallest pictographic element could be identified produced a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XXIX). Out of the symbol signs, the symbol on the Arrows sign could be seen at a mean distance of 50-60 feet compared to a mean distance of 35-40 feet for the symbols on the Median Nose, Nose Plus Arrows and Virginia signs. The symbol on the Permissive U Turn sign was seen the least well, at a mean distance of about 28 feet.

No significant relationship was found between the identification distance and the size of the largest dimension of each symbol. Correlations of $r = 0.27$ and $r = 0.45$ ($p<.01$) were obtained between the identification distances and the size of the median nose and the arrows

TABLE XXVIII

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR MISSOURI SYMBOL PRESENCE IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 95765 | 15961 | 32.29 | <.01 |
| Within Groups | 188 | 92930 | 494 | | |
| Total | 194 | 188695 | | | |

TABLE XXIX

ANALYSIS OF VARIANCE SUMMARY TABLE FOR

MISSOURI SMALLEST PICTOGRAPHIC ELEMENT IDENTIFICATION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 47700 | 7950 | 56.92 | <.01 |
| Within Groups | 202 | 28213 | 140 | | |
| Total | 208 | 75913 | | | |

or road pattern respectively, indicating that the larger features were identified at longer distances. No significant relationships were found between identification distances and biographic variables such as age, sex, weekly driving mileage, accidents and violations in the past five years and wearing corrective lenses.

A classification of the data according to sex showed that the females tended to identify all the features of the signs with the exception of reading the word signs at slightly longer distances than the males. However two-way analyses of variance did not show any significant effects of sex on the legibility distances except for symbol colour in which the effect of sex was significant ($p<.01$), see Table (XXVII). A classification of the data according to age did not show any consistent differences and two-way analyses of variance did not show any significant effects of age on the legibility distances.

2. Understanding: The subjects were again encouraged to guess the meaning of the signs as soon as possible and their answers were coded according to whether they made an incorrect guess before a correct one or could not guess the meaning. The results are shown in Table XXX. The Chi Square value for this contingency table was significant ($p<.01$), indicating that the frequency distributions of answers for each sign were different.

The sign that seemed to convey the meaning most successfully again was the Median Opening sign for which all but one of the subjects managed to give the correct meaning and 24 without a wrong guess first. The symbol signs all caused problems with only the Arrows sign being guessed by over half of the subjects.

TABLE XXX

MISSOURI FREQUENCIES OF CORRECTNESS OF ANSWER BY TYPE OF SIGN

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| Type of Answer | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Correct Answer Straight Away (1) | 12 | 24 | 12 | 9 | 11 | 14 | 9 |
| Partially Correct Answer Before Correct Answer (2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (2) + (3) | 13 | 5 | 2 | 4 | 4 | 8 | 5 |
| Incorrect Guess Before Correct Answer (3) | 13 | 5 | 2 | 4 | 4 | 8 | 5 |
| Incorrect Guess and No Correct Answer (4) | 3 | 1 | 6 | 8 | 11 | 7 | 8 |
| (4) + (5) | 5 | 1 | 16 | 17 | 15 | 8 | 16 |
| Don't Know (5) | 2 | 0 | 10 | 9 | 4 | 1 | 8 |

Because of cells with frequencies of less than 5, categories 2 and 3 and 4 and 5 were combined to give the frequencies shown between these pairs of categories and Chi Square analysis was performed using 3 categories.

Chi Square = 35.25, df = 12, $p<.01$

A record was again kept of misinterpretations of the meaning of the signs by the uncued subjects, of which there were over 100. Table XXXI shows the frequency of misinterpretations for each sign. The Nose Plus Arrows sign was misinterpreted most often, mainly with "divided highway" or "two way traffic". The Crossover sign was misinterpreted 20 times, mainly with "crossroads", "bridge ahead" or "pedestrian crossing". The Permissive U Turn sign was also misinterpreted a number of times especially with "bridge ahead" and "speed limit".

The most frequent misinterpretations of the signs are given in Table XXXII. Most of the misinterpretations with "hospital" were again associated with the Arrows sign and most of those with "divided highway" were associated with the Nose Plus Arrows sign. Some of the more obsure misinterpretations included "helicopters", "motorcycles", "farmer", "no trucks" and "butterflies".

Table XXXIII shows the frequency of misinterpretations for the six groups based on age and sex. The females misinterpreted the signs more often than the males, particulary in the under 30 and over 50 age groups but this again could be due to a greater willingness to guess rather than greater difficulty in understanding the signs. No pattern was found in the types of misinterpretations for each sign according to age or sex.

The mean distances at which subjects understood the meaning of the signs are given in Table XXXIV. The worded signs were again understood at much shorter distances than the symbolic signs because the subjects had to be able to read the signs before they could understand them. Of the symbol signs, the Arrows sign was again understood at the furthest

TABLE XXXI

MISSOURI FREQUENCIES OF MISINTERPRETATIONS BY TYPE OF SIGN

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Misinterpretations | 20 | 7 | 8 | 15 | 24 | 12 | 17 |
| Subjects who could not guess the meaning at all | 2 | 0 | 10 | 9 | 4 | 1 | 8 |

TABLE XXXII

MISSOURI MOST FREQUENT MISINTERPRETATIONS OF MEANING OF THE SIGNS

| Misinterpretation | Frequency |
|---|---|
| Divided Highway | 14 |
| Hospital | 9 |
| Bridge, Overpass | 8 |
| Two way Traffic | 8 |
| Traffic Signal, Lights | 7 |
| Crossroads, Intersection | 6 |
| Passing Lane | 5 |
| Pedestrian Crossing | 4 |
| Speed Limit | 3 |
| Highway Number | 3 |

TABLE XXXIII

MISSOURI FREQUENCIES OF MISINTERPRETATIONS BY AGE AND SEX

| Sex | Age: Under 30 | 30 - 49 | 50 & Over | Total |
|---|---|---|---|---|
| Male | 14 | 16 | 14 | 44 |
| Female | 20 | 15 | 24 | 59 |
| Total | 34 | 31 | 38 | 103 |

distance and also by the most subjects. An analysis of variance of the distances at which subjects understood the signs gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XXXV).

No significant relationships were found between understanding distances and biographic variables such as age, sex, weekly mileage, accidents and violations in the past five years and wearing corrective lenses. A classification of the data according to age and sex did not show any consistent differences.

3. Recognition: In this part of the experiment the subjects knew the meaning of the signs. Table XXXVI shows the mean distances at which they recognized the signs. The Virginia crossover sign was recognized at by far the greatest average distance again because of its distinctive colour and shape followed by the Arrows sign. The worded signs were again recognized at the closest mean distances. An analysis of variance of the mean recognition distances gave a significant F value ($p<.01$), indicating that at least one mean distance was significantly different (see Table XXXVII).

The total number of confusions with other signs was again 20. Nine of these involved the Nose Plus Arrows sign and were mainly confusions with "divided highway". The Arrows sign was confused six times. Table XXXVIII shows the frequency of confusions for each sign.

No significant relationships were found between recognition distances and biographic variables such as age, sex, weekly driving mileage, accidents and violations in the past five years and wearing

TABLE XXXIV

MEANS AND STANDARD DEVIATIONS OF MISSOURI UNDERSTANDING DISTANCES (FEET)

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Mean | 12.68 | 11.66 | 26.50 | 29.38 | 28.47 | 37.00 | 18.71 |
| SD | 3.31 | 3.60 | 7.88 | 9.426 | 13.10 | 13.23 | 7.87 |
| N | 25 | 29 | 14 | 13 | 15 | 22 | 14 |

Sample sizes (N) differ because not all subjects understood what all the signs meant.

TABLE XXXV

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR MISSOURI UNDERSTANDING DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 11995 | 1999 | 26.64 | <.01 |
| Within Groups | 125 | 9381 | 75 | | |
| Total | 131 | 21376 | | | |

TABLE XXXVI

MEANS AND STANDARD DEVIATIONS OF MISSOURI RECOGNITION DISTANCES (FEET)

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Mean | 33.63 | 29.27 | 75.70 | 47.60 | 45.30 | 58.90 | 57.83 |
| SD | 19.48 | 18.34 | 26.09 | 18.24 | 11.91 | 18.16 | 28.94 |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

TABLE XXXVII

ANALYSIS OF VARIANCE SUMMARY TABLE

FOR MISSOURI RECOGNITION DISTANCES

| Source of Variation | df | SS | MS | F | p |
|---|---|---|---|---|---|
| Among Groups | 6 | 45786 | 7631 | 17.58 | <.01 |
| Within Groups | 203 | 88105 | 434 | | |
| Total | 209 | 133891 | | | |

corrective lenses. A classification according to age and sex did not show any consistent differences in the mean recognition distances and two-way analyses of variance did not show any significant effects of age or sex on these distances. However, females again tended to confuse the signs with other meanings more than males.

4. Preference: Table XXXIX shows the mean preference ranks subjects gave to the signs. The sign they thought best conveyed the message of a median crossover was ranked as number 1 and the sign they thought least conveyed the messsage as number 7.

The Missouri subjects least preferred the Virginia and the Permissive U Turn signs. The Median Opening and the Median Nose signs were the most preferred, followed by the Arrows and the Crossover signs, A Friedman Chi Square value was not significant for this data, indicating there was no significant difference between the mean preference ranks of the signs, which can be seen from Table XXXIX to be very similar.

A classification of the preference rank data according to age and sex showed that there was significant agreement within the under 30 group and within the females in the preference ranks they gave to the signs. A coefficient of concordance, W = 0.2434 was obtained for the under 30 group and a Friedman Chi Square value of 13.14 was significant ($p<.05$). A coefficient of concordance, W = 0.2741 was obtained for the females and a Friedman Chi Square value of 23.02 was significant ($p<.001$). Within the females there was most agreement between the over 50s. A coefficient of concordance, W = 0.7457 was obtained for the over 50 females and a Friedman Chi Square of 22.37 was significant ($p<.01$).

TABLE XXXVIII

MISSOURI FREQUENCIES OF CONFUSIONS BY TYPE OF SIGN

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Confusions | 0 | 2 | 0 | 3 | 9 | 6 | 0 |
| Subjects who did not know the meaning | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE XXXIX

MEANS AND STANDARD DEVIATIONS OF MISSOURI PREFERENCE RANKINGS

| | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Mean | 4.10 | 3.52 | 4.76 | 3.62 | 3.79 | 3.66 | 4.62 |
| SD | 2.08 | 2.26 | 2.29 | 1.86 | 1.45 | 1.56 | 2.25 |
| N | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

Subjects were again asked questions on median crossovers in general. The replies in Table XL again showed that there appears to be a need that could be filled by the use of crossover signs. Twenty four of the subjects (80%) thought public use crossovers are a hazard on divided highways and 29 (97%) thought a sign would help them locate a crossover.

Table XLI shows the types of hazards the subjects associated with crossovers. The Missouri subjects were also aware of the problems that crossovers can produce. The most frequently mentioned hazards were slowing traffic in the fast lane and traffic accelerating into the fast lane followed by turning traffic and traffic pulling out from the side road infront of you. The possibility of rear end collisions was mentioned by six subjects and broadside collisions by five subjects. Only five subjects did not associate any hazards with crossovers.

The replies to the question about what effect a crossover sign would have on their driving of the Missouri subjects are shown in Table XLII. Seven subjects said they would look for the sign if they wanted to locate a crossover and one subject said they would be able to change lane when they saw the sign if they wanted to use a crossover. Twelve subjects said they would look for slowing traffic if they saw a crossover sign, eleven said they would slow down and three said they would change lane. Only three subjects said the sign would have no effect on their driving.

The replies to questions about worded signs are shown in Table XLIII. The subjects were asked which word out of "Crossover", "Crossing" and "Opening" conveyed the meaning to them the best. Twenty three of the

TABLE XL

MISSOURI SUBJECT OPINIONS ON MEDIAN CROSSOVERS

| | Yes | No |
|---|---|---|
| Do you think median crossovers constitute a hazard on a divided highway? | 24 | 6 |
| Do you think a sign would help identify a crossover if you wanted to use one? | 29 | 1 |
| Would the addition of a distance plate help you locate a crossover? | 25 | 5 |

TABLE XLI

TYPES OF HAZARDS ASSOCIATED WITH MEDIAN CROSSOVERS BY MISSOURI SUBJECTS

| Hazard | Frequency |
|---|---|
| Traffic slowing in fast lane | 10 |
| Traffic accelerating into fast lane | 10 |
| Turning Traffic | 8 |
| Traffic pulling out in front | 5 |
| Sudden lane changes | 2 |
| Overtaking at a cossover | 1 |
| Gravel crossovers | 1 |
| Rear end collisions | 6 |
| Broadside collisions | 5 |
| None | 5 |

TABLE XLII

EFFECT MISSOURI SUBJECTS SAID SIGN WOULD HAVE ON THEIR DRIVING

| Effect | Frequency |
|---|---|
| Would look for sign if wanted to use a crossover | 7 |
| Would change lane if wanted to use a crossover | 1 |
| Would look for slowing traffic | 12 |
| Would slow down | 11 |
| Would change lane | 3 |
| None | 3 |

TABLE XLIII

MISSOURI SUBJECT OPINIONS OF WORDED SIGNS

| | Crossover | Crossing | Opening |
|---|---|---|---|
| Which word best conveys the presence of such a facility to you? | 23 | 5 | 2 |

| | Yes | No |
|---|---|---|
| Would the addition of the word "median" help to clarify the meaning of the sign? | 22 | 8 |

subjects chose "Crossover", two chose "Opening" and five chose "Crossing". They were also asked if the addition of the word "Median" would help clarify the meaning and 22 (73%) said it would.

Questions were again asked about the appropriate advance for placing a crossover sign infront of it. Subjects did not necessarily have to reply in feet. The replies are shown in Table XLIV. Two thirds of the subjects again gave distances of over four hundred feet in terms of travelling time at 55 mph, stopping distance or miles. The most common replies were time to slow down and stop before the crossover and 300-399 feet. Table XL shows that 25 (83%) of the subjects thought that the addition of a distance plate beneath the sign would help to locate the crosssover.

## C. COMPARISON OF THE VIRGINIA AND MISSOURI RESULTS

1. Legibility: Although the different experimental conditions preclude statistical comparison, a comparison of Tables V and XXV shows that the legibility distances for both groups of subjects were very similar. The Missouri distances were slightly longer in the majority of but not all cases. From the values of N in the tables it can be seen that the Missouri subjects were somewhat better at remembering to mention all the features than the Virginia subjects (N tends to be closer to 30 in Table XXV than in Table V).

About the only difference of note in the two sets of results is that analysis of variance gave a significant F value for sign colour with the Missouri data but not the Virginia data, indicating that at least one mean distance for sign colour was significantly different in

TABLE XLIV

DISTANCE AT WHICH MISSOURI SUBJECTS THOUGHT SIGN

SHOULD BE PLACED IN FRONT OF A CROSSOVER

| Distance | Frequency |
|---|---|
| Less than 100 feet | 1 |
| 100-199 feet | 2 |
| 200-299 feet | 1 |
| 300-399 feet | 6 |
| 405 feet (5 seconds at 55 mph) | 1 |
| 500 feet (stopping distance at 55 mph) | 6 |
| 810 feet (10 seconds at 55 mph) | 1 |
| 1320 feet (1/4 mile) | 5 |
| 1620 feet (20 seconds at 55 mph) | 1 |
| 2420 feet (30 seconds at 55 mph) | 1 |
| 2640 feet (1/2 mile) | 2 |
| 4033 feet (50 seconds at 55 mph) | 1 |
| 4840 feet (60 seconds at 55 mph) | 1 |
| 7260 feet (90 seconds at 55 mph) | 1 |

Missouri but not in Virginia. From Tables V and XXV this can be seen to be due to a shorter identification distance for the Permissive U Turn sign colour in Missouri (85.55 feet compared to 96.37 feet in Virginia). The Missouri sign colour identification distance for the Virginia crossover sign was also shorter than in Virginia and during testing the Missouri subjects gave the impression of having more difficulty identifying the green signs than the Virginia subjects.

Significant correlation coefficients between the size of the median nose and arrows or road pattern and identification distances were obtained for the Missouri data but not the Virginia data. Significant correlation coefficients were obtained between visual acuity and nearly all the identification distances for the Virginia data but as visual acuity could only be classified as 20/20 or 20/30 in Missouri, such correlations could not be obtained for the Missouri data.

In Virginia, females tended to identify the shape and colour of the signs and the presence and colour of the symbols at slightly longer distances and males tended to identify the details on the signs at longer distances. In Missouri, females tended to identify all the features of the signs with the exception of reading the word signs at slightly longer distances than males. These differences were not statistically significant lowever with the exception of symbol colour in Missouri where two-way analysis of variance showed a significant effect of sex and the symbol colour identification distances were 6-15 feet longer for the females than for the males.

2. Understanding: Tables XLV shows that the Missouri subjects had more difficulty in guessing the meaning of the signs than the Virginia

TABLE XLV

COMPARISON OF THE UNDERSTANDING OF THE SIGNS IN VIRGINIA AND MISSOURI

| | | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Understanding Distance (ft) | VA | 14.12 | 11.40 | 24.94 | 32.57 | 30.61 | 41.08 | 22.07 |
| | MO | 12.68 | 11.66 | 26.50 | 29.38 | 28.47 | 37.00 | 18.71 |
| Correct Answer Straight Away | VA | 16 | 27 | 13 | 18 | 15 | 13 | 9 |
| | MO | 12 | 24 | 12 | 9 | 11 | 14 | 9 |
| Incorrect Guess Before Correct Answer | VA | 10 | 3 | 4 | 5 | 8 | 11 | 6 |
| | MO | 13 | 5 | 2 | 4 | 4 | 8 | 5 |
| Don't Know | VA | 4 | 0 | 13 | 7 | 7 | 6 | 15 |
| | MO | 5 | 1 | 16 | 17 | 15 | 8 | 16 |
| Misinterpretations | VA | 18 | 5 | 10 | 11 | 18 | 23 | 13 |
| | MO | 20 | 7 | 8 | 15 | 24 | 12 | 17 |
| Subjects who could not guess the meaning at all | VA | 0 | 0 | 8 | 3 | 2 | 0 | 10 |
| | MO | 2 | 0 | 10 | 9 | 4 | 1 | 8 |

| | | Age | | | |
|---|---|---|---|---|---|
| Sex | | Under 30 | 30 - 49 | 50 & Over | Total |
| Male | VA | 11 | 21 | 14 | 46 |
| | MO | 14 | 16 | 14 | 44 |
| Female | VA | 19 | 19 | 14 | 52 |
| | MO | 20 | 15 | 24 | 59 |
| Total | VA | 30 | 40 | 28 | 98 |
| | MO | 34 | 31 | 38 | 103 |

subjects. This was particularly so for the symbol signs, for which only the Arrows sign was guessed by over half the subjects in Missouri whereas all the symbol signs were guessed by at least half of the subjects in Virginia. However, these two frequency distributions were compared using a Chi Square test for multi-category data (Walsh, 1965) and were found not to be significantly different (Chi Square = 16.82, df = 12).

The total number of misinterpretations of the signs by uncued subjects was approximately the same (98 in Virginia and 103 in Missouri). Table XLV shows that the Missouri subjects misinterpreted all the signs more often than the Virginia subjects except for the Virginia crossover sign and the Arrows sign. They also could not make any attempt to guess the meaning of all the signs more frequently except for the Permissive U Turn sign. However, a Chi Square test of two samples with categorical data was used to compare the frequency distributions of misinterpretations and they were found not be be significantly different (Chi Square = 6.43, df = 6).

In Virginia, the Arrows sign was misinterpreted most often, followed by the Nose Plus Arrows sign and then the Crossover sign. In Missouri, the Nose Plus Arrows sign was misinterpreted most often, followed by the Crossover sign and then the Permissive U Turn sign. The most frequent misinterpretations of the signs were basically the same for both groups of subjects, although in a slightly different order (Tables XII and XXXII).

A comparison of Tables XIII and XXXIII shows some differences in the distribution of misinterpretations according to age and sex although the female under 30 group in both data sets tended to misinterpret the signs more often than males of the same age group. A Chi Square test for multi-category data showed that the two frequency distributions were not significantly different (Chi Square = 4.05, df = 2).

Tables XLV shows that the mean distances at which subjects understood the meaning of the signs were very similar. The worded signs were understood at much shorter distances and the Arrows sign was understood at the furthest distance out of the symbol signs.

3. Recognition: Table XLVI shows that the mean distances at which subjects recognized the signs were somewhat similar, with the Missouri recognition distances being slightly shorter for all the signs except for the Arrows sign. The largest difference was for the Median Opening sign which was recognized in Missouri at a mean distance approximately 12 feet shorter than in Virginia. In both sets of results the Virginia crossover sign was recognized at by far the greatest average distance and the worded signs were recognized at the closest distances.

The total number of confusions with other signs for both data sets was 20 and followed a very similar pattern. In Missouri all the signs were recognized by all the subjects whereas in Virginia one subject did not recognize the Median Nose sign.

Significant correlation coefficients were obtained between age and recognition distance for some of the signs in Virginia but such correlations were not obtained in Missouri. Acuity was also found to be negatively correlated to recognition distances for the symbol signs in Virginia but this relationship could not be tested in Missouri. Females

TABLE XLVI

COMPARISON OF THE RECOGNITION AND PREFERENCE

RANKINGS OF THE SIGNS IN VIRGINIA AND MISSOURI

| | | Type of Sign | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Cross-over | Median Opening | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U-Turn |
| Recognition Distance (ft) | VA | 39.30 | 41.87 | 82.37 | 48.48 | 47.13 | 56.53 | 60.53 |
| | MO | 33.63 | 29.27 | 75.70 | 47.60 | 45.30 | 58.90 | 57.83 |
| Confusions | VA | 2 | 2 | 0 | 2 | 8 | 5 | 1 |
| | MO | 0 | 2 | 0 | 3 | 9 | 6 | 0 |
| Subjects who did not know the meaning | VA | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | MO | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean Preferences | VA | 3.47 | 3.37 | 4.57 | 3.07 | 3.23 | 4.30 | 6.00 |
| | MO | 4.10 | 3.52 | 4.76 | 3.62 | 3.79 | 3.66 | 4.62 |

tended to confuse the signs with other meanings more than males in both Missouri and Virginia but this was not statistically significant.

4. Preference: Table XLVI shows that the Virginia subjects had a much more clearly defined set of preferences than the Missouri subjects. (Their mean preference rankings ranged from 3.07 for the Median Nose sign to 6.00 for the Permissive U Turn sign compared to 3.52 for the Median Opening sign to 4.76 for the Virginia crossover sign in Missouri.) This is borne out by the fact that a significant coefficient of concordance was obtained for the Virginia data but not for the Missouri data. This indicates that there was some agreement between the Virginia subjects on the ranks they gave to the signs but not the Missouri subjects. In both data sets there was most agreement within the under 30 group in the preference ranks they gave to the signs.

The Virginia subjects least preferred the Permissive U Turn sign and then the Virginia crossover sign whereas the Missouri subjects least preferred the Virginia crossover sign followed by the Permissive U Turn sign. The Virginia subjects most preferred the Median Nose sign, followed by the Nose Plus Arrows sign and then the word signs. The Missouri subjects most preferred the Median Opening sign, followed by the Median Nose sign and then the Arrows and Nose Plus Arrows signs.

Mann-Whitney U tests (Siegel, 1956) were used to compare the ranks given to each sign by the Virginia and Missouri subjects and these were found to be significantly different for all the signs except for the Crossover and the Virginia crossover signs ($U = 240$ to $333$, $z = 1.5729$ to $2.9895$, $p<.04$).

A comparison of the subjects' opinions on median crossovers shows that 24 of the Missouri subjects considered crossovers to be hazardous compared to 22 in Virginia (Tables XX and XL). However, more of the Missouri subjects did not associate any particular hazards with crossovers (5 compared to 2 in Virginia). The types of hazards associated with median crossovers were slightly different. Traffic accelerating into the fast lane was seen as as much of a hazard as traffic slowing in the fast lane in Missouri but not in Virginia (Tables XXI and XLI). The Missouri subjects seemed to be more concerned with traffic crossing the divided highway than the Virginia subjects (13 subjects mentioned traffic pulling out in front of them or turning traffic compared to four subjects in Virginia). One subject in Missouri mentioned gravel crossovers as being dangerous.

The replies to the effect a crossover sign would have on their driving were basically the same for both sets of subjects (Tables XXII and XLII). However, more of the Missouri subjects said they would slow down if they saw a crossover sign (11 compared to five in Virginia) and more said such a sign would have no effect on their driving (three compared to one in Virginia).

"Crossover" was chosen as best conveying the intended meaning by most subjects in both groups (20 in Virginia and 23 in Missouri, see Tables XXIII and XLIII). "Opening" was next favoured by the Virginia subjects (seven) and "Crossing" by the Missouri subjects (five).

The distances at which subjects thought the sign should be placed in front of a crossover tended to be longer in Missouri than in Virginia (Tables XXIV and XLIV). This is reflected in the mean distances which were 838 feet in Virginia and 1322 feet in Missouri. Twenty eight of the Virginia subjects thought that a distance plate would help them locate a crossover compared to 25 of the Missouri subjects (see Tables XX and XL).

# VI. CONCLUSIONS

From this study there appears to be justification for the use of signs indicating the presence of a median crossover which can be used by the general public. The majority of both groups of subjects tested perceived crossovers as hazardous locations and from their replies to questions about them, were clearly aware of the potential hazards that crossovers can cause. Such a sign would likely have a beneficial effect on their driving behaviour if installed, as indicated by their replies to questions on this.

A median crossover sign could be worded or symbolic. The Median Opening sign was the word message sign understood the best by uncued subjects in both Virginia and Missouri. However the majority of both groups of subjects chose "Crossover" as conveying the intended meaning better than "Crossing" or "Opening". It would therefore seem that "Median Crossover" would be a better word message sign.

Table XLVII shows that the legibility, understanding and recognition distances for the Median Crossover sign were about the same as for the other word message signs. An intermediate percentage of uncued subjects guessed the meaning of the Median Crossover sign without a wrong guess first (87.5% compared to 90% by the Virginia subjects and 80% by the Missouri subjects for the Median Opening sign and all of the subjects managed to guess the meaning. There were only three misinterpretations of the sign by the uncued subjects compared to five for the Median Opening sign in Virginia and seven in Missouri and no

TABLE XLVII

COMPARISON OF THE "MEDIAN CROSSOVER" SIGN WITH THE "MEDIAN OPENING" AND "CROSSOVER" SIGNS

| | Crossover | | Median Opening | | Median Crossover |
|---|---|---|---|---|---|
| | Virginia | Missouri | Virginia | Missouri | Missouri |
| Legibility Distances (feet) | | | | | |
| Sign Shape | 99.90 | 103.83 | 106.67 | 106.03 | 102.38 |
| Sign Colour | 106.30 | 108.67 | 107.87 | 107.63 | 107.29 |
| Legend Colour | 74.96 | 82.93 | 70.95 | 76.40 | 93.42 |
| Letter Presence | 48.10 | 41.47 | 53.93 | 50.33 | 48.74 |
| Read Legend | 12.27 | 12.40 | 11.40 | 11.93 | 11.58 |
| Understanding Distance (feet) | 14.12 | 12.68 | 11.40 | 11.66 | 11.96 |
| Recognition Distance (feet) | 39.30 | 33.63 | 41.87 | 29.27 | 27.74 |
| Correct Answer Straight Away | 16 (53.3%) | 12 (40.0%) | 27 (90.0%) | 24 (80.0%) | 21 (87.5%) |
| Incorrect Answer Before Correct One | 10 (33.3%) | 13 (43.3%) | 3 (10.0%) | 5 (16.7%) | 3 (12.5%) |
| Don´t Know | 4 (13.3%) | 5 (16.7%) | 0 | 1 ( 3.3%) | 0 |
| Misinterpretations | 18 | 20 | 5 | 7 | 3 |
| Confusions | 2 | 0 | 2 | 2 | 0 |

confusions with other signs by the trained subjects compared to two for the Median Opening sign in both Virginia and Missouri. It is therefore recommended that if a word message sign is used it should be "Median Crossover".

Although word message signs can usually be understood once they are read, they are less legible than symbolic signs. This is clearly borne out by the results of the legibility, understanding and recognition distance sections of the study and has been found in other studies such as Jacobs et. al. (1975). The word "Crossover" is rather long and in order to fit in on a standard diamond sign the lettering would have to be quite small or an oversized sign used.

Table XLVII show a comparison of the symbolic signs, of which the Arrows sign had the best average legibility distances and understanding distance in both Virginia and Missouri but it had by far the most misinterpretations by naive subjects in Virginia. Although it was ranked second of the symbol signs by the Missouri subjects, it was only ranked fifth by the Virginia subjects in the preference test and is not recommended.

Of the other symbolic signs, the Permissive U Turn sign had low average legibility distances and understanding distances in both Virginia and Missouri and was not well understood by the subjects. This is reflected by the fact that it was ranked last by the majority of subjects in Virginia and many of the subjects in Missouri in the preference test. The significance of the green periphery to indicate a permissive sign was not understood at all and this sign is not recommended.

TABLE XLVIII

COMPARISON OF THE SYMBOLIC SIGNS

| | | XO Virginia | XO Nose | XO Nose + Arrows | XO Arrows | Perm U Turn |
|---|---|---|---|---|---|---|
| Legibility Distances (feet) | | | | | | |
| Sign Shape | VA | 62.77 | 101.96 | 103.63 | 108.20 | 100.64 |
| | MO | 65.43 | 102.00 | 102.77 | 109.23 | 102.28 |
| Sign Colour | VA | 99.03 | 105.67 | 107.40 | 107.80 | 100.27 |
| | MO | 96.37 | 107.77 | 108.00 | 105.50 | 85.55 |
| Symbol Colour | VA | 57.48 | 78.82 | 84.04 | 89.16 | 54.92 |
| | MO | 55.03 | 93.47 | 95.13 | 100.53 | 76.21 |
| Symbol Presence | VA | 51.75 | 82.54 | 84.86 | 89.56 | 65.88 |
| | MO | 69.05 | 92.60 | 95.27 | 100.53 | 84.54 |
| Understanding Distance (feet) | VA | 24.94 | 32.57 | 30.61 | 41.08 | 22.07 |
| | MO | 26.50 | 29.38 | 28.47 | 37.00 | 18.71 |
| Recognition Distance (feet) | VA | 82.37 | 48.48 | 47.13 | 56.53 | 60.53 |
| | MO | 75.70 | 47.60 | 45.30 | 58.90 | 57.83 |
| Correct Answer Straight Away | VA | 13 | 18 | 15 | 13 | 9 |
| | MO | 12 | 9 | 11 | 14 | 9 |
| Incorrect Answer Before Correct One | VA | 4 | 5 | 8 | 11 | 6 |
| | MO | 2 | 4 | 4 | 8 | 5 |
| Don't Know | VA | 13 | 7 | 7 | 6 | 15 |
| | MO | 16 | 17 | 15 | 8 | 16 |
| Misinterpretations | VA | 10 | 11 | 18 | 23 | 13 |
| | MO | 8 | 15 | 24 | 12 | 17 |
| Confusions | VA | 0 | 2 | 8 | 5 | 1 |
| | MO | 0 | 3 | 9 | 6 | 0 |
| Mean Preference Rankings | VA | 4.57 | 3.07 | 3.23 | 4.30 | 6.00 |
| | MO | 4.76 | 3.62 | 3.79 | 3.66 | 4.62 |

The Virginia sign also had low average legibility distances out of the symbolic signs and again was not well understood by uncued subjects in both Virginia and Missouri. It was not well liked in the preference test by either group of subjects. However it did very well in the recognition test in both places, presumably because of its different colour and shape. It was recognized at a far greater average distance than any of the other signs and was the only sign not confused at all in Virginia. Several subjects in both Virginia and Missouri mentioned that if they had initially known the meaning of the sign they thought this sign would be the best one to use. However as the meaning of the sign was not at all obvious to the subjects in either place, it would require extensive education of drivers in order to make it a useful traffic engineering tool.

Of the remaining symbolic signs, the Nose plus Arrows sign had slightly better average legibility distances but the Median Nose sign had slightly better average understanding and recognition distances in both Virginia and Missouri. The latter sign also had less misinterpretations and confusions in the understanding and recognition parts of the experiment than the former in both places. It was also given the best average rank out of all the signs in the Virginia preference test and the best average rank out of the symbol signs in Missouri and had the simplest design of all the signs tested. Of the symbol signs tested, the Median Nose sign is therefore the sign recommended to indicate the presence of a median crossover.

From the replies to questions about the advance placement distance of a crossover sign it would appear that it should be placed at least the stopping sight distance infront of a crossover and on a 55 mph highway a distance of 500-1000 feet or even 1/4 of a mile would seem to be appropriate.

Despite the different experimental conditions, the legibility, understanding and recognition distances of all the signs were very similar for both groups of subjects. However, the Missouri subjects had more difficulty in identifying the green (Virginia crossover and Permissive U Turn) signs than the Virginia subjects.

The Missouri subjects had more difficulty in guessing the meaning of nearly all the signs than the Virginia subjects, especially the symbol signs. They misinterpreted the signs more often and could not guess the meaning of the signs as frequently.

The greatest differences between the Virginia and Missouri results were in the preference rankings the subjects gave to the signs. The Virginia subjects had a much more clearly defined set of preferences whereas the Missouri subjects' preferences were much more evenly spread with little agreement among the subjects. The Missouri subjects also preferred the word message signs more than the Virginia subjects. This was especially so for the females, particularly the females over 50. The Virginia subjects preferred the Median Nose and Nose plus Arrows signs before the word message signs whereas the Missouri subjects most preferred the Median Opening sign.

Although there were some differences in the Virginia and Missouri results, both led to the same conclusions - that a Median Crossover sign would be the best word message sign to use and the Median Nose sign would be the best symbolic sign to use to indicate the presence of a median crossover, out of the signs tested. Despite the Missouri preferences for word message signs, legibility of the symbolic signs was so much greater that the Median Nose sign is the sign recommended for field evaluation to identify median crossovers.

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# VITA

Gillian Mary Worsey was born on the 7th of January 1957 in Enfield, England. She received her primary and secondary education in Southend-on-Sea, England. She received her college education from the University of Bristol, in Bristol, England; the University of Newcastle upon Tyne, in Newcastle upon Tyne, England; and the University of Missouri-Rolla, in Rolla, Missouri. She received a Bachelor of Science (Honours) degree in Physical Geography from the University of Bristol, in Bristol, England in June 1978 and a Master of Science degree in Transport Engineering from the University of Newcastle upon Tyne, in Newcastle upon Tyne, England in January 1982.

She has been enrolled in the Graduate School of the University of Missouri-Rolla since January 1982 and held a Federal Highway Administration Grants for Research Fellowship for the period May 1985 to September 1985.

# APPENDIX A

## SURVEY OF STATES PRACTICES OF SIGNING AND DELINEATING MEDIAN CROSSOVERS SENT TO STATE TRAFFIC ENGINEERS

UNIVERSITY OF MISSOURI-ROLLA

Transportation Technical Assistance Office

Director Dr Charles E Dare
Room 223 Civil Engineering
Rolla, Missouri 65401-0249
Telephone (314) 341-4553
(314) 341-4465

April 11th 1985

State Traffic Engineer
AK Department of Transportation
600 University Ave
Fairbanks, AK 99701

Subject: Standard Signing and Delineation Practice at Rural Median Crossovers

Gentlemen:

This survey is being conducted by the University of Missouri-Rolla (UMR) in cooperation with the Federal Highway Administration (FHWA) as an approved project in the FHWA Grants for Research Fellowship Program. The Graduate Research Investigator is Ms. Gillian Worsey and the UMR Principal Investigator is Dr. Charles Dare.

Our primary objective in this survey is to obtain current practices on the signing, marking, delineation and geometric design of the median crossover on rural divided highways.* The attached pages are intended to assist you in supplying the needed information; however standard design sheets may be substituted if they contain sufficient detail.

Those responding will automatically receive a compilation of the survey results. Completed survey forms should be sent to:

Charles E. Dare (Ph. 314-341-4553)
Rm. 223 Civil Engineering
University of Missouri-Rolla
Rolla, Missouri 65401

Thank you very much for your cooperation and interest in our study.

Sincerely yours,

Gillian M Worsey

Ms. Gillian M. Worsey

* In the context of this survey, a median crossover is a non-signalized intersection formed by a minor cross road and a divided highway carrying high speed traffic. A median crossover is sometimes described as a median opening through which the following vehicle movements can occur:

A. Cross road vehicle crossing the major highway in two operations,
B. Cross road vehicle turning left onto major highway in two operations,
C. Major road vehicle turning left to go onto cross road and
D. Major road vehicle making a U-turn.

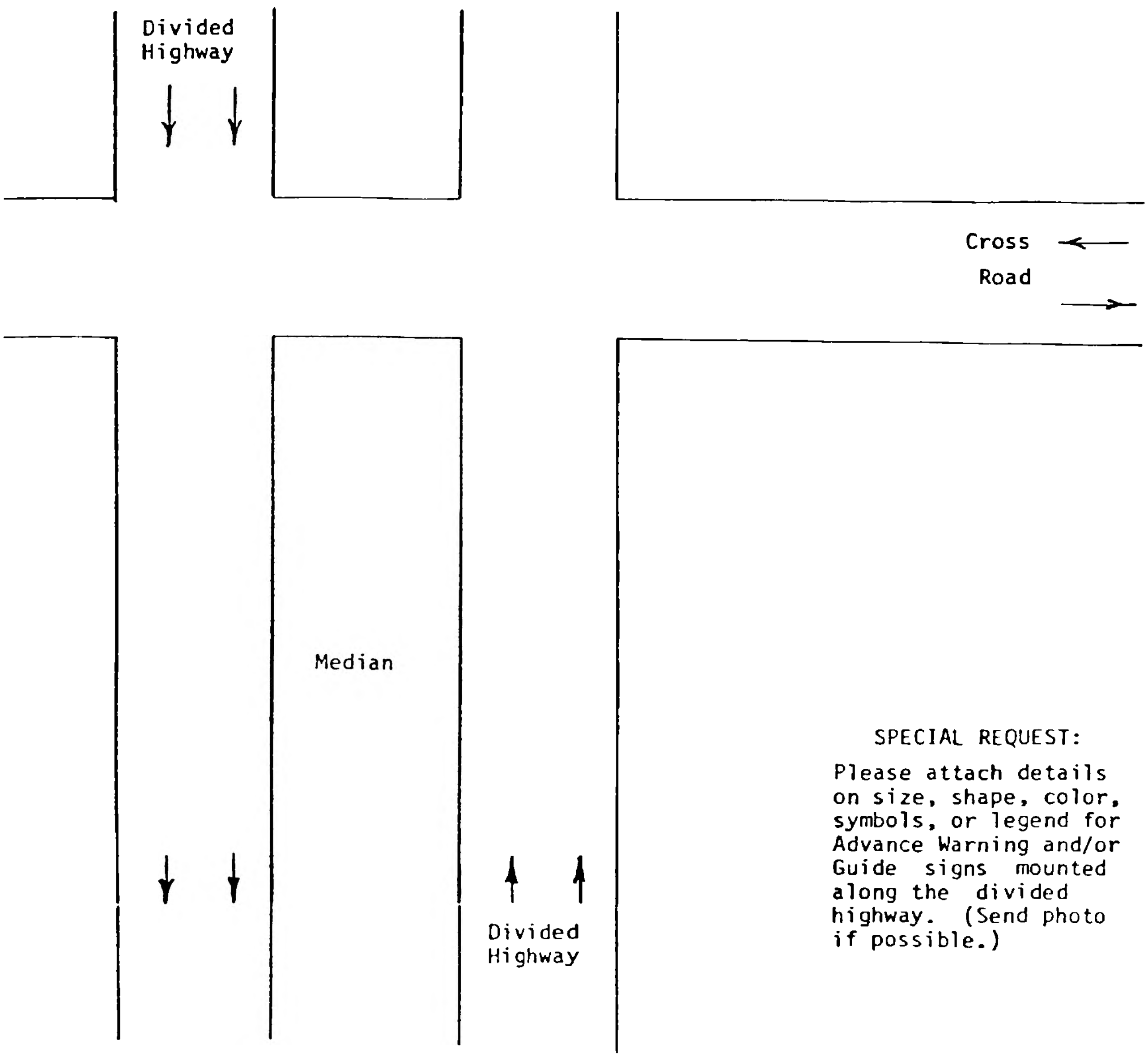
Special purpose median crossovers are occasionally provided to accommodate maintenance vehicles, law enforcement vehicles and for access to commercial establishments along the divided highway.

an equal opportunity institution

1

STANDARD SIGNING PRACTICE FOR MEDIAN CROSSOVERS ON RURAL DIVIDED HIGHWAYS

1. Show all Warning, Regulatory and Guide signs that are standard practice for installation at and in advance of a median crossover. If you have more than one practice for such locations, please submit the others on attached pages. Be certain to identify sign types (as Divided Highway, Advance Warning, Stop, Yield, Do Not Enter, Turn Prohibition, One Way Traffic, etc.) along with the mounting location. Please note the SPECIAL REQUEST on the sketch below:



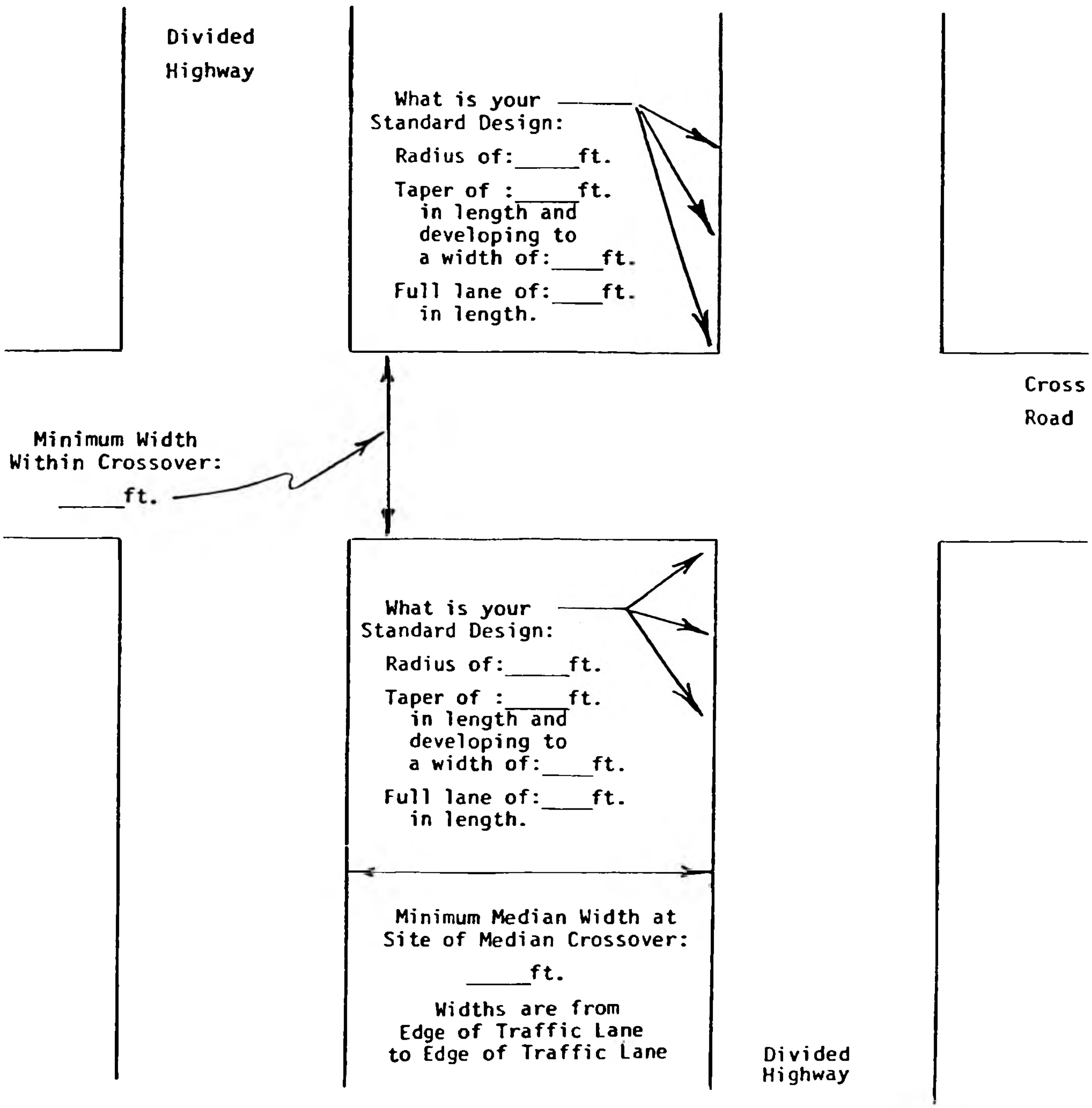

SPECIAL REQUEST:

Please attach details on size, shape, color, symbols, or legend for Advance Warning and/or Guide signs mounted along the divided highway. (Send photo if possible.)

2

STANDARD PAVEMENT MARKING, DELINEATION AND GEOMETRIC DESIGN
PRACTICE FOR MEDIAN CROSSOVERS ON RURAL DIVIDED HIGHWAYS

2. Show all pavement markings including lines, symbols and legends that are used on the divided highway, on the cross road and in the median crossover. Show any other delineation that may be used. Be certain to show the size and position of any islands, especially those in the median crossover. If you have more than one marking/delineation/geometric design practice, please submit the others on attached pages



STANDARD SIGNING AND DELINEATION PRACTICE FOR SPECIAL PURPOSE

MEDIAN CROSSOVERS ON RURAL DIVIDED HIGHWAYS

3. Special purpose median crossovers may be provided to accommodate maintenance vehicles, enforcement vehicles, or to allow access to commercial developments along a divided highway. Please list the signs and their location, as well as any delineation, that may be used in advance of and at the following types of median crossovers. Include sufficient details on the signing to describe size, shape, color, symbols or legend.

A. Crossover for maintenance vehicles (signing and delineation);

B. Crossover for enforcement vehicles (signing and delineation):

C. Crossover for commercial development (signing and delineation):

MEDIAN CROSSOVER SURVEY

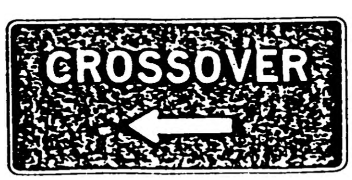
4. Revision 3 (9/84) to the MUTCD contains the CROSSOVER SIGN (D13-1) and the ADVANCE CROSSOVER SIGN (D13-2) which may be erected to mark median openings not otherwise marked by Warning or Guide Signs. As a practicing traffic engineer, do you believe the CROSSOVER SIGN(S) to be meaningful and helpful to motorists. Would you have any suggestions for changing the legend, design or any other aspect of the sign? (Note: Sec. 2D-52 of the MUTCD is attached.)

**2D-52 Crossover Signs (D13-1, D13-2)**

The CROSSOVER sign may be erected on divided highways to mark median openings not otherwise marked by Warning or Guide signs. It shall not be used to mark median openings that are restricted to the use of official or authorized vehicles. The sign shall be a horizontal rectangle of appropriate size to carry the word CROSSOVER and a horizontal directional arrow. If used, it should be erected immediately beyond the median opening either on the right side of the roadway or in the median. II-7 (c) Rev. 3

The Advance Crossover sign may be erected in advance of the CROSSOVER sign to provide advance information of the crossover. The sign shall be a horizontal rectangle of appropriate size to carry the word CROSSOVER and a distance. The distance shown should be either 1, ½, or ¼ mile, unless unusual conditions require some other distance. If used, the sign should be erected on the right side of the roadway at approximately the distance shown. Rev. 9/84

CROSSOVER signs shall have a white reflectorized legend and border on a green background.




D13-1
72"x36


D13-2
72"x36"

MEDIAN CROSSOVER SURVEY

5. Has your agency, or any other organization you are aware of, performed any studies of median crossovers that might give some insights regarding desirable signing, pavement marking, delineation, or channelization of such locations?

No: ____

Yes: ___ Please list sources: ________________________________

________________________________

________________________________

________________________________

________________________________

________________________________

6. Who can we contact in your agency if we have additional questions about the responses to this survey?

Name: ________________________________ Phone: ____________________

Address: ________________________________

________________________________

________________________________

7. Who should we send the compilation of survey results to if different from the individual in item 4 above?

Name: ________________________________

Address: ________________________________

________________________________

________________________________

We highly appreciate your cooperation with respect to this survey and trust that our investigation will provide information of value to those who have responded. When the survey is completed, please send to:

Charles E. Dare, P.E.
Rm. 223, Civil Engineering
University of Missouri-Rolla
Rolla, Missouri 65401

(Phone: 314-341-4553)

# APPENDIX B

## DESIGNS FOR MEDIAN CROSSOVER SIGNS

## CONSIDERED BUT NOT TESTED

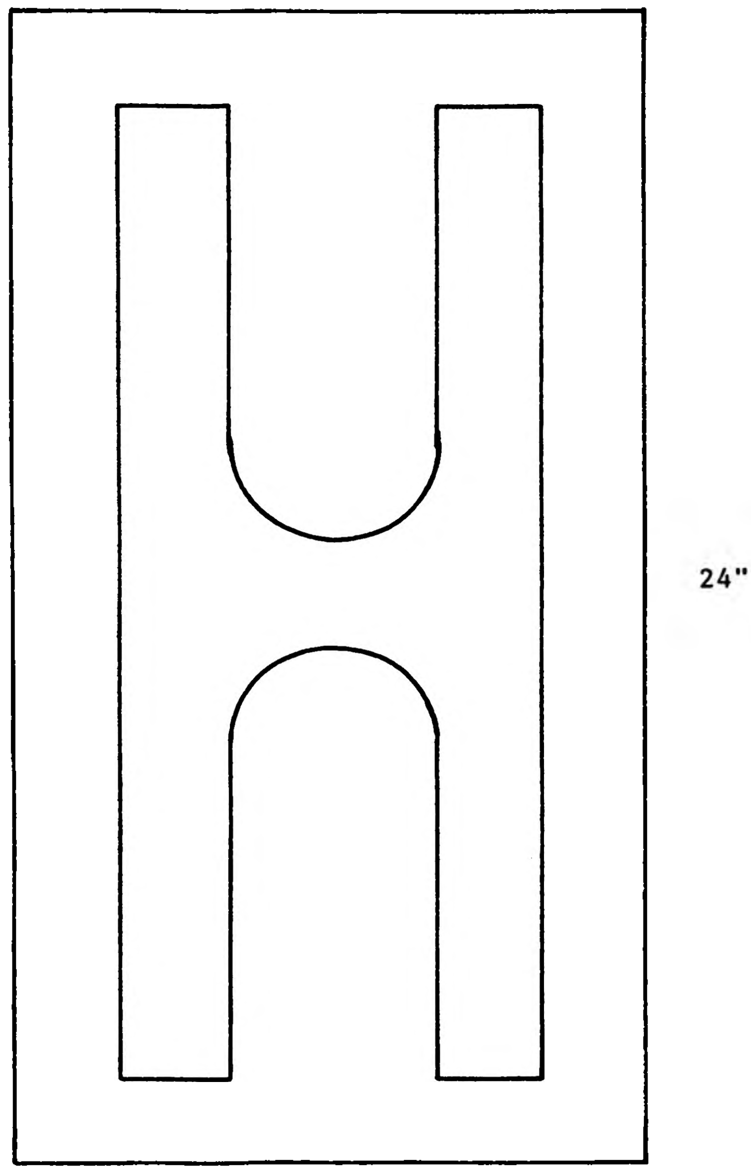
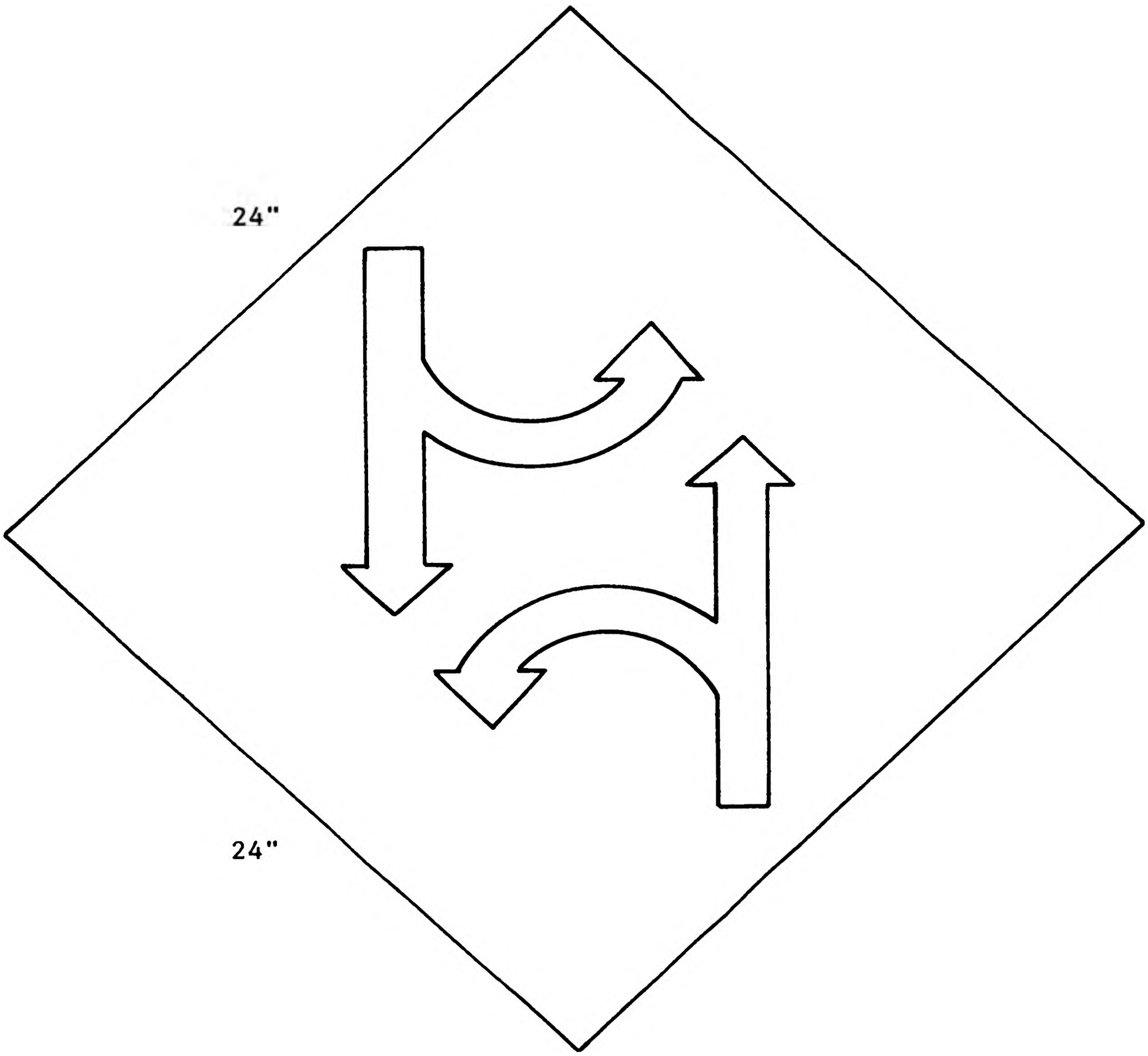
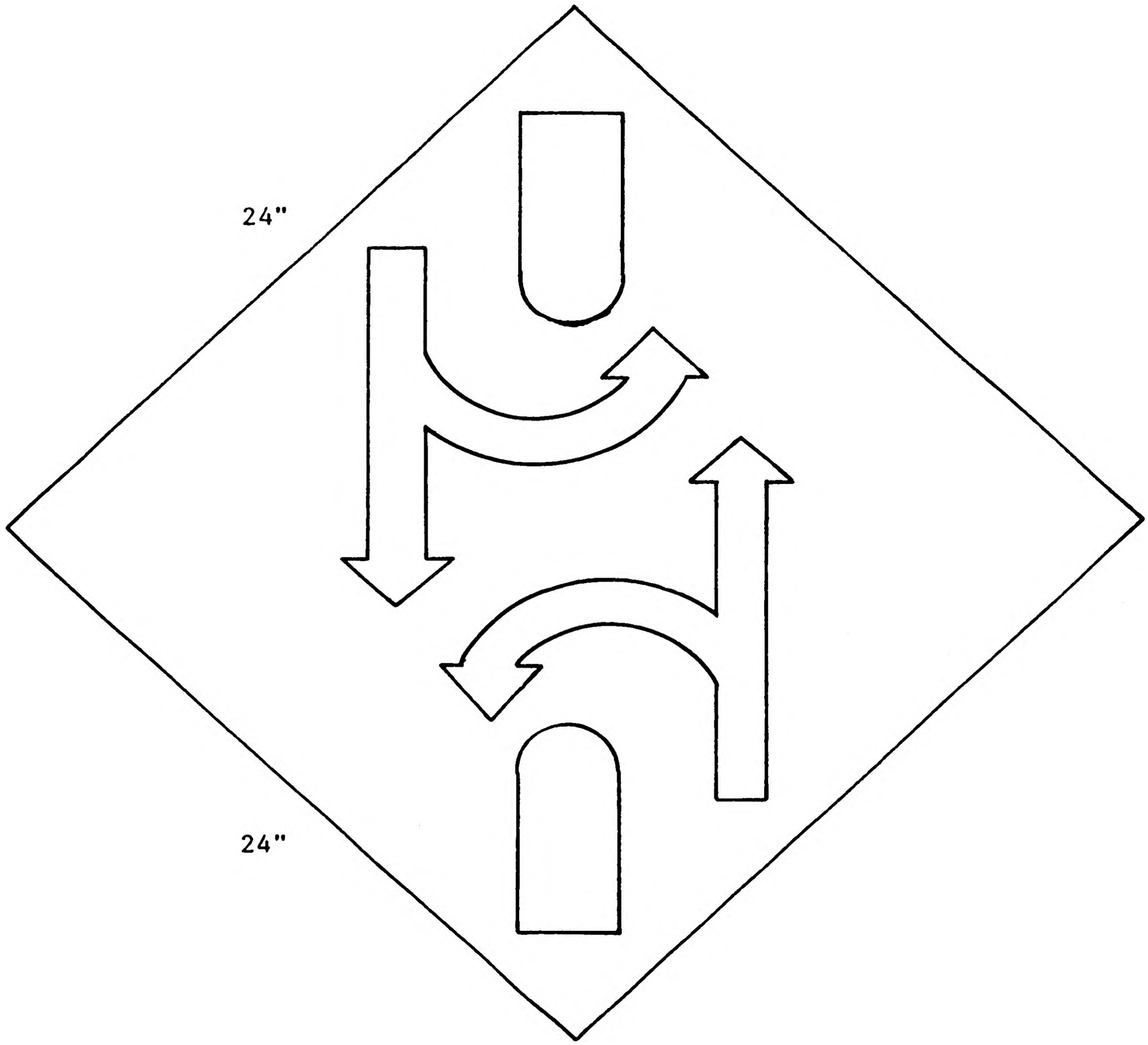



Figure 17. Sign Suggested by Department of the Army Transportation Engineering Agency in Response to Federal Register Proposed Rule



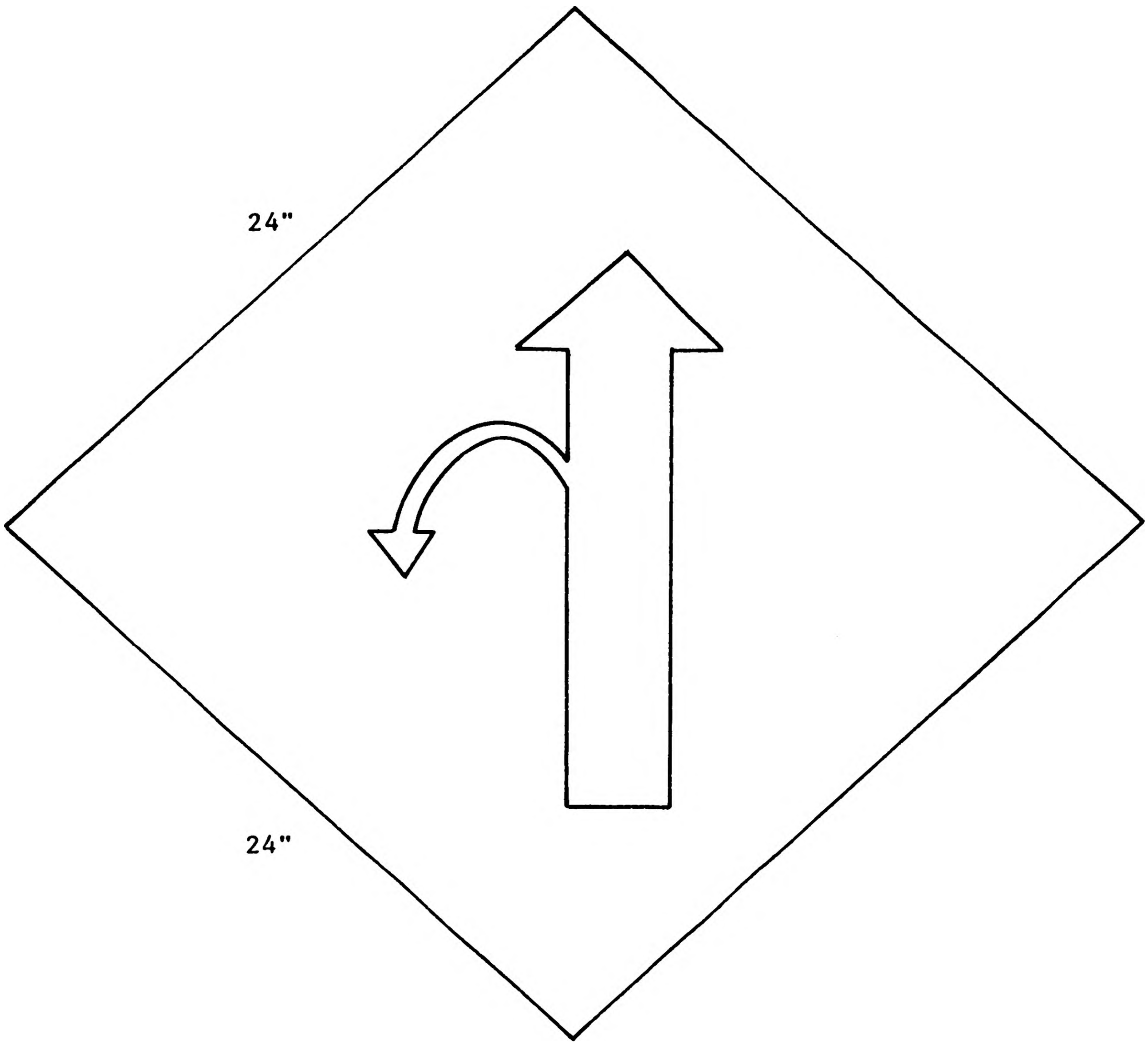

black on yellow

Figure 18. Original Permissive U Turn Sign Suggested by FHWA Personnel



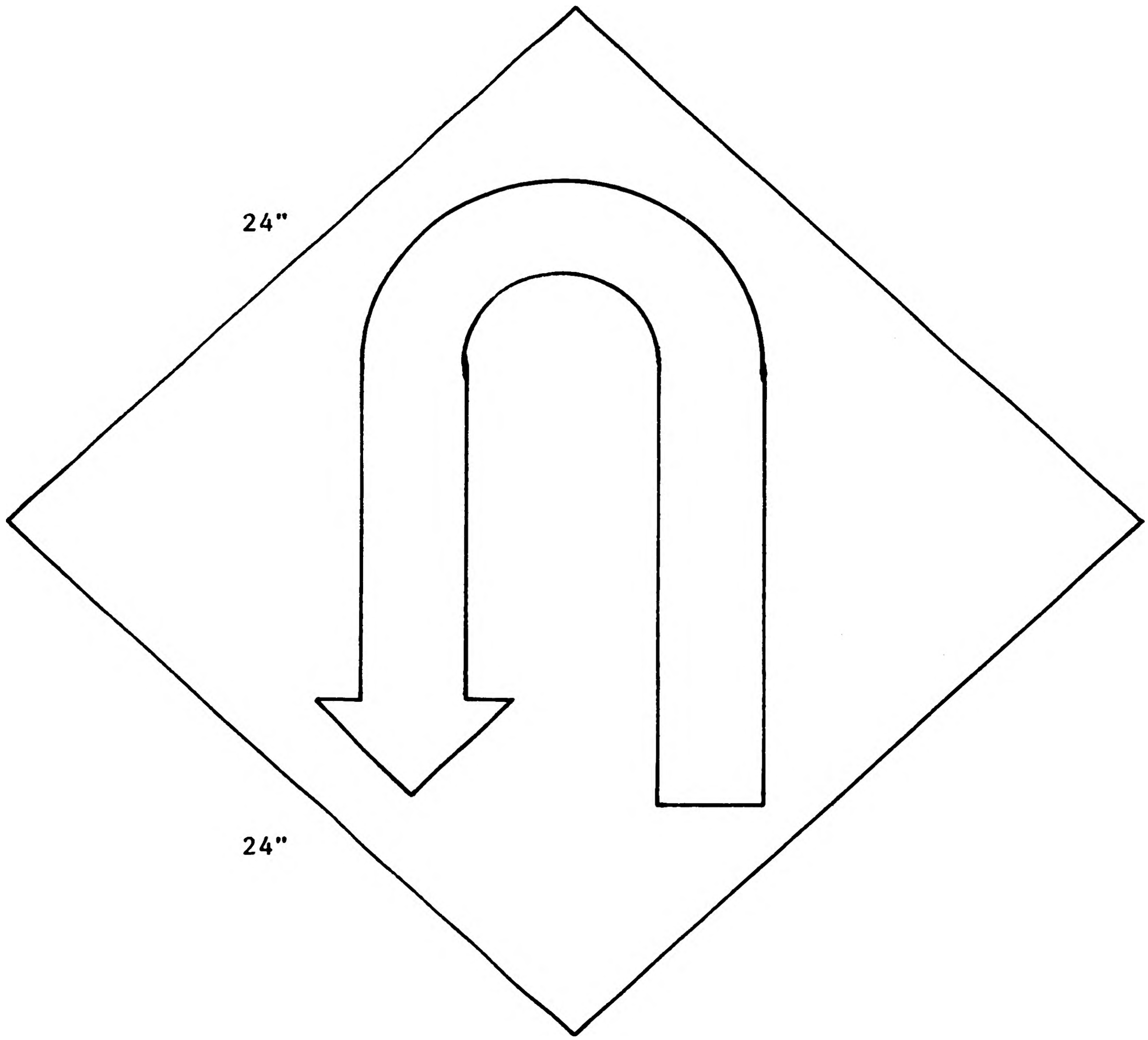

black on yellow

Figure 19. Alternative Permissive U Turn Sign Suggested by FHWA Personnel



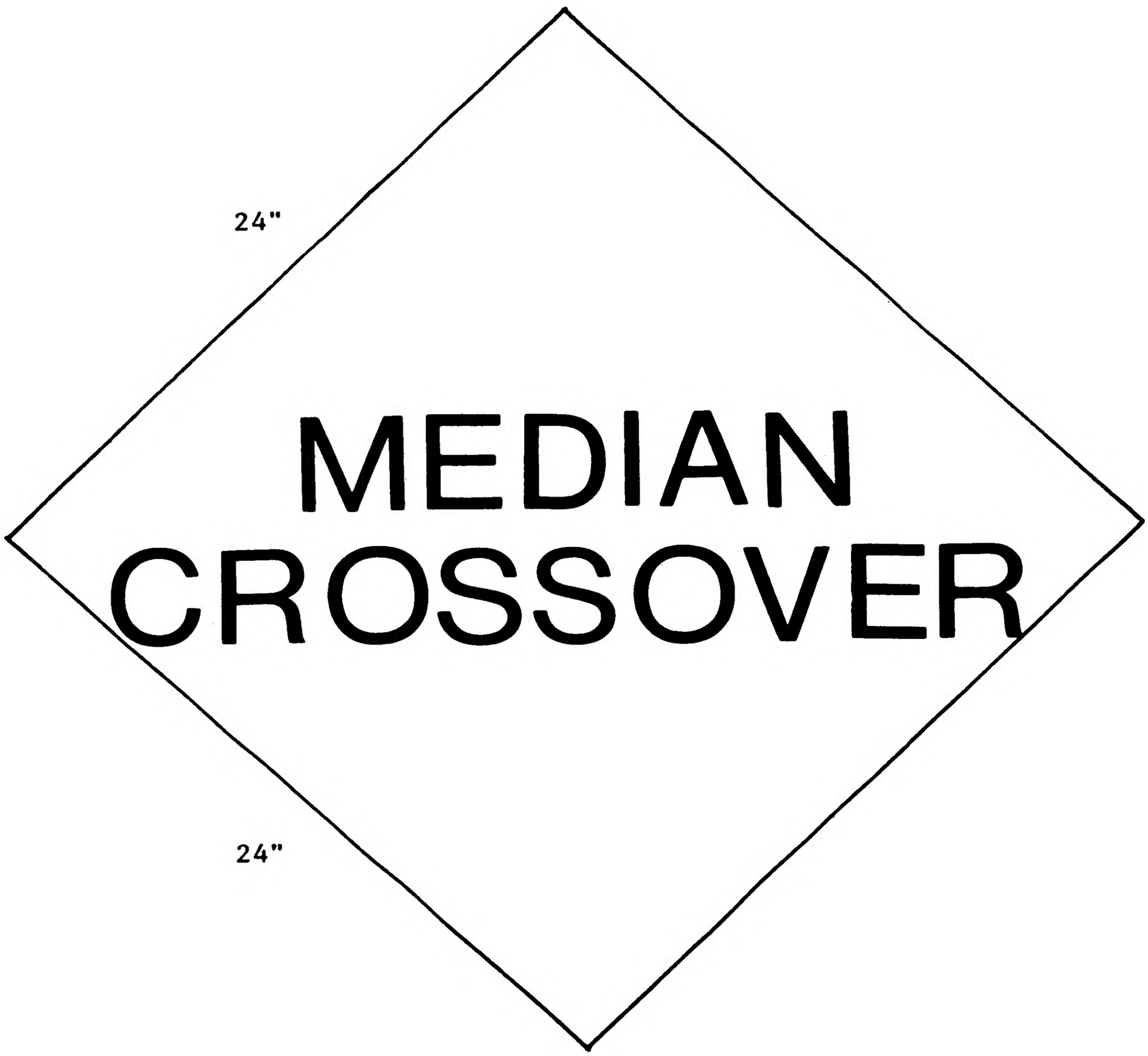

black on yellow

Figure 20. Crossover Sign Based on a Sign Used in Michigan



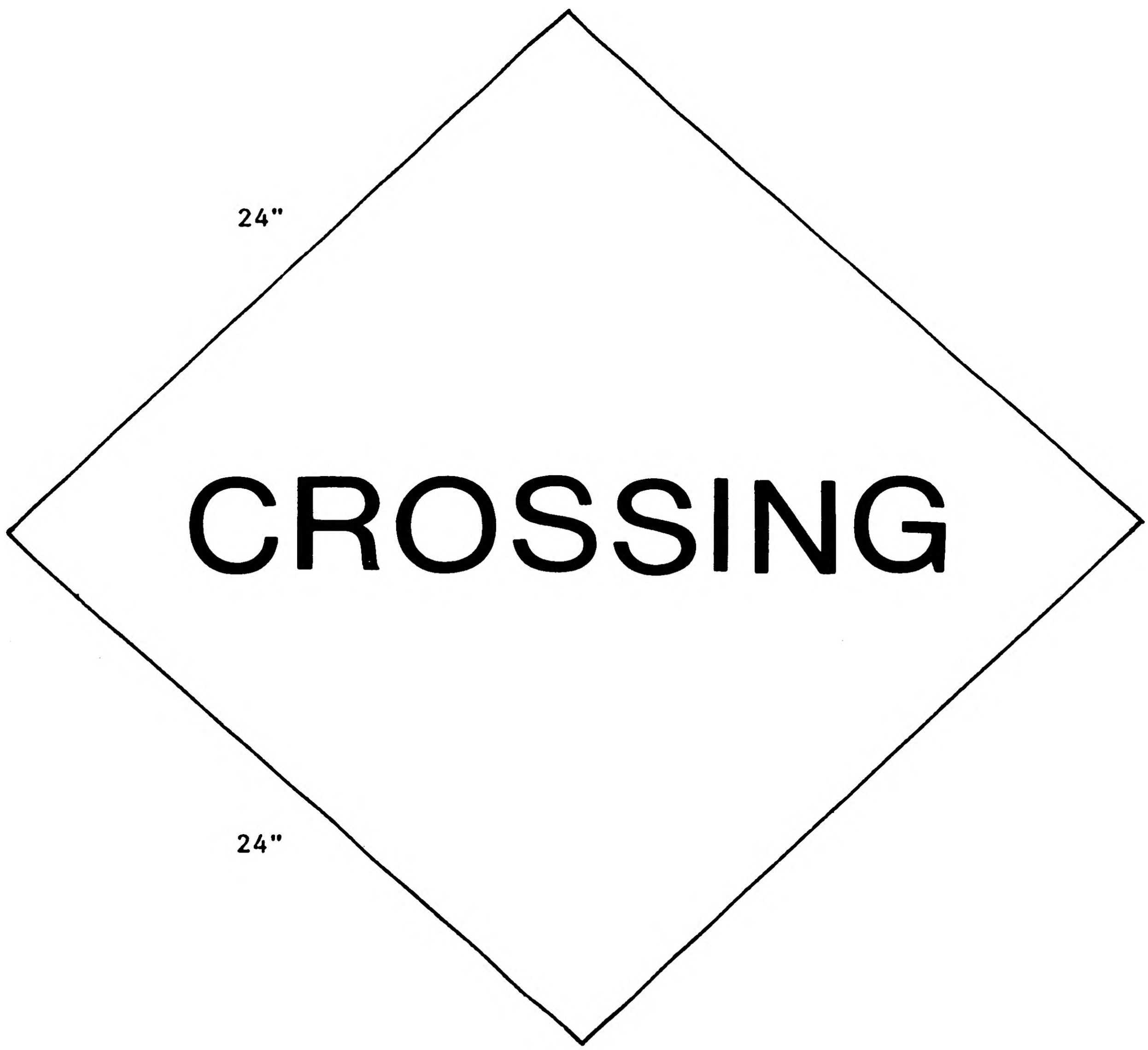

black on yellow

Figure 21. Crossover Sign Showing U Turn Suggested by FHWA Personnel




black on yellow

Figure 22. "Median Crossover" Sign Suggested by FHWA Personnel




black on yellow

Figure 23. "Crossing" Sign Suggested by FHWA Personnel

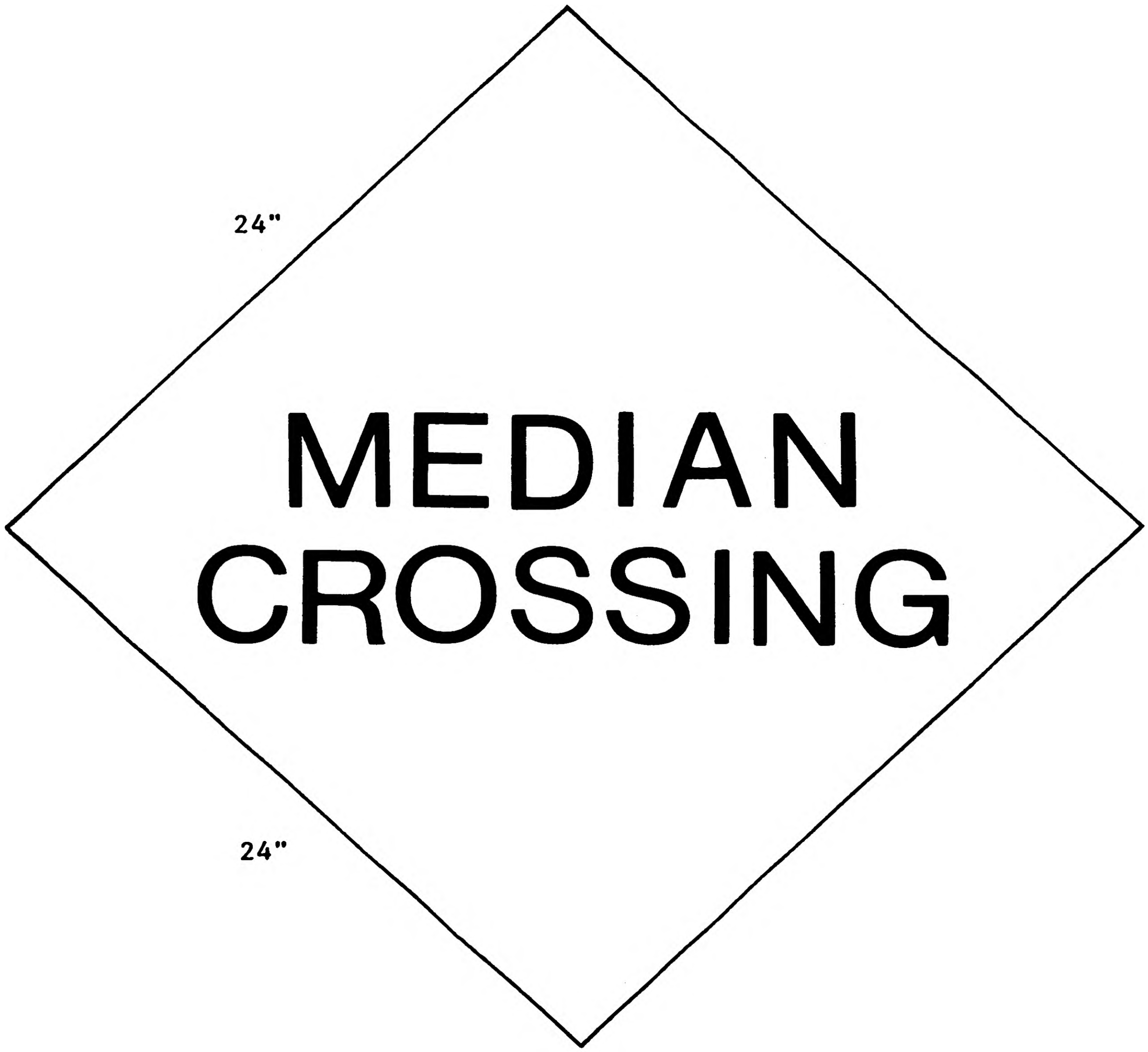



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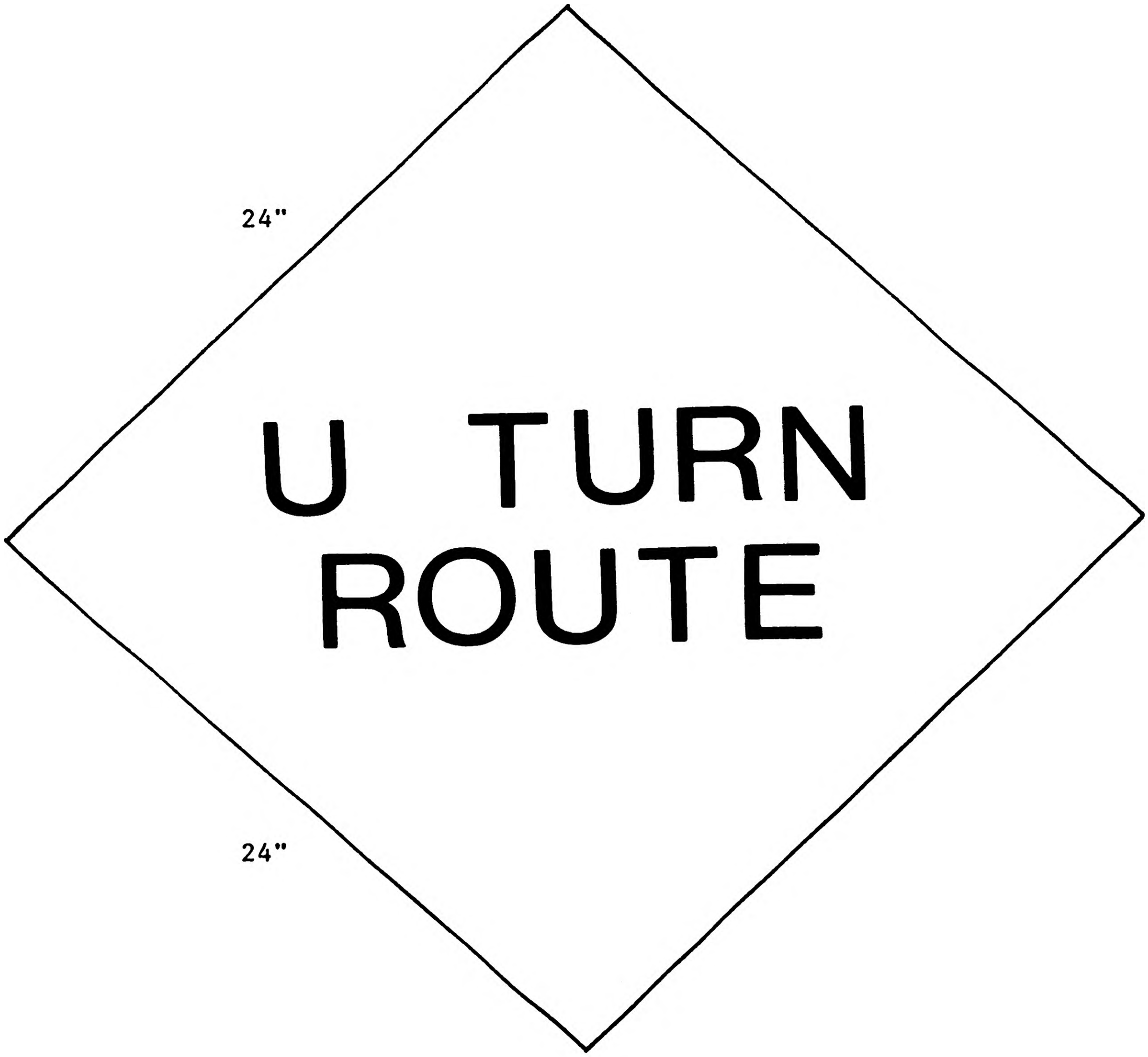
Figure 24. "Median Crossing" Sign Suggested by FHWA Personnel




black on yellow

Figure 25. "U Turn Route" Sign Based on a Sign Used in Washington

# APPENDIX C

## INSTRUCTION AND DATA COLLECTION SHEETS USED IN MEDIAN CROSSOVER SIGN EXPERIMENT

MEDIAN CROSSOVERS SIGN STUDY - INSTRUCTIONS TO SUBJECTS

Parts I and II, Legibility and Meaning

I am going to present roadway signs to you one at a time on the screen in front of you. Chances are you have not seen the signs before. When each sign is presented you will be asked to walk towards it until you can identify any feature on the sign such as its shape, colour, presence of a symbol, legend etc. and I will record the distance at which you identified the feature. Also I would like you to tell me what you think the sign means as soon as you can. Please take a guess as soon as you think you know the meaning of the sign. We will repeat this procedure until all the major features of the sign have been identified and if you gave me the wrong meaning for the sign I will ask you to try again.

Do you have any questions?

Part III, Recognition

Seven of the signs you just saw are being considered as signs to show the position of "median crossovers" or openings in the median of a divided highway where U turns and/or left turns are permitted. I will show you prints of these seven signs.

I am going to present the slides you saw before on the screen in front of you again and when each sign is presented you will be asked to walk towards it until you can recognize the sign and tell me its name. I will record the distance at which you recognized the sign. Please take a guess as soon as you think you know what the sign is. If you gave me the wrong name for the sign we will repeat this procedure once or twice until you can give me the correct name for the sign.

Do you have any questions?

Part IV, Preference

I would like you to tell me which sign of the seven "median crossover" signs you like best, which one you like second best and so on, based on how well each sign conveys its intended meaning to you. You can use these prints of the seven signs to help you. Then I would like you to answer a few general questions about median crossovers.

Do you have any questions?

RECORD OF INFORMED CONSENT

Part 46, Subtitle A to Title 45 of the Code of Federal Regulations relating to the Protection of Human Subjects in research requires your informed consent for participation in Federal Highway Administration driving studies. Section 46.103(c) gives the following definition: "Informed consent means the knowing consent of an individual or his legal authorized representative, so situated as to be able to exercise free power of choice, without undue inducement or any element of force, fraud, deceit, duress, or other form of constraint"

Your participation as a subject in a study to evaluate highway signs is requested. Please consider the following elements of information in reaching your decision whether or not to consent.

1. You will be asked for a minimum amount of biographical information necessary to the study. All information you provide is confidential and the source (your name) will not be disclosed to the public.

2. You will walk towards 20 highway signs presented on slides, identify various features on them and give the name or meaning of each and what affect each would have on your driving and also walk towards them again until you can recognize each sign.

3. You will look at 7 signs and rank them according to how well they convey the meaning they are supposed to and also answer some general questions about the signs.

4. You are free to decline consent or withdraw consent and discontinue participation in the session at any time.

5. Upon completion of the session you will be paid $10.00 for your participation.

The basic elements of information have been presented and understood by me, and I consent to participate as a subject.

NAME (please print): ______________________________

SIGNATURE: ______________________________

DATE: ______________________________

AGE: ______________ SEX: ______________

How many miles a week do you drive in your car? ________

How many accidents in your car in the last 5 years? ________

How many moving violations in your car in the last 5 years? ________

ID # ________

Visual Acuity ________ Colour Vision ________

Lenses ________

MEDIAN CROSSOVER SIGN STUDY - DATA SHEET

Part I. Legibility Distances

| Sign | Order | Shape of Sign | Colour of Background | Colour of Symbol/Letters | Colour of Circle | Symbol Unspecified | Letters Unspecified | Arrows or Road Pattern | Median Nose | Crossover Movement | Read Legend |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crossover | ___ | ___ | ___ | ___ | | | ___ | | | | ___ |
| Median Open | ___ | ___ | ___ | ___ | | | ___ | | | | ___ |
| XO Virginia | ___ | ___ | ___ | ___ | | ___ | | | ___ | | |
| XO Nose | ___ | ___ | ___ | ___ | | ___ | | | ___ | | |
| XO Nose+Arr | ___ | ___ | ___ | ___ | | ___ | | ___ | ___ | | |
| XO Arrows | ___ | ___ | ___ | ___ | | ___ | | ___ | | ___ | |
| Perm U Turn | ___ | ___ | ___ | ___ | ___ | ___ | | ___ | ___ | ___ | |
| Perm R Turn | ___ | ___ | ___ | ___ | ___ | ___ | | ___ | | | |
| No R Turn | ___ | ___ | ___ | ___ | ___ | ___ | | ___ | | | |
| No U Turn | ___ | ___ | ___ | ___ | ___ | ___ | | ___ | | | |
| Crossbuck | ___ | ___ | ___ | ___ | | | | | | | |
| Obj Mark 3 | ___ | ___ | ___ | ___ | | | | | | | |
| Rev Curve | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| Curve R | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| Winding Rd | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| Merge | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| Crossroads | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| Side Rd L | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| 2 Way Traf | ___ | ___ | ___ | ___ | | ___ | | ___ | | | |
| Div Hwy End | ___ | ___ | ___ | ___ | | ___ | | ___ | ___ | | |

MEDIAN CROSSOVER SIGN STUDY - DATA SHEET

Part II. Recognition

| Sign | Order | Confusion 1 | Dist. | Confusion 2 | Dist. | Distance at which correctly identified |
|---|---|---|---|---|---|---|
| Crossover | | | | | | |
| Median Open | | | | | | |
| XO Virginia | | | | | | |
| XO Nose | | | | | | |
| XO Nose+Arr | | | | | | |
| XO Arrows | | | | | | |
| Perm U Turn | | | | | | |
| Perm R Turn | | | | | | |
| No R Turn | | | | | | |
| No U Turn | | | | | | |
| Crossbuck | | | | | | |
| Obj Mark 3 | | | | | | |
| Rev Curve | | | | | | |
| Curve R | | | | | | |
| Winding Rd | | | | | | |
| Merge | | | | | | |
| Crossroads | | | | | | |
| Side Rd L | | | | | | |
| 2 Way Traf | | | | | | |
| Div Hwy End | | | | | | |

Code Distance as D for "don't know" if can't recognize sign.