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16. Abstract
This project was conducted to provide results that the Texas Department of Transportation could use to help make decisions about their guide sign policies. The specific issues that were addressed include the type of font and retroreflective sheeting that should be specified on guide signs ranging from large shoulder-mounted freeway guide signs, to medium-sized guide signs such as destination and distance signs, and even including small guide signs such as county road name signs.

The researchers performed a nighttime legibility study using a total of 30 subjects divided into three age groups. A new highway font called Clearview was compared against the standard highway font currently in use. The full-scale tests were constructed with various combinations of retroreflective sheeting, including TxDOT's current practice.

The findings for the large guide signs showed that the Clearview font provides longer legibility distances than the Series E(Modified) font. The findings for the destination and distance signs shows that the 6-inch all uppercase Clearview font produced the same legibility distances as the 6-inch Series D font, which is also an all uppercase font. However, an 8-inch Clearview font with initial capital letters was also tested and it provided significantly longer legibility distances than either of the 6-inch all uppercase fonts. For all types of guide signs studied herein, the findings consistently show that guide signs fabricated with microprismatic retroreflective legends on high-intensity backgrounds provide the longest legibility distances.

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NIGHTTIME GUIDE SIGN LEGIBILITY FOR MICROPRISMATIC CLEARVIEW LEGEND ON HIGH INTENSITY BACKGROUND

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The engineer in charge was Paul J. Carlson, P.E. (Texas #85402).

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Nada Trout and Alicia Williams were vital to the data collection effort. Nada was responsible for recruiting and scheduling human subjects and assisting with the Texas A&M University Institutional Review Board's (IRB) approval for conducting research with human subjects. Alicia was responsible for greeting the subjects at the test facility and running them through the study. Her assistance was greatly appreciated.

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This research project relied on the help of many student workers, especially Patricia Johnson and Camille Brown. Patricia and Camille were extremely helpful in fabricating the test word panels and preparing the field equipment. In addition, Patricia was essential in preparing the data collection forms and completing the data analysis. Other student workers were responsible for changing the test words after each data collection run. These students spent several late nights on the runways of Texas A&M University's Riverside Campus battling insects and humidity. These students include: Taylor Baumgartner, Jason Dominguez, Lane Roberts, Lisa Schifani, Scott Schmidt, and Leslie Stengele. In addition, TTI researcher Austin Bischoff also volunteered his time to assist in changing signs.

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CHAPTER 1: SUMMARY

In a previous project sponsored by TxDOT, research showed that a new font called Clearview could significantly improve nighttime legibility of freeway guide signs when microprismatic sheeting was used to construct the guide signs (*1*). As a result of this finding, TxDOT became interested in adopting Clearview for all white-on-green signs under their jurisdiction. However, several issues remained unknown and therefore this project was commissioned to provide the necessary answers.

For freeway guide signs, a question was raised about the performance of signs with microprismatic legends on the now-standard, high-intensity background. This mixed sheeting design may provide even better nighttime legibility because of a higher internal contrast ratio, and the costs of the signs materials would be less than guide signs constructed in microprismatic sheetings for both the legend and background.

Another issue concerning guide signs was that the Clearview font produced longer words than the Series E(Modified) font. This could be a concern as old signs are replaced with new, larger signs requiring more robust signs supports. Therefore, several versions of Clearview that produced word lengths approximately equivalent to Series E(Modified) were tested.

Up to this point, Clearview had not been tested on signs other than large freeway guide signs. Therefore, there were some concerns as to how Clearview would perform on destination and distance signs typically found on conventional highways, and even smaller white-on-green signs such as county road name signs. Therefore, the project included evaluations of these sign types as well. In addition, the researchers also varied the headlamp flux to create different luminance levels to investigate the effects of luminance on the legibility of the Clearview fonts and on the mixed sheeting signs.

In the experimental procedure, test subjects driving the test vehicle started at a distance where the test signs were not legible. They then accelerated to 35 mph and began to concentrate on reading the test word, while maintaining lane control and speed. When the subject read the word correctly, a researcher recorded the distance traveled. Each subject read 66 randomly selected test words out of a pool of 78 words. The test words were approximately equally distributed between the various font, luminance, and sheeting combinations. The 66 words were displayed as follows: 24 were shoulder-mounted guide signs, 36 were destination/distance signs, and six were Texas county road name signs. Thirty subjects completed the evaluation. There were 10 young drivers, 10 middle-aged drivers, and 10 elderly drivers.

The results show that the Clearview 5W font provides longer legibility distances than Series E(Modified) for shoulder mounted guide signs. The 6-inch Clearview 3W font performed only as well as the 6-inch Series D font. However, the 8-inch Clearview 3W font shows a significant increase in legibility distance above that of Series D. The research findings also show that guide signs made with a microprismatic legend (such as Type IX and Type VIII sheeting) on glass-beaded background (Type III) produce longer legibility distances than signs manufactured from a single material type.

With these findings, the researchers recommend a statewide implementation of Clearview on freeway guide signs. The researchers also recommend that 8-inch Clearview be used on destination and distance signs. The design should include initial capital letters instead of all capital letters as the current standard requires. Where 8-inch Clearview cannot be used because of size constraints, 6-inch initial capital letter Clearview should be used. The researchers also recommend that all white-on-green signs be fabricated with microprismatic legends on high-intensity backgrounds.

CHAPTER 2: INTRODUCTION

Concerns have been raised that the advent of microprismatic retroreflective sheeting may increase the occurrence of blooming on freeway signs, which could potentially shorten legibility distances. The relatively high luminance levels that can be produced with microprismatic sheeting as compared to glass-beaded retroreflective sheeting cause this concern. The effect of blooming (also known as halation, overglow, or irradiation) is a washing out of a sign's legend and a reduction in the sign's legibility. The Clearview font has been developed to counter the effect of blooming seen with the current standard highway fonts.

The Texas Transportation Institute (TTI) has conducted two studies involving Clearview fonts (*1*, *2*). These projects are reviewed and summarized in this report. The first project evaluated the then-current form of Clearview on Type III sheeting. The results of the project showed potential for the application of Clearview but were not conclusive. The second project examined a refined Clearview font on microprismatic sheeting (Type VIII and Type IX) for freeway guide signs. This report determined that the Clearview font did provide an increased legibility distance and a positive benefit over Series E(Modified).

PROJECT OVERVIEW

The research project described herein was conducted by TTI from September 1, 2002 to August 31, 2003. The overall objective of this project was to evaluate the legibility of the Clearview 3W font for destination/distance signs as compared to the standard Series D font. In addition, the project evaluated the use of Clearview on freeway guide signs using a mix of sheeting types (combinations of microprismatic and glass-beaded sheeting). The activities that were completed and the report organization are described below.

- Literature Review – The research team reviewed current pertinent research on legibility and the Clearview font. Chapter 3 describes the results of these activities.
- Research Preparation – Before data collection could begin, the researchers had to obtain several approvals and complete many preparation activities. These approvals and activities are summarized below.

- Research Procedure Approval – After refining the project objectives, the researchers developed an experimental plan and submitted it to the project director for approval. Once approved, the researchers submitted the experimental plan to the Texas A&M University Institutional Review Board (IRB) for approval. IRB approval is a federal requirement for any experiment or research that involves human subjects. The researchers also sought permission to use the runways at Texas A&M's Riverside Campus and approval to temporarily install raised pavement markers and traffic cones on the runways (to guide the test subjects during testing).
- Data Collection Preparation – Sign structures and test word panels were ordered and fabricated for use during the nighttime study. In addition, subject packets that included consent forms, study explanations, the randomized word display order, and blank test forms were created for each subject
- Data Collection – During the last week of July 2003 and continuing through August, researchers collected the nighttime legibility data. TTI recruited 30 subjects, who each went through the hour-long evaluation. Chapter 4 details the data collection activities.
- Data Analysis – Once the data collection was completed, the researchers analyzed the data using the appropriate statistical technique. The researchers also prepared the data for comparisons to previous TTI Clearview studies. Chapter 5 presents the results from these analyses.

Chapter 6 provides the conclusions and final recommendations.

CHAPTER 3:
BACKGROUND

LITERATURE

Hawkins, et al. wrote a very in-depth literature review on signing in the report, "Legibility Comparison of Three Freeway Guide Sign Alphabets" (*2*). The review covers all relevant legibility research up to 1995 and details the evolution of freeway signing and the development of the U.S highway alphabets. Therefore, this literature survey will cover only relevant research completed from 1995, including the Hawkins report.

NIGHTTIME PHOTOMETRIC EVALUATION OF UNLIGHTED OVERHEAD GUIDE SIGNS

Zwahlen et al. studied the nighttime luminance and luminance contrast ratio of freeway overhead guide signs (*3*). These signs were made using combinations of sheeting material and were illuminated by low-beam vehicle headlamps and also with external luminaries in addition to the vehicle headlamps. The sheeting combinations used in the evaluation included:

- Type III legend on Type III background (Sign A),
- Type IX legend on Type IX background (Sign B),
- Type VII legend on Type III background (Sign C), and
- Type IX legend on Type III background (Sign D).

Test Method

The evaluation was carried out at the 3M Transportation Safety Research Center in Cottage Grove, Minnesota. This facility is equipped with a motorized sign bridge, which was used in the evaluation. All photometric measurements were conducted on a flat and level test track provided by the facility. Each test sign had an identical legend, the word "Dover" and an interstate shield. While the legends were new, the background material of the signs was slightly weathered. The four signs were mounted on the sign bridge, in the order (from left to right, viewing the signs) A, C, B, D.

Three vehicles were used to evaluate the sign luminance and luminance contrast ratio; a small sedan, a minivan, and a semi truck cab. Measurements were taken with the test vehicle centered in the right lane and then centered in the left lane of the test track. Measurements were taken at distances of 200, 600, and 1000 ft. In addition, the semi truck also had measurements taken at 100, 400, and 80 ft. Measurements were taken for lighted and unlighted sign conditions and all signs were measured in pairs (A, C and B, D).

All luminance measurements were taken using a ProMetric^{TM} CCD Light and Color Measurement System. The measurements were analyzed using the Ohio University Detection and Legibility Analysis Program.

Results

The researchers found that at distances of 200 ft with an unlighted sign, the Type IX on Type III combination performed the best for all vehicles (high luminance contrast ratio). At 600 ft, the Type IX on Type III and Type VII on Type III combinations performed similarly. At a distance of 1000 ft, the Type VII on Type III combination exhibited the highest luminance contrast ratio for all vehicles. Measurements for the semi truck showed that at all distances the Type VII on Type III combination performs the best overall. However, at 1000 ft, the Type IX on Type IX combination with an unlighted sign exhibited the best luminance contrast ratio.

Conclusions and Recommendations

Under low-beam illumination and for approach distances of 400 ft or greater, the use of Type VII legend on Type III background will provide the driver with superior luminance and luminance contrast and negate the need for external sign lighting. At distances under 400 ft, the use of Type IX sheeting on Type III will provide superior luminance and luminance contrast. The researchers recommend the use of microprismatic legends in combination with glass-beaded background sheeting for freeway guide signs.

Using photometric measurements, the researchers determined that signs constructed with microprismatic legend in combination with a Type III background material provide an increased level of luminance and luminance contrast to drivers.

NIGHTTIME EXPERT PANEL EVALUATION OF UNLIGHTED OVERHEAD GUIDE SIGNS

This study, performed by Zwahlen, Russ, and Vatan, evaluated four different retroreflective overhead sign sheeting combinations using an expert panel of state department of transportation (DOT) engineers and technicians (*4*). The objective of the study was to determine if certain combinations of sheeting materials have adequate conspicuity, legibility, and quality of appearance to be used without external lighting.

Method

The sheeting combinations used in the evaluation were:

- Type III legend on Type III background,
- Type IX legend on Type III background,
- Type IX legend on Type IX background, and
- Type VII legend on Type III background.

In addition, each sign combination was evaluated in lighted and unlighted conditions. The evaluation was conducted on U.S. Route 30 near Mansfield in central Ohio. The evaluation course was 22.3 miles in length. Panelists rode in 2002 model year minivans. The unlighted condition was driven twice by the panelists. One circuit was completed in the right lane and one in the left lane of the route. Only one circuit of the road course was completed for the lighted condition, and it used the right lane of the route. The panel consisted of 12 Ohio DOT engineers. The average age was 38 and the average years of experience was 12. Two panelists were female. The panelists were asked to evaluate each sign based on its conspicuity, legibility, and overall appearance.

Results

Conspicuity

The panelists judged that the unlighted Type III on Type III combination was not equal in conspicuity to the lighted condition. Eighty-three percent of the panelists judged that diamond grade on Type III signs has adequate conspicuity for unlighted use and 50 percent determined that the Type IX on Type IX sheeting combination was also adequate for unlighted use.

Legibility

Approximately 60 percent of the panelists thought that microprismatic legends were equally legible when lighted and unlighted. However, there was a preference for the Type IX on

Type III combination. Only 8 percent of the panelists thought that the Type III on Type III combination was equally legible in the lighted and unlighted conditions.

Conclusions

The researchers determined from the expert panel that the practice of lighting overhead signs could be discontinued provided that Type VII, Type VIII, or Type IX white legends are used on glass-beaded green Type III background. The use of microprismatic Type III sheeting would most likely reduce the contrast ratio and the legibility of the signs.

The researchers determined from the expert panel that signs constructed using microprismatic legend on a Type III background material provides adequate luminance such that external lighting of overhead signs could be discontinued.

ELDER ROADWAY USER PROGRAM: TEST SECTIONS AND EFFECTIVENESS STUDY

This study, performed by the University of Miami in 2002, researched several highway design elements that are considered "problematic" to older drivers. Study tasks of interest included an evaluation of existing traffic control devices (TCD) for older drivers and an evaluation of the Clearview font on ground-mounted street-name signs and advance street-name signs as compared to Series C, D, and E(Modified) fonts (*5*).

Evaluation of Existing Traffic Control Devices

Five TCDs were evaluated in this task. Two large overhead street-name signs and advance street-name signs are of concern. In all, 12 signs were evaluated.

Methodology

The research task used a daytime road course of approximately 15 miles and a nighttime road course approximately 6 miles in length. Subjects were required to be licensed drivers, at least 55 years of age. While driving the road course, subjects were asked to read the indicated street-name signs at the moment they were legible.

The task sample included 51 drivers aged 42 to 90, 26 male and 25 female. Subjects were divided into two groups, young and old; older drivers were 65 to 90 years old and young drivers were 42 to 57 years old. All drivers participated in the daytime portion and 12 of the older drivers participated in the nighttime evaluation.

The signs used in the evaluation were ranked by letter height and stroke width. The sign legends were not physically measured; however, the county sign shop supervisor was consulted for identification of letter height and stroke width on each sign. Six overhead street-name signs were used in the evaluation and ranked according to Table 1 and 2. Higher rank (lower number) indicates a greater letter height and thicker stroke width (Series D or E). Six advance street-name signs were also used in the evaluation. These signs are the companion signs to the overhead street-name signs.

Table 1. Legibility Distance of Overhead Street-Name Signs.

Sign Presentation Order	Street Name	Rank	Mean Legibility Distance (ft)
1	NW 2nd Street	1	254
2	NW 17th Street	2	290
3	Johnson St	3	226
4	Douglas Rd	3	197
5	NW 86th Ave	2	272
6	NW 83rd Ave	2	215

Table 2. Mean Legibility Distance Advance Street-name Signs.

Sign Presentation Order	Street name	Rank	Mean Legibility Distance (ft)
1	NW 2nd Street	2	774
2	NW 17th Street	1	683
3	Johnson St	4	303
4	Douglas Rd	3	610
5	NW 86th Ave	5	240
6	NW 83rd Ave	5	253

Results

Multivariate analyses of variance (MANOVA) were performed on the collected data to determine any significant difference in legibility distance. Legibility distance was found to be dependent on letter height. A larger letter height and stroke width provided an increased legibility distance. Age was also found to have an effect on legibility distance, with older drivers reading from a shorter distance than younger drivers. There was no interaction between age and specific overhead signs, indicating that factors that impact legibility distance affect young and old drivers similarly. The researchers also determined that drivers read the advance street-name signs at a greater distance than the overhead street-name signs. Again, legibility distance was dependent on letter height. Unlike the overhead street-name signs, there was no age effect for advance street-name signs.

The researchers also investigated the effects of age and other individual driver characteristics (driving experience, acuity, cognitive and psychomotor tasks) to legibility distance. Analysis revealed that individual driver traits had more impact than age alone. The most prevalent traits were visual acuity and the ability to divide attention.

Evaluation of Clearview Font

The objective of the second study task was to evaluate the legibility distance of the Clearview font as compared to fonts currently in use (Series C and D). Signs used in the evaluation were advance street-name signs and ground-mounted cross-street signs. Six signs were used in the evaluation.

Methodology

The evaluation was performed on roads open to public use at the Opa-Locka Airport in Miami-Dade. The roadways consisted of four-lane divided arterials and two-lane roads for the advance street-name signs and ground-mounted signs, respectively. Vehicles were driven at night with the high beams on and at a speed of approximately 30 mph. Drivers were instructed to read the indicated signs out loud and as quickly as possible. Drivers were also given sign color and location descriptions. Advance street-name signs were all located in the median, and ground-mounted street-name signs were located at the corner of the street on the driver's right. The task sample consisted of 37 drivers, aged 65 to 92.

Three advance street-name signs and three ground-mounted street-name signs were used in the evaluation. Word length was controlled to six or seven letters. The advance street-name signs used 8-inch Series D and Series C, uppercase letters on 24-inch x 48-inch blanks. The Clearview font used for comparison was ClearviewOneCD-45. Three ground-mounted signs were also used in the evaluation. The signs used a 6-inch Series C legend on 9-inch x 36-inch blanks. All material was 3M VIP for the legend and green 3M overlays for the background. Series C was compared to ClearviewOneUC-35.

Results

The researchers conducted an ANOVA to determine the difference in the legibility distance for the fonts. Clearview was found to be more legible than either Series C or D with the greatest difference occurring between Clearview and Series C fonts. Table 3 gives the mean legibility distances for each font for the advance street-name signs.

Table 3. Legibility Distance by Font.

Font	Mean Legibility Distance (ft)	Std. Error	95% Confidence Interval		Mean Difference from Clearview (ft)
			Lower Bound	Upper Bound	
Clearview	198.1	11. 2	175	221	0.0
Series D	178.1	11.0	155	200	-20
Series C	151.1	11.0	128	174	-47

The ground-mounted signs were also analyzed using an ANOVA. In this case, only two fonts were compared (Series C and Clearview). Analysis indicated that Clearview provides legibility distance increase for two signs. However, the third sign showed a higher legibility distance for Series C. The researchers concluded that there is no significant difference in mean legibility distance for Clearview and Series C fonts.

Using a larger letter height and an increased stroke width can improve the legibility of a sign. In addition, the Clearview font provides longer legibility distances as compared to Series C and Series D on signs made from a single material type (both legend and background).

NIGHTTIME LEGIBILITY OF GROUND-MOUNTED TRAFFIC SIGNS AS A FUNCTION OF FONT, COLOR, AND RETROREFLECTIVE SHEETING TYPE

This research project was conducted to determine the best font and sheeting type combination for nighttime legibility for small, ground-mounted signs (*6*). The researchers used three different sheeting types in combination with four colors and three fonts. The focus of the project was on shoulder-mounted conventional road guide signs such as destination/distance signs. In addition, the researchers studied warning and regulatory signs.

Sign Materials and Design

The researchers tested three retroreflective sheeting types:

- ASTM Type III: a high-intensity encapsulated glass bead material,
- ASTM Type VIII: a super high-intensity microprismatic material, and
- ASTM Type IX: a very high-intensity microprismatic material.

Each material used four colors: green, yellow, orange, and white. A fluorescent orange was used for both microprismatic materials. Series D was used as the control font and was used on all signs and all combinations. Combinations that produced a positive contrast sign (light legend on dark background) used Clearview Condensed Road font. Negative contrast signs (black legend on light background) used the D-Modified font. All signs used a letter height of 6 inches.

Field Study

The field study took place at night on Texas A&M's Riverside Campus, a former U.S. Air Force base. The project used a total of 24 subjects, aged 55 to75. The subjects were split into age groups of 55 to 64 and 65 to 74. Gender was evenly split among the age groups. Each subject was tested for visual acuity, contrast sensitivity, and color vision. Subjects also completed a questionnaire about their driving habits. All testing took place at night on a prescribed road course. The test vehicle was a 1998 Chevy Lumina.

The field study used short words to ease cost and installation and also to reduce variability in response time. All signs were mounted 14 ft from the right edge line and at a height of 8 ft to the center of the sign. The driving path was delineated using retroreflective pavement markers. Signs were positioned 500 ft apart from each other along the road course. All sign legends used a 6-inch letter height. The order of the signs along the course was changed a total of three times during the course of the field study to minimize systematic effects on the placement of particular signs (start of the course, at turning points, etc.). The subject sat in the driver's seat and drove the study vehicle through the road course. Subjects were asked to say the word as soon as they could correctly identify it. The road course took approximately 20 minutes to complete, and any comments made by the subject were recorded.

Results

The experiment produced a total of 1152 data points for analysis (24 subjects and 48 signs). A mixed-model ANOVA analysis was conducted using age group as a between-subjects factor and font, sign color, and sheeting type as within-subjects factors. The model produced an R^2 value of 0.88 ($F_{574,144} = 7.25$, $p<0.0001$). Performance based on age did not show any significant effects, while performance based on color indicated that the white and yellow signs were equivalent in performance with mean legibility distances of 190 and 180 ft, respectively. Green signs performed as well as white (but not yellow) with a mean distance of 179 ft. Orange signs performed the worst with a mean distance of 164 ft. Also, younger drivers had more trouble with the orange signs than the older drivers. Table 4 lists the mean legibility distance and standard deviation for each sheeting and font combination.

Table 4. Mean Legibility Distance for Each Treatment.

Background Color	Sheeting Type	Font	Mean (ft)	Std. Dev. (ft)
Green	III	Clearview Cond. Road	167	61
		Highway Series D	179	68
	VIII	Clearview Cond. Road	171	71
		Highway Series D	180	70
	IX	Clearview Cond. Road	176	69
		Highway Series D	200	71
Orange	III	D-Modified	153	61
		Highway Series D	143	61
	VIII	D-Modified	166	59
		Highway Series D	185	62
	IX	D-Modified	163	71
		Highway Series D	175	70
White	III	D-Modified	203	75
		Highway Series D	180	66
	VIII	D-Modified	184	76
		Highway Series D	181	68
	IX	D-Modified	198	67
		Highway Series D	184	65
Yellow	III	D-Modified	179	73
		Highway Series D	186	74
	VIII	D-Modified	206	72
		Highway Series D	192	75
	IX	D-Modified	181	79
		Highway Series D	194	69

Sheeting type also had significant effects on legibility distance. Across all fonts and colors, the two microprismatic sheetings performed similarly with mean legibility distances of 184 and 183 ft for Type IX and Type VIII sheeting, respectively. Type III sheeting had a mean legibility distance of 174 ft. Sheeting performance was also affected by the sheeting color.

Series D and Clearview Condensed Road were compared using only green colored signs. In this project, the Series D font performed significantly better than the Clearview Condensed Road font with mean legibility distances of 187 and 171 ft, respectively. There were no significant differences in using green Type VIII over green Type III sheeting as well as no significant difference in using Type IX over Type VIII. However, Type IX did perform significantly better than Type III.

Overall, the researchers found that, in the order of increasing legibility distance, the sign color follows an order of increasing brightness, illustrating the importance of luminance in sign legibility. In addition, the researchers theorized that the unexpected performance of the Clearview Condensed Road font might be attributed to the use of all uppercase letters in the legend. Previous usage of the Clearview font used a mixed-case legend. Further research in this area may be required. However, the researchers did not find any advantage in the alternative fonts used in this project over Series D.

Signs constructed using microprismatic material exhibited higher legibility distances than those constructed using high-intensity or Type III material. The Clearview font used in this research however did not perform better than the standard Series D highway font.

EFFECTS OF FONT AND CAPITALIZATION ON LEGIBILITY OF GUIDE SIGNS

Garvey, Pietrucha, and Meeker used the Clearview font to evaluate different methods of improving the legibility and recognition of legends on road guide signs (*7*). Four fonts were used in this evaluation, identified as: Series D, Series E(Modified), Clearview 100, and Clearview 112.

Evaluations

Effect of Font Case and Reflective Sheeting on Word Recognition

This study compared recognition distance of mixed-case Clearview with Standard Highway Series D in all uppercase font and the mixed-case Standard Highway Series E(Modified). The study used older drivers and day and night viewing conditions. This study also evaluated the effect of sheeting on recognition distance.

Twenty-four subjects aged 65 and older were recruited for the study. All subjects were licensed drivers. The dependent variable was identified as "threshold distance for word recognition". This represented the furthest distance at which a subject could correctly identify a given word. The study was conducted at the Pennsylvania Transportation Institute (PTI) Bus Research and Testing Facility. Capital letter heights for the Series D and Series E(Modified) fonts were 5 inches. The Clearview 100 and Clearview 112 fonts had capital letter heights of 5.6 inches. Six test words were used in the evaluation. Words were selected based on length and similarity of initial letter footprint.

Each subject was tested individually. The subject was tested while seated in the front-passenger seat of the test vehicle. At a distance of 305 m (991 ft) from the test sign, the subject was asked to locate the position of a given word (top, middle, or bottom). At the same time, the experimenter began to drive the test vehicle toward the sign at 10 mph. Once the subject correctly located the test word, the car was driven back to the 305 m (991 ft) mark and the procedure was repeated. Twelve repetitions were completed.

The researchers determined that the mixed-case Clearview 112 outperformed the all uppercase Series D by as much as 14 percent during the day and 16 percent at night. There was no difference between the mixed-case Clearview 100 and Series D fonts. The Series E(Modified) and Clearview fonts showed no difference during the day, while the Clearview 112 outperformed the Series E(Modified) by 16 percent at night. The researchers found no significant effect of material type and no interaction between material type and font.

Effect of Font and Reflective Sheeting on Word Legibility

This study compared the legibility distances of mixed-case Clearview with Standard Highway Series D in all uppercase font and the mixed-case Standard Highway Series

E(Modified). The study used older drivers and day and night viewing conditions. This study also evaluated the effect of sheeting on recognition distance.

Twenty-four subjects, different from the previous study, aged 65 and older were recruited for the study. All subjects were licensed drivers. The dependent variable was identified as "threshold distance for word legibility." This represented the furthest distance at which a subject could correctly read a given word. The study was conducted at the PTI Bus Research and Testing Facility. Capital letter heights for the Series D and Series E(Modified) fonts were 5 inches. The Clearview 100 and Clearview 112 fonts had capital letter heights of 5.6 inches. Six test words were used in the evaluation. Words were selected based on length and similarity of initial letter footprint.

Each subject was tested individually. The subject was tested while seated in the front-passenger seat of the test vehicle. At a distance of 305 m (991 ft) from the test sign, the subject was asked to read a single word on the test sign. The subject was not told the word. At the same time, the experimenter began to drive the test vehicle toward the sign at 10 mph. Once the subject correctly read the test word, the car was driven back to the 305 m (991 ft) mark and the procedure was repeated. Twelve repetitions were completed.

The researchers determined that there were no significant differences in legibility distances for any font during the daytime condition. In addition, there was no significant difference between Clearview 112 font and the Series E(Modified) font. The all uppercase Series D font performed better than the Clearview 100 font. The researchers found no significant effect of material type and no interaction between material type and font. In the nighttime condition, the Clearview 112 font performed 22 percent better than the Series E(Modified) font. The all uppercase Series D also outperformed the Clearview 100 font in the nighttime condition.

Conclusions

The researchers concluded that mixed-case words should be used on all guide signs including conventional road and street-name signs. The researchers found that the Clearview font produced longer legibility and recognition distances compared to Series E(Modified). However, the recommend further research in this area.

The Clearview font provides increased nighttime legibility over that of Series E(Modified) but not over that of Series D. In addition, the use of mixed-case words (initial upper and lower case letters) should be expanded to all guide signs.

EVALUATION OF CLEARVIEW ALPHABET WITH MICROPRISMATIC RETROREFLECTIVE SHEETING

This research project was conducted to determine the legibility of the Clearview alphabet on full-scale freeway guide signs as compared to Series E(Modified) (*1*). Signs were constructed using microprismatic and high-intensity sheeting. Both overhead and shoulder mounted guide signs were studied.

Experiment Factors

The Clearview alphabet was developed to reduce the irradiation or overglow effect of using microprismatic retroreflective sheeting. Since this affects the nighttime visibility of words, this project was performed only at night and the nighttime legibility distance was used at the measure of effectiveness. The experiment variables include:

- alphabet – comparison of Clearview Regular Express to Series E(Modified) using 16-inch capital letters with appropriately sized lowercase letters;
- sign position – right-shoulder-mounted and overhead freeway guide signs;
- sheeting type – Type VIII and Type IX microprismatic retroreflective sheetings;
- vehicle type – a 2001 Chevy Suburban four-wheel drive and a 1989 Ford Crown Victoria LTD equipped with distance-measuring instruments (DMI); and
- subject age – three age categories: 18 to 34, 35 to 54, and 55 and older.

Words were presented on 12 ft wide by 9 ft tall sign backgrounds. The subjects drove the test vehicles at a speed of approximately 35 mph. All data were collected under dry pavement and sign conditions and at night. No external sign lighting was used, and there was little ambient lighting from nearby buildings and communities.

The words used in the evaluation were selected from a previous TTI Clearview project and allowed comparison between the projects. Table 5 lists the words used in the project. In an effort to prevent learning/remembering effects, words were chosen that had similar footprints.

Table 5. Test Words.

Neutral Words			Ascender/Descender Words		
Houses	Oceans	Senior	Barley	Felony	Plunge
Honors	Ounces	Sensor	Bishop	Flange	Shapes
Nerves	Senior	Series	Dearly	Forget	Target
Nurses			Eatery		

Experimental Procedure

Each subject was given a visual acuity test and asked about color blindness before moving to the driving course. Two drivers were tested at one time in a "following" method. The first vehicle began the course and after passing the first sign installation, approximately 2500 ft downstream, the second vehicle started the course.

Two road courses were used, as shown in Figure 1. The courses were laid out using colored reflective pavement markers to provide positive course guidance for the subjects. The first course followed an oval pattern and simulated the right-shoulder-mounted guide signs. Two signs were viewed in each circuit, and a total of eight circuits were completed. The second course followed a figure-eight pattern. Three signs were viewed on each circuit with a total of four circuits completed. Two of the signs were overhead guide signs and one was a right-shoulder-mounted guide sign.

The drivers began each circuit at a predetermined location. The driver then drove along the road course and was asked to say out loud the word displayed on the sign. When the driver correctly identified the word on the sign, the distance displayed on the DMI was recorded. The driver did not stop the vehicle but continued on to the second sign where again the driver said out loud the word on the sign and the experimenter recorded the distance traveled. The lead vehicle paused before returning to the start point until the second vehicle had passed a predetermined point. This was so that the headlamps would not interfere with the second driver.

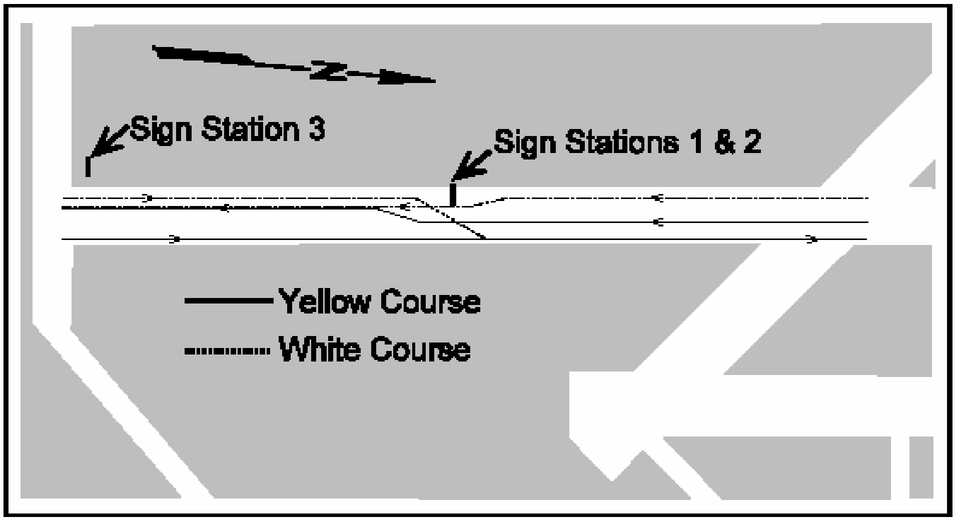

Figure 1. Course Layout.

Results

Sign type--either shoulder mounted or overhead guide sign--separates the analysis and results for this project. Researchers completed 3360 observations. There were 2400 shoulder-mounted sign observations and 960 overhead sign observations. Missing data reduced the numbers to 2365 and 951 for the shoulder-mounted and overhead signs, respectively. Sixty subjects completed the study, 30 male and 30 female, split evenly across the age categories. Driver visual acuity (Snellen) ranged from 20/10 to 20/50. No drivers were colorblind.

Shoulder-Mounted Guide Signs

The overall mean legibility distance for Clearview was 32 ft longer (5.2 percent) than that of Series E(Modified). When vehicle type and sheeting type were analyzed, improvement ranged from 18 ft to 58 ft. The largest difference was found with the Crown Victoria viewing Type IX sheeting. Percentage increases range from 3.1 to 9.4 percent. In all cases, Clearview outperformed Series E(Modified). Table 6 shows each sheeting and alphabet combination and results for shoulder-mounted guide signs.

Table 6. Descriptive Statistics for Shoulder-Mounted Signs.

Vehicle	Sheeting	Alphabet*	N	Average (ft)	Std. Dev. (ft)	Differences	
						Magnitude (ft)	Percent
Crown Victoria	VIII	Clvw	351	693	216	21	3.1
		E(M)	356	672	214		
	IX	Clvw	240	675	224	58	9.4
		E(M)	235	617	217		
Suburban	VIII	Clvw	351	628	201	26	4.3
		E(M)	356	602	202		
	IX	Clvw	244	588	188	18	3.2
		E(M)	232	570	187		

*Clearview font (Clvw), Series E(Modified) (E(M))

Overhead Guide Signs

The overhead guide signs were used to conduct two comparisons. The first was to compare the use of Type III and Type IX sheeting (using only Series E(Modified) alphabet) in order to make comparisons to an earlier TTI project. The second tested Series E(Modified) against Clearview on Type IX sheeting only. There were 480 total observations for this comparison. Cumulative distribution plots of the data indicate that Clearview performs better than Series E(Modified) overall and that Clearview has a greater impact on older drivers.

Table 7 lists the descriptive statistics for overhead-mounted guide signs. The overall mean legibility distance for Clearview was 40 ft (6.7 percent) greater than that of Series E(Modified). Drivers in the Crown Victoria saw an improvement of 56 ft, while drivers in the Suburban realized a 26 ft increase in legibility distance.

Table 7. Descriptive Statistics for Overhead Signs.

Vehicle	Sheeting	Alphabet	N	Average (ft)	Std. Dev. (ft)	Difference	
						Magnitude (ft)	Percent
Crown Victoria	IX	Clvw	100	678	190	54	8.6
		E(M)	135	624	204		
Suburban		Clvw	102	595	172	26	4.6
		E(M)	137	569	170		

Conclusions and Recommendations

The researchers found microprismatic sheeting gives the driver a statistically significant longer legibility distance (44 ft) over Type III sheeting for overhead guide signs. Using the collected legibility data and legibility models, the researchers also determined that shoulder-mounted guide signs using microprismatic sheeting have an increased legibility distance of 41 ft.

Use of the Clearview font resulted in an increased legibility distance of 32 ft over Series E(Modified) on shoulder-mounted guide signs made with microprismatic sheeting. The greatest improvement occurred with older drivers, who experienced a 6 percent increase in their legibility distance.

Use of the Clearview font on overhead guide signs made with microprismatic sheeting showed a legibility distance increase of 40 ft over Series E(Modified). Again, the greatest difference occurred with older drivers, producing a 6.8 percent increase in the legibility distance.

The researchers also determined that the use of the Clearview font increases sign legibility regardless of the amount of luminance. Using luminance-dependent factors (sign position, sheeting type, and vehicle type), the researchers found that as luminance increases, the signs become more legible and that the benefits of Clearview also increase (i.e., longer legibility distance).

Microprismatic sheeting provides a statistically significant longer legibility distance compared to Type III sheeting. The Clearview font also provides an increased legibility distance over that of Series E(Modified).

LEGIBILITY COMPARISON OF THREE FREEWAY GUIDE SIGN ALPHABETS

In this project, Hawkins et al. evaluated legibility distances for overhead and shoulder-mounted guide signs. The evaluation used Series E(Modified), British Transport Medium, and Clearview legends to determine if the performance of a white Type III legend on a green Type III background could be improved (reduction in the blooming effect) (*2*). The project used 54 subjects in three age groups. Subjects aged 21 to 35 were the “young” group, those 56 to 64 years old were the “young-old group, and those 65 to 84 years old were the “old” group. Each driver was tested for visual acuity (using a Snellen Visual Acuity Chart), contrast sensitivity (using a Vistech chart), and reaction time (using the Porto-Clinic driver testing unit).

Experimental Design

In this experiment, subjects performed a recognition study and a legibility study (simultaneously) in both day and night scenarios. The experiment used three signboards: one ground-mounted, one overhead, and one combination. The ground-mounted signboards were used for a recognition study while the overhead signboards were used for a legibility study. Twenty-one words were used in the project (see Table 5). However, the words were repeated across the alphabets. Word display panels were created that consisted of two recognition words and one legibility word. All words were matched by word form (ascender/descender words paired with ascender descender, neutral words with neutral words). Each three-word display used the same alphabet in each word, and the order of each panel's display was randomized for each subject and from day to night.

The researchers tested three subjects at a time, with one subject in the front passenger seat and two subjects in the rear passenger seats of the test vehicle. The researcher drove subjects along a road course at a speed of 20 mph toward the signboards. In the recognition test, subjects were shown a word on a flash card and then asked to identify the word by noting the word's position on the guide sign (top, middle, bottom) by pressing a button on a keypad. In the legibility test, subjects were asked to indicate when they could read a word on the sign by saying the word out loud and again pressing a button corresponding to the word's location on the sign. Subject responses were monitored, and the researcher noted incorrect answers. Subjects were given the opportunity to change any wrong answers by saying the correct word out loud and pressing the correct button.

The experiment used a 1991 Ford Crown Victoria, equipped with a DMI and a laptop computer. The DMI was used to measure the distance away from the sign face at the point when the subject identified the word's location. The laptop recorded distance, word position, trial number, and subject number and task (legibility or recognition) for each subject. The subjects were also required to wear earphones to listen to white noise during testing. This prevented the subjects from hearing the other subject's responses. All testing took place at the Texas A&M Riverside Campus. There was no external illumination of the signs other than vehicle headlamps.

Results

The researchers found that the Clearview font was more effective than Series E(Modified) in both day and night conditions for overhead signs. An improvement of approximately 2 to 8 percent was observed. The researchers also noted that a greater improvement was found in the recognition test than in the legibility test.

Clearview ground-mounted signs showed mixed results. In the daytime condition, there was no significant improvement over Series E(Modified). In the nighttime condition, Clearview did not provide consistently better performance (legibility and recognition) than Series E(Modified). The British Transport Medium was generally less effective than Series E(Modified).

Statistical analysis showed no statistically significant improvement of using Clearview or British Transport Medium over Series E(Modified).

The researchers determined that the Clearview font can provide increased nighttime legibility to freeway guide signs and, in the case of overhead signs, increased daytime legibility as well.

SUMMARY

The preceding studies illustrate the potential of the Clearview font, throughout its evolution, to provide increased legibility to large freeway guide signs. However, the benefit of Clearview to smaller, conventional highway guide signs requires more study. The literature also shows that legibility can be increased by the use of mixed-case words and microprismatic sheeting.

CHAPTER 4:
FIELD EVALUATION

DEVELOPMENT OF CLEARVIEW 5WR

The most recent release of the Clearview fonts comes in two different types; one type for positive-contrast signs and another type for negative-contrast signs. Each type of Clearview comes in six different styles. An example of the Clearview fonts is shown in Figure 2.

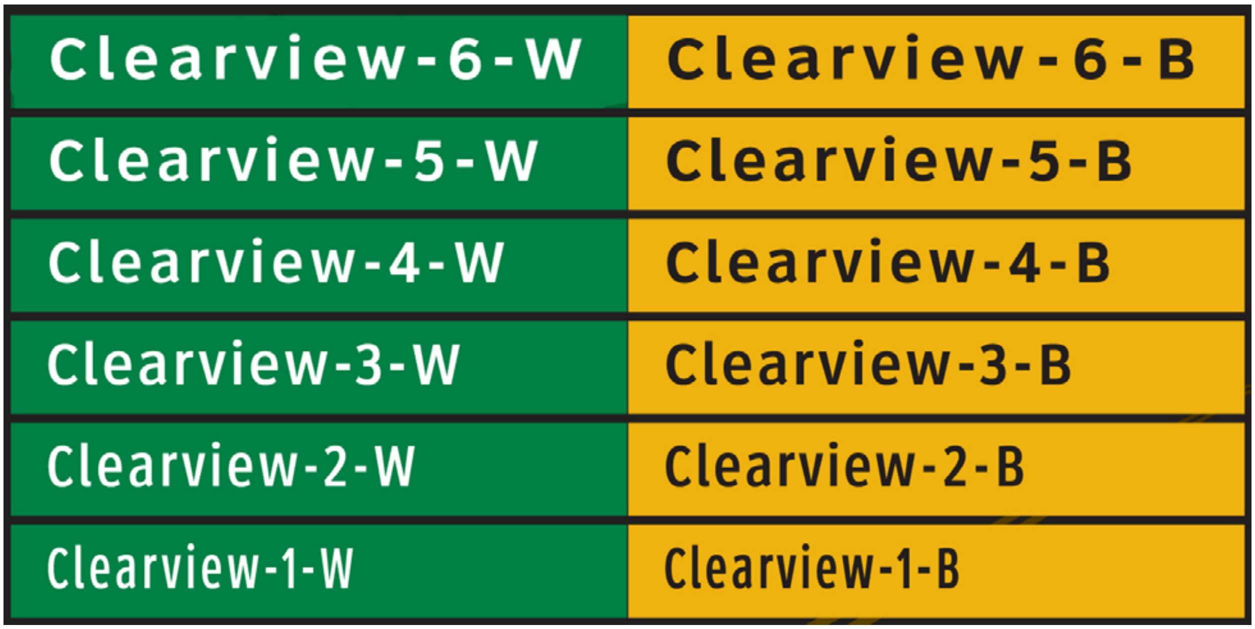

Figure 2. Clearview Fonts.

The style of Clearview corresponds to specific highway gothic fonts as indicated in below:

- 1W = Series B,
- 2W = Series C,
- 3W = Series D,
- 4W = Series E,
- 5W = Series E(Modified), and
- 6W = Series F.

The use of Clearview 5W on highway guide signs was pilot tested in Texas on a small number of signs in the field. One of the concerns was that the legends made with Clearview 5W were usually longer (or wider) than legends made with Series E(Modified). In order for replacement signs to fit within the existing structures, it is important that the same size sign be installed. It is also important not to crowd the borders of guide signs in order to maintain maximum legibility performance. Therefore, personnel from TxDOT and the researchers developed a list of 28 common guide sign destinations (for Texas), submitted them to the developer of Clearview, and asked to have a modified version of Clearview 5W that produced, on average, the same width legends as Series E(Modified). Figure 3 compares the 28 words that were submitted and their overall word length difference. For each word pair, the top word is Series E(Modified) and the bottom is Clearview 5W. Based on the average of these results, a modified version of Clearview 5W was developed. The modified version is called Clearview 5WR (R for reduced). Clearview 5WR has letter spacings reduced by 6.4 percent from the standard Clearview 5W.

Figure 3. Test Words for Texas Clearview 5WR Development.

Galveston		Corpus Christi	
Galveston	7.7	Corpus Christi	4.0
Houston		Lubbock	
Houston	7.6	Lubbock	8.1
Dallas		Amarillo	
Dallas	5.2	Amarillo	4.1
Texarkana		Beaumont	
Texarkana	5.0	Beaumont	2.9
Ft Worth		Shreveport	
Ft Worth	6.8	Shreveport	7.0
San Antonio		Lake Charles	
San Antonio	3.5	Lake Charles	4.8
Abilene		Oklahoma City	
Abilene	7.0	Oklahoma City	4.9
Midland		Nacogdoches	
Midland	6.0	Nacogdoches	11.0
Odessa		Waxahachie	
Odessa	12	Waxahachie	6.4
El Paso		Tyler	
El Paso	5.6	Tyler	3.5
Waco		Wichita Falls	
Waco	16.1	Wichita Falls	4.9
Austin		College Station	
Austin	1.7	College Station	6.7
Laredo		Rio Grande Valley	
Laredo	8.7	Rio Grande Valley	5.5
		Brownsville	
		Brownsville	6.4

Because no formal field testing of Clearview letter spacing had occurred in the past, the researchers worked with the TxDOT and the developer of Clearview to develop a third version of Clearview 5W. The third version was an intermediate letter spacing that split the difference between the standard Clearview 5W and the reduced version, Clearview 5WR. The intermediate version had a reduced letter spacing of 3.2 percent compared to the standard Clearview 5W. All three versions of the font are shown in Figure 4 along with Series E(Modified).

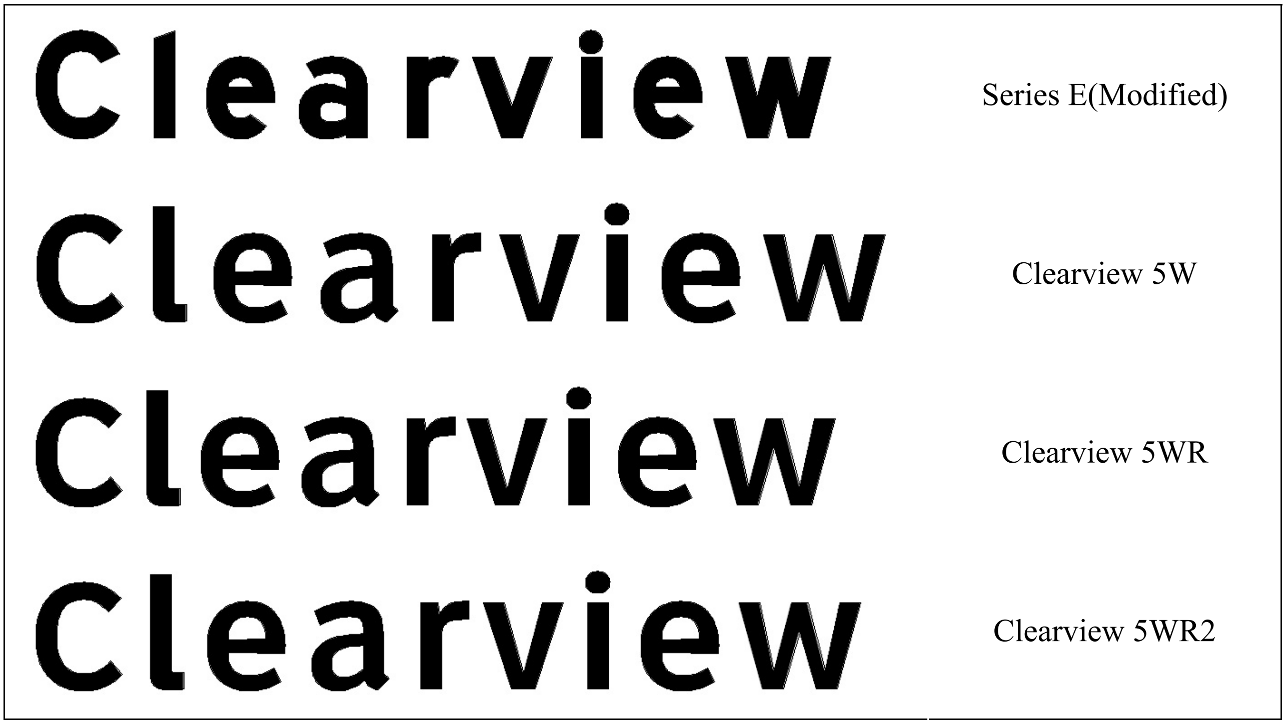

Figure 4. Clearview 5W Versions Compared to Series E(Modified).

SELECTION OF VARIABLES

The objective of the field evaluation was to determine the legibility distances of shoulder-mounted destination and distance signs and freeway guide signs fabricated with combinations of microprismatic and high-intensity retroreflective sheeting and using Clearview 5W and Series E(Modified) legends (guide signs) and Clearview 3W and Series D legends (destination/distance signs). In addition, legibility data for county road name signs were also obtained.

Dependent Variable

The measure of effectiveness used in this project (and in previous Clearview studies) was legibility distance. This is the distance at which a subject can read an unknown word. Legibility distance provides a sound measure of readability and performance of a given alphabet.

Independent Factors

Several independent factors were also identified and tested during the nighttime evaluation. These are described below.

Global Factors

- **Subject age –** Three-subject age categories were selected for this project. The young group was classified as 18 to 34, the middle-aged group as 35 to 54, and the elderly group was classified as 55 and older. There were a total of 10 subjects in each age category with an equal gender split.
- **Vehicle/Headlamp type –** The test vehicle was a 2000 Ford Taurus.

Destination and Distance Signs

- **Alphabet –** Two alphabets were evaluated using the destination and distance signs; Series D and Clearview 3W. These fonts were evaluated at a 6-inch, all uppercase letter height. In addition, the Clearview 3W font was also evaluated at an 8-inch letter height with initial capital letters.
- **Sign height and offset –** All signs were positioned on the right side of the roadway, approximately 18 ft from the driving lane. Signs were mounted at a height of 7 ft from the ground to the bottom of the sign.
- **Retroreflective sheeting –** Three sign assemblies were used to evaluate the destination and distance signs. Two assemblies used green Type III background sheeting while the third used green Type VIII background sheeting. Legends were created using white Type III, Type VIII, and Type IX sheeting.
- **Inter-letter spacing –** Inter-letter spacing was kept constant, and the standard spacing for each font was used.

Freeway Guide Signs

- **Alphabet –** The freeway guide signs used 16-inch mixed-case legends. Two alphabets were used, Series E(Modified) and Clearview 5W.
- **Sign height and offset –** All signs were positioned approximately 24 ft from the outside edge of the travel lane on the right side of the roadway. The signs were mounted at a height of 9 ft from the ground to the bottom of the sign.
- **Retroreflective sheeting –** Two sign assemblies were used for evaluating the freeway guide signs. One sign assembly used green Type III background sheeting while the other used green Type IX. Legends were created using white Type III, Type VIII and Type IX sheeting.
- **Inter-letter spacing –** Inter-layer spacing for the Series E(Modified) font was kept constant and used the standard spacing. Three spacings were used in evaluating the Clearview 5W font; the standard spacing, a 3 percent reduction in the standard spacing (labeled Clearview 5WR2 in this report), and a 6 percent reduction in the standard spacing (previously identified as Clearview 5WR).

County Road Name Signs

- **Alphabet –** The county road name signs used a 4-inch Series D font.
- **Sign height and offset –** All signs were positioned approximately 15 ft from the outside edge of the driving lane, on the right side of the roadway. Signs were mounted at a height of 7 ft from the ground to the bottom of the sign.
- **Retroreflective sheeting –** All six county road name signs used Type III green sheeting for background. Sign legends used white Type III, Type VIII, and Type IX sheeting (two signs each).
- **Inter-letter spacing** – Inter-letter spacing was kept constant and used the standard Series D spacing.

Fixed Factors

The factors that were held constant throughout the evaluation include:

- **Seat position** – Each subject performed the study from the driver's seat of the test vehicle.

- **Vehicle speed** – Each trial was performed at approximately 35 mph.
- **Environmental conditions** – All data were collected under dry, nighttime conditions (i.e., no rain or dew on the signs).
- **External sign illumination** – With the exception of the test vehicle headlamps, no external lighting was used to light the signs.
- **Ambient lighting** – The study was performed at Texas A&M University's Riverside Campus. This campus is an old Air Force base that was donated to Texas A&M University. It is located approximately 12 miles from the main campus and is situated in a dark, rural environment. There is little lighting from buildings or nearby communities (Figure 5).

Figure 5. Aerial Photograph of Texas A&M Riverside Campus.

Measured Factors

In addition to the independent variables and fixed factors, there were also factors measured each night of testing. These factors are listed and described below.

- **Driver visual acuity** – Each of the 30 subjects was required to have a valid driver's license. The State of Texas requires a uncorrected visual acuity of 20/40 to drive without restrictions. The researchers also measured the visual acuity of the subject using the Snellen visual acuity chart.

Sign luminance – The sign luminance was varied during testing from a high value to a low value. The high value is the full power output of the vehicle low beam headlamps. The low value represents the 85th percentile minimum luminance required by older drivers for sign legibility

- Table 7Table 8). Carlson and Hawkins determined minimum luminance values for older drivers in a 2001 study on minimum retroreflectivity for guide signs (*8*).

Table 8. Study Luminance Values.

Value	Luminance (cd/m^2)*
High	13.0
Low	3.6

*measured at a distance of 640 ft on a 2 ft square high-intensity sign blank

TEST EQUIPMENT

Test Vehicle

One vehicle was used throughout the study: a 2000 Ford Taurus (Figure 6). The vehicle was equipped with a Nu-metrics Nitestar DMI. The DMI was calibrated and used to measure and record the legibility distances of the test subjects (Figure 7). Figure 8 shows the vehicle headlamp dimmer. This device was created for a previous TTI project.

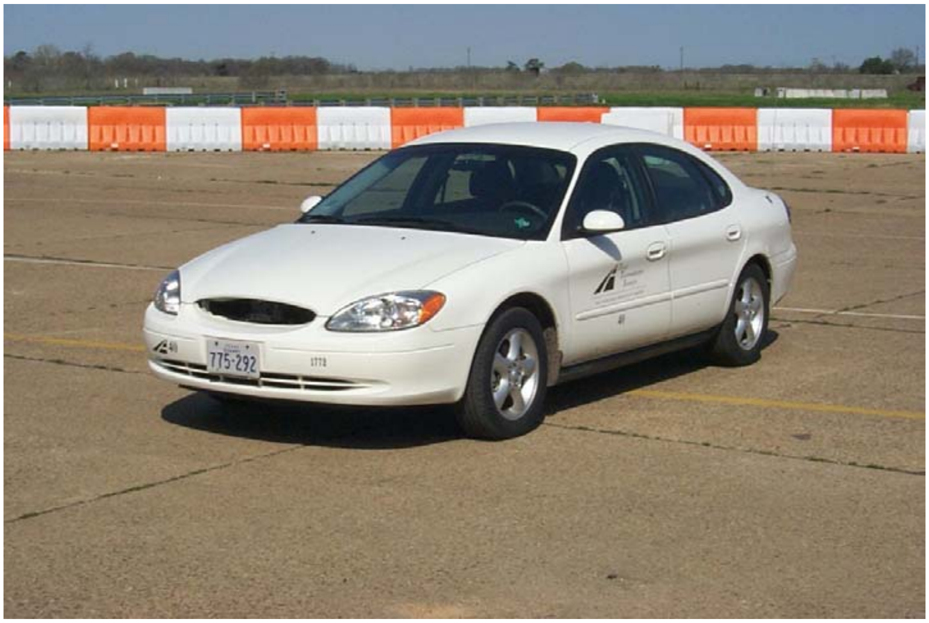

Figure 6. Test Vehicle 2000 Ford Taurus.

Figure 7. Image of DMI Used to Collect Distance Data.

Figure 8. Headlamp Dimming Device.

Sign Structures

A total of 11 sign structures were used in this project. Two of the structures were fabricated for previous TTI projects (Figure 9). These signs measure 12 ft x 9 ft and were used to simulate a shoulder-mounted guide sign on a freeway. Three sign structures were fabricated for this project (Figure 10). These signs measure 8 ft x 5 ft and were used to simulate destination and distance signs on conventional highways. The remaining six sign structures simulate county road name signs. The signs are 1 ft high in various lengths mounted on single sign poles (Figure 11).

Figure 9. Guide Sign Structures Used in the Study.

Figure 10. Destination/Distance Sign Structure.

Figure 11. County Road Name Sign.

All the sign structures were located on one of the runways and the accompanying taxiway at the Texas A&M University Riverside Campus. Figure 12 illustrates the arrangement of runways and taxiways at the Riverside Campus and the locations of the sign structures used in this experiment. The runways and taxiways are level and have no sight distance obstructions.

Sign Positioning

Signs were positioned in accordance with current TxDOT signing practices. The bottom of the guide signs were positioned 9 ft above the road surface and approximately 24 ft. from the travel lane. The destination distance signs were at a height of 7 ft from the road surface and approximately 18 ft from the travel lane. The county road name signs were also at a height of 7 ft from the road surface and 18 ft from the travel lane.

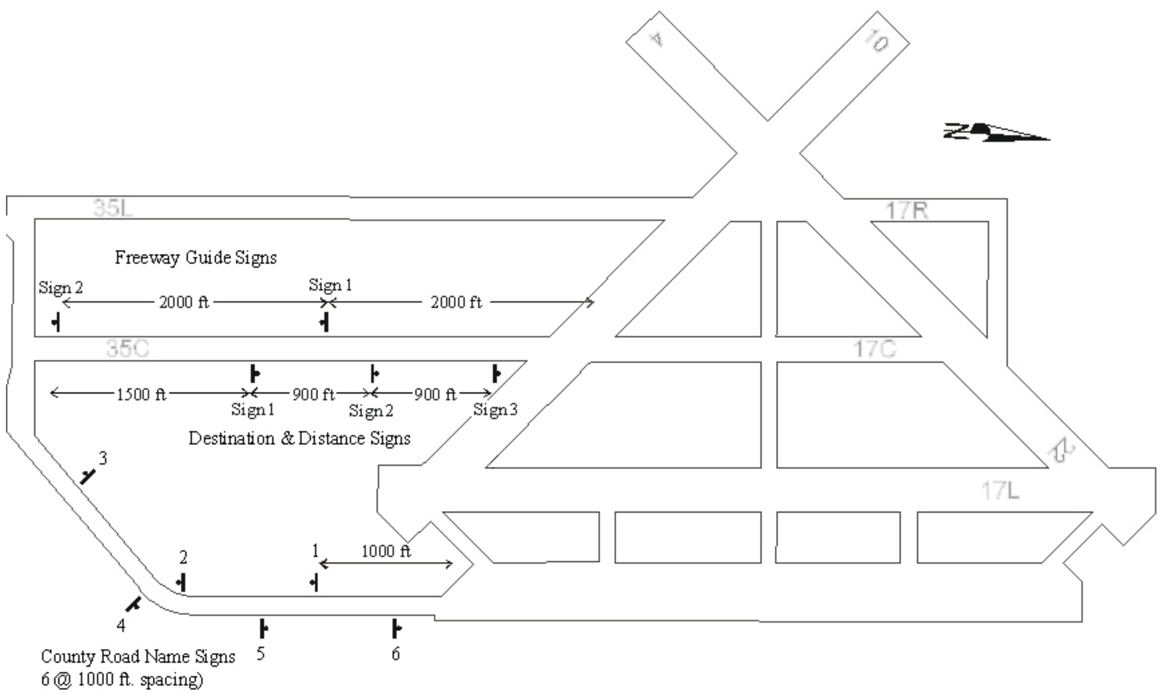

Figure 12. Runway Layout and Sign Structure Locations.

RESEARCH STIMULI

Test Words

A total of 78 unique words were used in this project. Several of the test words used were the same as used in previous TTI Clearview studies; however, the majority are new additions.

Also, with the exception of the six county road name signs, no words were repeated across the alphabet and sheeting combinations. Each word, alphabet, and sheeting combination was unique. Table 9 lists the words used for the highway guide sign signs. Table 10 lists the test words used for the destination/distance signs. Table 11 lists the words used for the county road name signs.

Table 9. Highway Guide Sign Test Words.

Alphabet	Neutral Words				Ascender/Descender Words			
Series E(M)	Person Honors Horses	Cancer Sensor Voices	Ounces Farmer Canoes	Nurses	Expect Gutter	Jacket Kettle	Carbon	
Clvw 5WR	Banner Oceans	Houses Prison	Nerves Corner	Burner Series	Basket Batter	Garden Raffle	Report Gasket	Gender
Clvw 5W	Senior				Putter	Battle		
Clvw 5WR2.	Poison	Career			Expert			

Table 10. Destination/Distance Sign Test Words.

6-inch Series D	6-inch Clvw 3W	8-inch Clvw 3W
CONWAY	BENTON	Dearborn
LYNNWOOD	BUTLER	Granite
PILLSBURY	ROCKFORD	Appleton
COOPERTON	WESTLAND	Spencer
LAKEWOOD	JEFFERSON	Hoover
DURANGO	LEONARD	Roseville
ROSEMEAD	BROCKTON	Burton
BONANZA	HANNAH	Calvin
CONCORD	SUNDOWN	Danville
HILLSVIEW	PALMDALE	Mound
ORANGE	BREWSTER	Basset
DALTON	PATERSON	Greenville
ANDERSON	ROCKWOOD	Shoreline
LEONA	PRESTON	Pioneer

Table 11. Test Words for County Road Name Signs.

4-inch Series D
LAKEWOOD
PATERSON
SUNDOWN
BENTON
LEONARD
BURTON

Sign Luminance

Sign luminance was varied by lowering the output of the test vehicle headlamps. This was accomplished using the device shown in Figure 8. The device uses a technique called pulse-width modulation to lower the output of the headlamps. This method applies full voltage to the headlamps at all times, but the voltage is interrupted at rapid and controllable rates. With the voltage turning on and off 2000 times per second, the ratio between the on time and the off time controls the brightness of the lamps. For example, if the voltage to the lamps was on for 50 microseconds (µs) and off for 450 µs, repetitively, the overall effect would be that the lamp is only receiving power for 10 percent of the time. Because of the high frequency, the eye perceives a reduced output instead of a flickering light.

DATA COLLECTION AND PROCESSING

Preparation

The researchers fabricated 138 signs for this evaluation. In addition, the three sign bases used to display the destination/distance signs were built and installed along the runway. Using the test words, the researchers generated a random display ordering for each driver. However, the researchers made an effort to have each word viewed only once and for each driver to see the same number and type of sheeting combinations (i.e., two Type IX on Type III signs, two Type VIII on Type III signs, etc.) and to achieve a minimum number of data points for each font and sheeting combination.

Table 12 and 13 illustrate the intent of the data collection effort. Subjects were recruited from Bryan/College Station and the surrounding counties. Table 14 lists the test subject demographics. The overall average age of the test subjects was 44, and the overall visual acuity was 20/22.

Table 12. Data Collection Goal for Guide Signs.

Sign Type	Alphabet	Background Sheeting	Legend Sheeting	Repetitions	
				Per Subject	Total
Shoulder-Mounted Guide Sign	Clvw 5W	Type IX	Type IX	2	60
	Clvw 5WR	Type III	Type III	2	60
			Type VIII	2	60
			Type IX	2	60
		Type IX	Type VIII	2	60
			Type IX	2	60
	Clvw 5WR2	Type IX	Type IX	2	60
	Series E(Modified)	Type III	Type III	2	60
			Type VIII	2	60
			Type IX	2	60
		Type IX	Type VIII	2	60
			Type IX	2	60

Table 13. Data Collection Goals for Destination/Distance Signs and County Road Name Signs.

<table>
<tr><th rowspan="2">Sign Type</th><th rowspan="2">Alphabet</th><th rowspan="2">Background Sheeting</th><th rowspan="2">Legend Sheeting</th><th colspan="2">Repetitions</th></tr>
<tr><th>Per Subject</th><th>Total</th></tr>
<tr><td rowspan="12">Destination/Distance Sign</td><td rowspan="4">6-inch Series D</td><td rowspan="3">Type III</td><td>Type III</td><td>4</td><td>48</td></tr>
<tr><td>Type VIII</td><td>2</td><td>24</td></tr>
<tr><td>Type IX</td><td>2</td><td>24</td></tr>
<tr><td>Type VIII</td><td>Type VIII</td><td>4</td><td>48</td></tr>
<tr><td rowspan="4">6-inch Clvw 3W</td><td rowspan="3">Type III</td><td>Type III</td><td>4</td><td>48</td></tr>
<tr><td>Type VIII</td><td>2</td><td>24</td></tr>
<tr><td>Type IX</td><td>2</td><td>24</td></tr>
<tr><td>Type VIII</td><td>Type VIII</td><td>4</td><td>48</td></tr>
<tr><td rowspan="4">8-inch Clvw 3W</td><td rowspan="3">Type III</td><td>Type III</td><td>4</td><td>24</td></tr>
<tr><td>Type VIII</td><td>2</td><td>24</td></tr>
<tr><td>Type IX</td><td>2</td><td>24</td></tr>
<tr><td>Type VIII</td><td>Type VIII</td><td>4</td><td>48</td></tr>
<tr><td rowspan="3">County Road Name Sign</td><td rowspan="3">4-inch Series C</td><td rowspan="3">Type III</td><td>Type III</td><td>2</td><td>60</td></tr>
<tr><td>Type VIII</td><td>2</td><td>60</td></tr>
<tr><td>Type IX</td><td>2</td><td>60</td></tr>
</table>

Table 14. Test Subject Goals.

Statistics	Young	Middle	Old
Age Group	18-34	35-54	55+
Sample Size	Male: 5 Female: 5	Male: 5 Female: 5	Male: 5 Female: 5

Execution

During the latter part of July 2003, the researchers made several pilot runs. During the pilot runs, the data collection procedure was refined and the road course was modified to better guide the subject (i.e., addition of cones for more positive guidance in turns). The pilot runs also provided the opportunity to train the all those involved, especially the coordination between the researcher in the vehicle and the technicians changing the test words between runs.

Starting the last week of July 2003 and continuing through the third week of August, researchers collected the nighttime legibility data. Researchers recruited 30 subjects to complete the project. Each subject required approximately one hour to complete the study.

Subjects were asked to arrive at the testing facility at approximately 8:30 PM, as data collection could not begin until approximately 9:00 PM each evening. While the course was being prepared for the evening's evaluation by the technicians, the researchers had each subject read and sign a consent form and take an eye exam. The researcher also explained the study and how it was to be conducted. The researchers conducted a binocular vision test using a Snellen visual acuity chart.

The researcher then drove the subject out to the runway road course. The subject moved to the driver's seat of the test vehicle and conducted one practice run around the road course to become familiar with the course layout. The layout is shown in Figure 13. The course was laid out using white retroreflective raised pavement markers (RRPMs). The starting point was located at the north end of the runway and was marked using orange traffic cones. The subject accelerated to 35 mph from the start point, following the delineated course. Maintaining a speed of 35 mph throughout the course, the subject then read the word displayed in the middle of each sign out loud. The researcher then recorded the distance traveled from the DMI readout. The subject saw the two guide signs first, made a U-turn, and then passed the three destination/distance signs. The road course was repeated twelve times.

Following completion of the runway road course, the researcher drove the subject to a taxiway road course. This course evaluated the county road name signs. The course was set up similarly to the first road course. RRPMs delineated the route and cones marked the starting points. Again, the subject started and accelerated to 35 mph. In this case there was only one word on each sign. The subject read three signs, made a U-turn, and lined up on a second set of cones. After the researcher had reset the DMI, the test resumed, and the subject read three more signs. At that point, the evaluation was completed. Subjects were compensated $40 for participating in the study.

In an effort to obtain the best experimental control possible, the test vehicle was dedicated exclusively to this project throughout the duration of the data collection activities. No other individuals were permitted to use the vehicle. The vehicle's windshield and headlamp lenses were cleaned each night. Furthermore, the test vehicle did not leave the Riverside Campus. These precautions were implemented to avoid the possibility of anything happening that might cause headlamp misalignment. In addition, each test subject received the same set of instructions, including directions not to guess at the legibility of a word. Rather, the subjects were informed only to respond when they were reasonably confident of their answer.

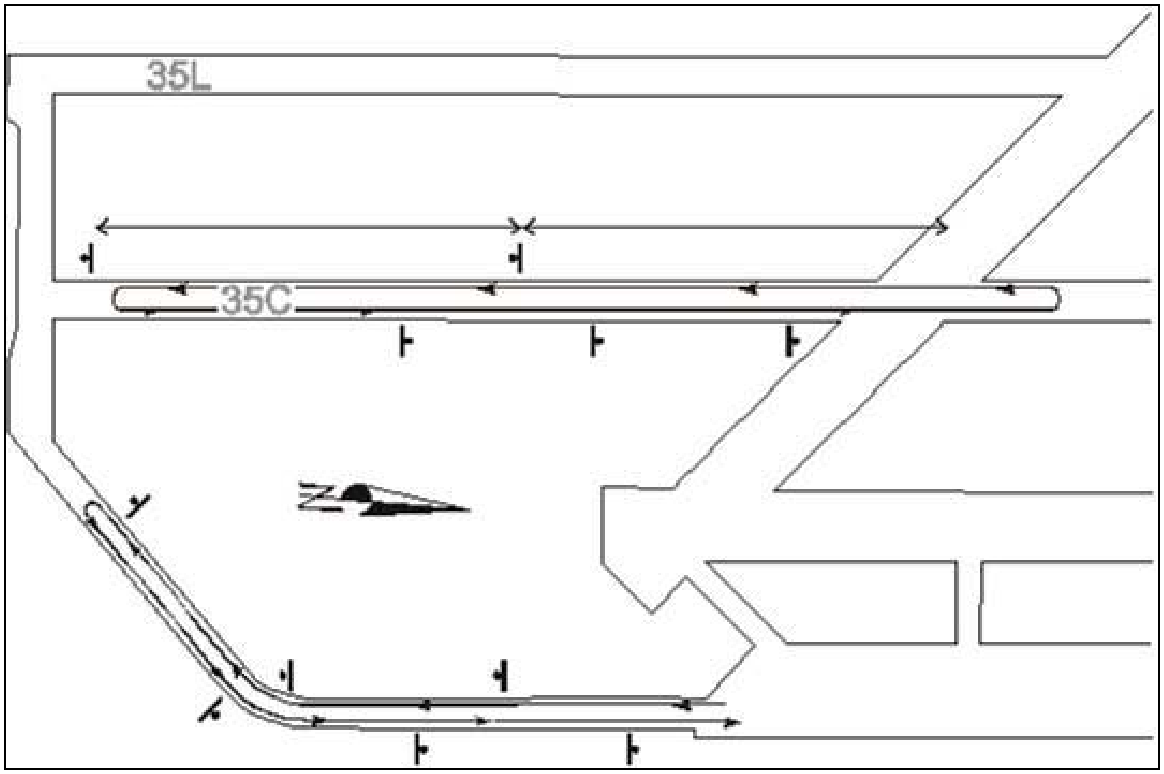

Figure 13. Road Course Layouts.

Data Reduction

The raw data from the DMI represented the distance from the starting point of the road course to the point where the subject correctly identified the word on the sign. In order to calculate the legibility distance, the course lengths were measured (from starting point to each sign location). The raw DMI data were then subtracted from the appropriate course length. This calculation results in the distance between the sign and the vehicle, at the point where the subject correctly identified the word. These are the legibility distances. In all, 1849 legibility distances were recorded throughout the project. These data represent the legibility of seven alphabets, three sign types, one vehicle, and three types of sheeting. Theoretically, 1980 legibility distances should have been recorded; however, the researchers elected to discard certain data points because of periodic subject inattentiveness while approaching the test signs (i.e., subject forgot to read the word or read the word at an unreasonably short legibility distance).

CHAPTER 5:
ANALYSIS AND RESULTS

SUBJECT DATA

Table 15 details the subject data for this project. Thirty subjects were recruited and completed this project. A total of 1849 observations were successfully recorded during the evaluation (out of 1980 possible).

Table 15. Subject Data.

Age	N	Male	Female	Average Visual Acuity*	Average Age
18-34	10	5	5	20/18	27
35-54	10	5	5	20/22	39
55+	10	5	5	20/25	66
Total	30	15	15	20/22	44

*Visual Acuity was measured with both eyes and with corrective lenses if worn for driving.

LEGIBILITY ANALYSIS FOR SHOULDER-MOUNTED FREEWAY GUIDE SIGNS

Two shoulder-mounted guide signs were used in the project. Each sign held one test word in the middle of the sign. In addition, a route marker and directional arrow were added to enhance the simulation of a guide sign on a freeway facility. The route marker and arrow were constant for each subject. A total of 713 observations were recorded.

Results

Appendix A contains the descriptive statistics of the data used in the analysis for the shoulder mounted freeway guide signs. Figure 14 and 15 are cumulative distribution plots of the data. Figure 14 compares the fonts evaluated in the study (across all ages, luminance levels, and sheeting combinations). Figure 15 compares the sheeting combinations evaluated (across all ages, fonts, and luminance levels).

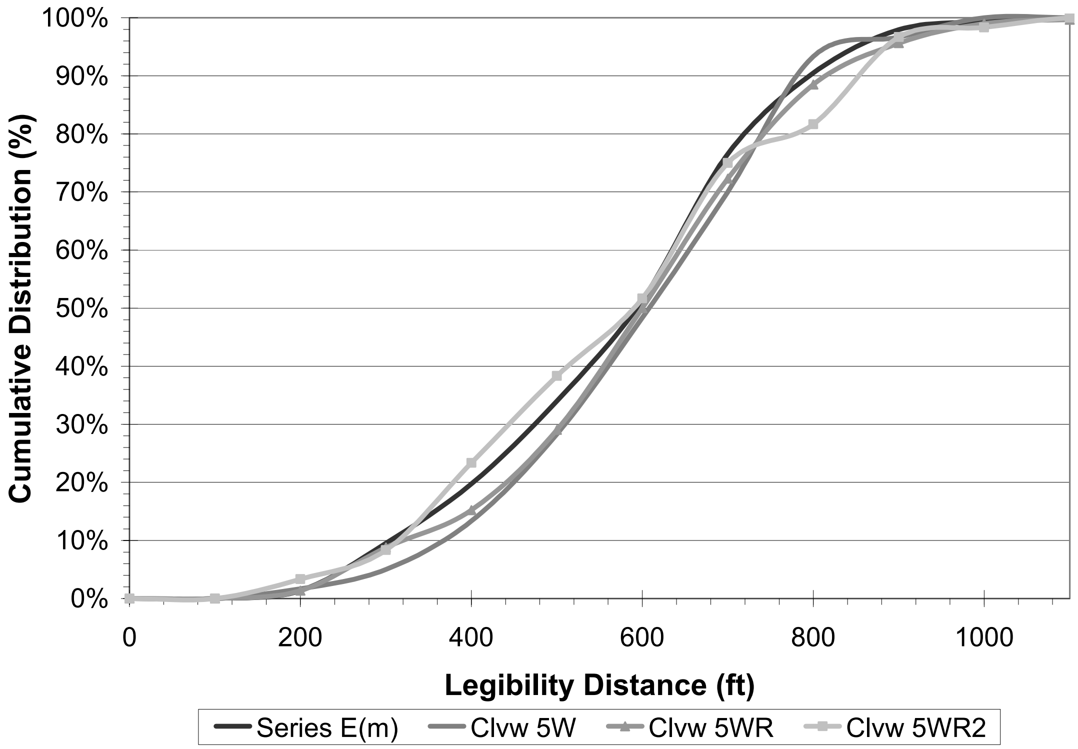

Figure 14. Cumulative Distribution Plot Comparing Fonts.

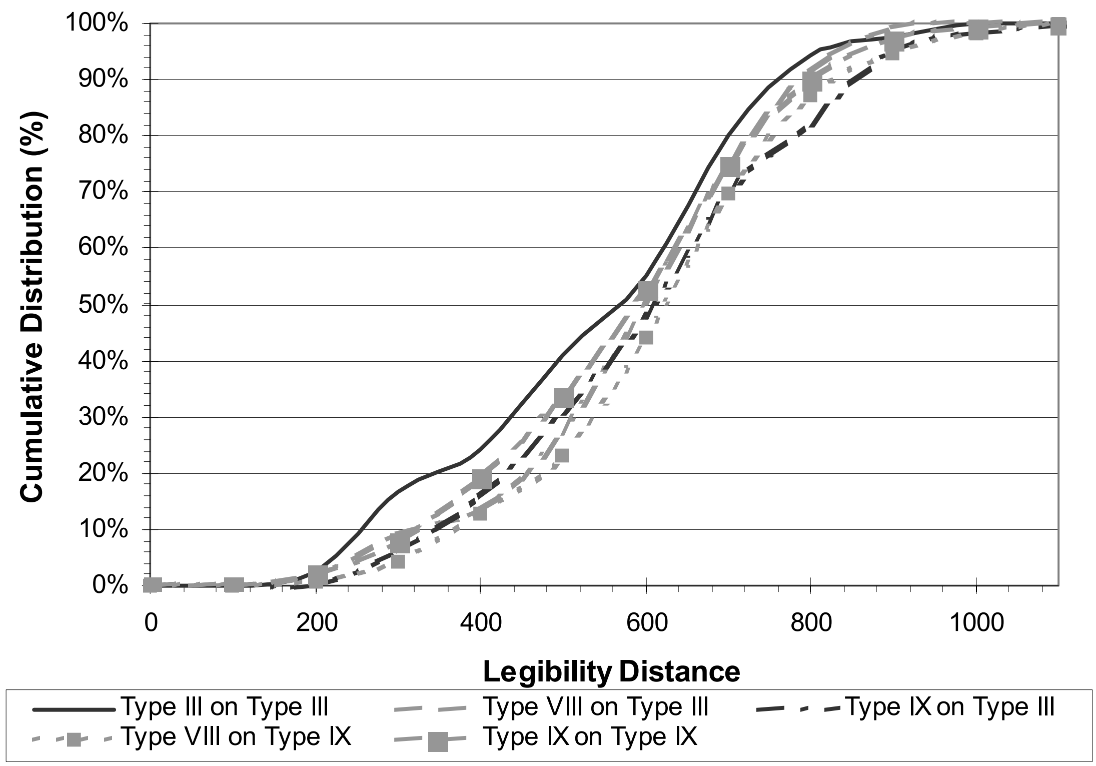

Figure 15. Cumulative Distribution Plot Comparing Sheeting Combinations.

Series E(Modified) vs. Clvw 5WR

One of the main objectives of this research was to determine if the customized reduced letter spacing of Clearview 5W (called Clearview 5WR) was at least but preferably more legible than Series E(Modified). To determine whether the differences identified in the descriptive statistics are meaningful, the researchers conducted a battery of statistical evaluations. The first statistical test was a mixed-factor repeated measures ANOVA. This test was performed to identify the differences between the traditional guide sign font, Series E(Modified) and the alternative font, Clearview 5WR. The statistical test used was a three-way, within-subjects repeated measures ANOVA with a between-subjects effect. The dependent factor was legibility distance. The independent factors were font, sheeting combination, luminance level, and subject age. The independent variables, font, sheeting combination, and luminance level, were within-subjects factors because all levels of all factors were presented to all subjects. Subject age was a between-subjects factor because each subject has one and only one age. The PROC GLM command with the REPEATED option was used in the SAS software package to produce the ANOVA table shown in Table 16.

Table 16. ANOVA Table for Freeway Guide Signs.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age group	2	6734234.488	3367117.244	16.87	<.0001
Error	27	5388205.146	199563.154		
Font	1	79117.4592	79117.4592	10.89	0.0027
Font*age group	2	14044.5865	7022.2933	0.97	0.393
Error(Font)	27	196093.9525	7262.739		
Luminance	1	437836.4658	437836.4658	50.7	<.0001
Luminance*age group	2	92852.0884	46426.0442	5.38	0.0108
Error(Luminance)	27	233189.1081	8636.6336		
Sheeting	4	369805.7893	92451.4473	10.54	<.0001
Sheeting*age group	8	64220.5545	8027.5693	0.92	0.5066
Error(Sheeting)	108	946927.3466	8767.8458		
Font*Luminance	1	10534.5106	10534.5106	1.17	0.2884
Font*Luminance*age group	2	157.827	78.9135	0.01	0.9913
Error(Font*Luminance)	27	242500.2466	8981.4906		
Font*Sheeting	4	8526.8047	2131.7012	0.34	0.8487
Font*Sheeting*age group	8	78700.9612	9837.6201	1.58	0.139
Error(Font*Sheeting)	108	672202.2452	6224.0949		
Luminance*Sheeting	4	157164.0741	39291.0185	4.94	0.0011
Luminance*Sheeting*age group	8	88839.3243	11104.9155	1.39	0.2068
Error(Luminance*Sheeting)	108	859752.1926	7960.6684		
Font*Luminance*Sheeting	4	35070.914	8767.729	0.86	0.4881
Font*Luminance*Sheeting*age group	8	108983.536	13622.942	1.34	0.2304
Error(Font*Luminance*Sheeting)	108	1095823.65	10146.515		

One of the main objectives of this project was to determine the performance difference between guide signs with Series E(Modified) legends and legends made with the revised version of Clearview 5W (Clearview 5WR, the version that was tweaked to produce approximately the same length words as Series E(Modified)). From the ANOVA table (Table 16), it can be seen that the difference in legibility distances by font style were statistically significant ($F_{1,27} = 10.89$, $p = 0.0027$). In other words, the increased legibility distances associated with the Clearview 5WR font (overall Clearview 5WR average equals 593 ft compared to 570 ft for Series E(Modified)) were statistically significant. Figure 16 shows the legibility distances by subject age group.

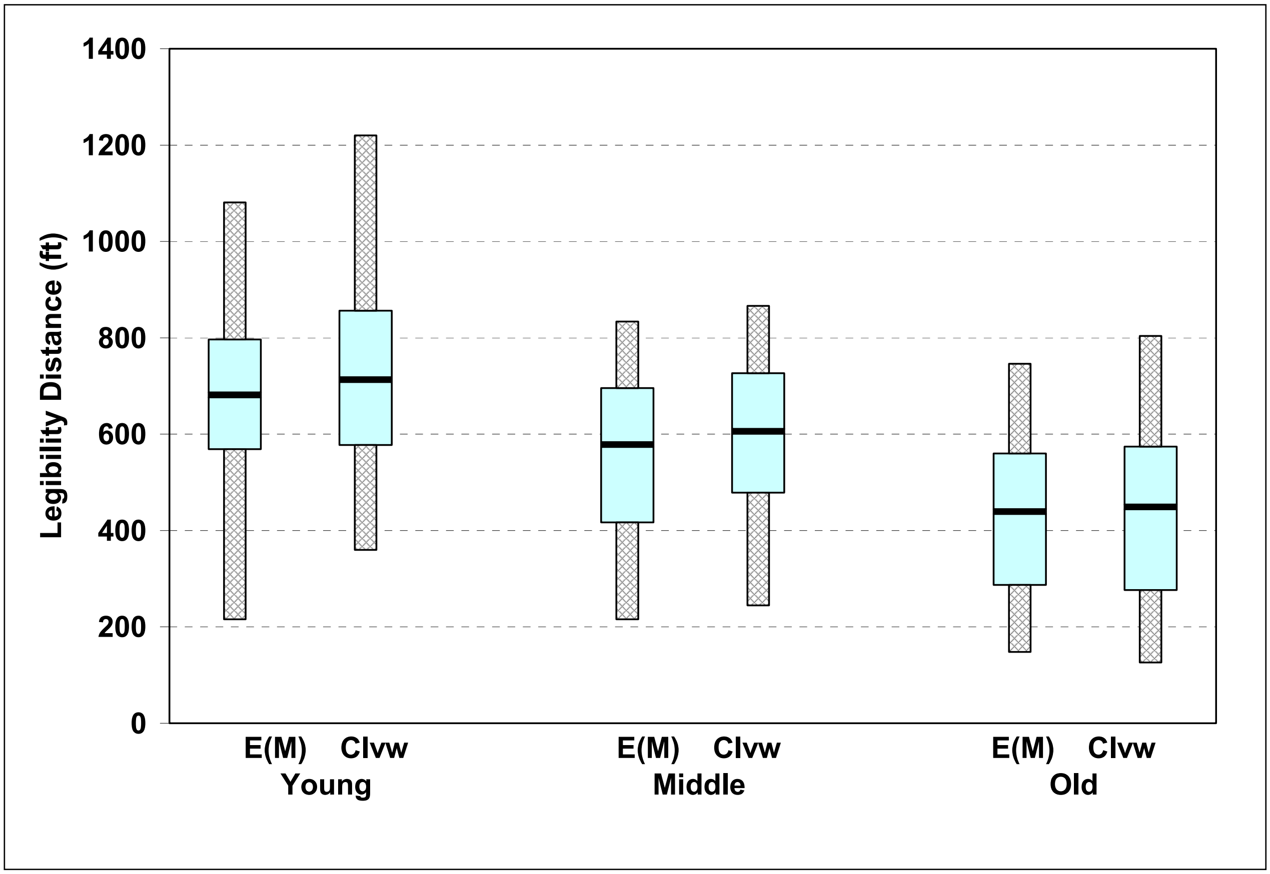

Figure 16. Box Plots Font Results for Freeway Guide Signs.

Figure 16 shows the Clearview 5WR font outperformed Series E(Modified) for all three age groups. It is also evident that the participants in the young age group (overall average legibility distance equals 713 and 682 ft for Clearview 5WR and Series E(Modified), respectively) were able to read the signs from further than the participants in the middle age group (overall average legibility distance equals 606 and 578 ft for Clearview 5WR and Series E(Modified), respectively) who were able to read the signs from further than the participants in the old age group (overall average legibility distance equals 449 and 440 ft for Clearview 5WR and Series E(Modified), respectively). In terms of legibility indices, by age group the overall means equate to 44 ft/inch for the young age group, 37 ft/inch for the middle age group, and 28 ft/in for the old age group. This finding is consistent with the literature findings.

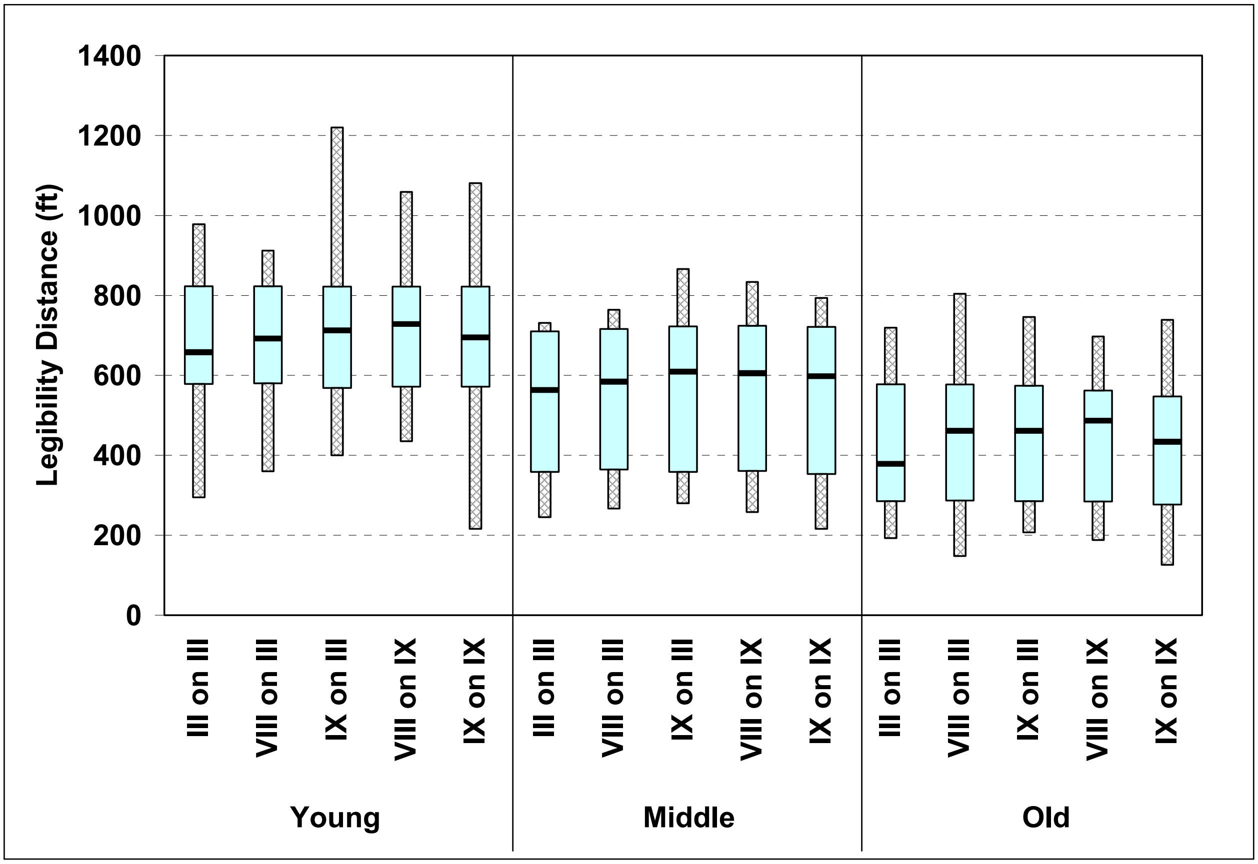

Figure 17. Box Plots Sheeting Results for Freeway Guide Signs.

Figure 17 shows the impact of sheeting on the legibility distances. Like the previous findings, the results are categorized by age group. One of the most evident findings shown in Figure 17 is the increased legibility distances within each age group for all combinations of sheeting compared to Type III on Type III. More focused analyses and discussions of the impacts of various retroreflective sheeting combinations are provided later.

The researchers also wired the headlamps so that the subjects would see two different luminance levels, depending on which run they were on. This was done by controlling the headlamp luminous intensity. The "high" condition was the headlamps operating under normal low-beam conditions. The "low" position was approximately 27 percent of the "high" position. The difference in the illumination of the headlamps produced the most statistically significant difference in legibility distances ($F_{1,27} = 50.70$, $p \leq 0.0001$) but as Figure 17 shows, the impact on legibility distance is not nearly as drastic as expected based on the difference in the headlamp illumination.

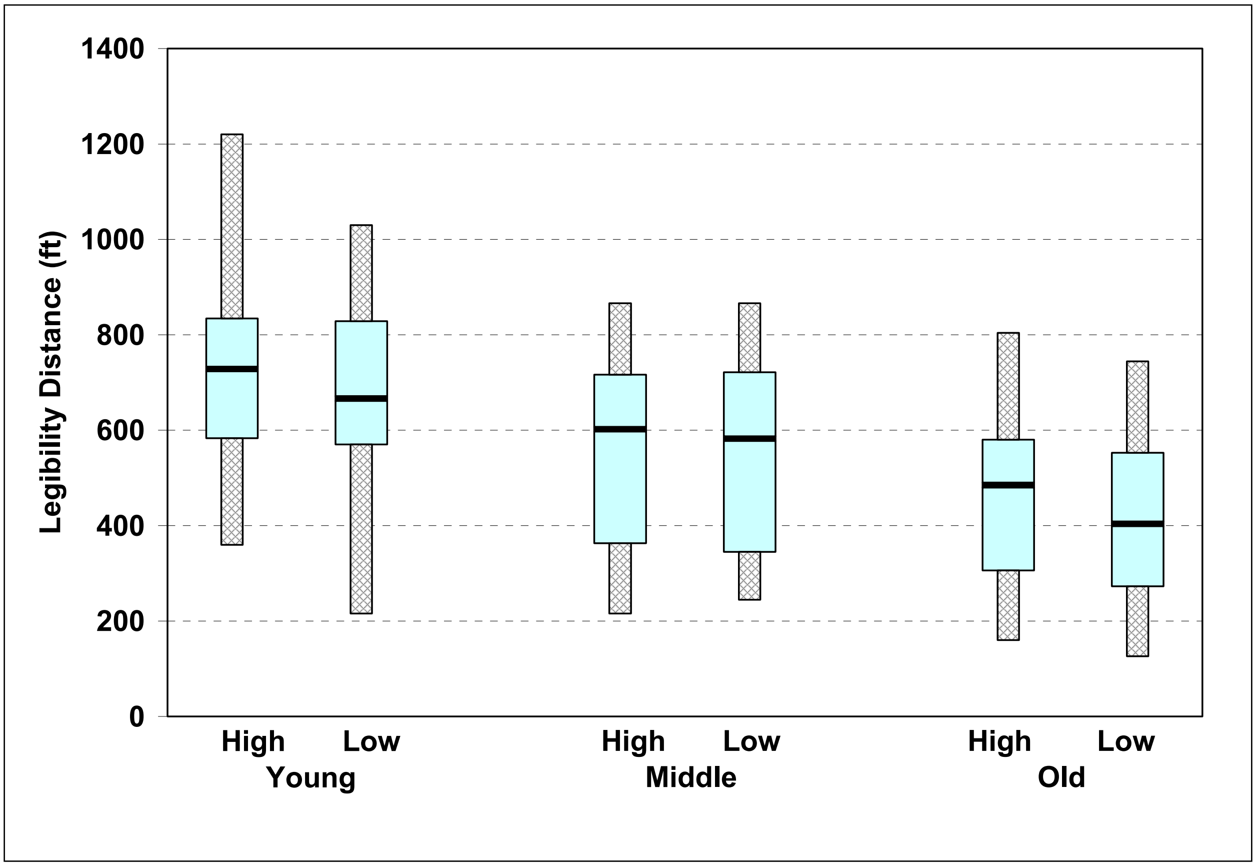

Figure 18. Box Plots Luminance Results for Freeway Guide Signs.

Figure 18 shows that the test subjects were able to read the sign at a greater distance when the test vehicle was operated with the low beams on full power (shown as "high" in Figure 18). The mean legibility distances by age group for the "high" condition were 728 ft for the young age group, 602 ft for the middle age group, and 485 ft for the old age group. For the "low" condition, the mean legibility distances were 666 ft for the young age group, 582 ft for the middle age group, and 404 ft for the old age group. The percent decrease in mean legibility distance by age group equates to 8.5 percent for the young age group, 3.3 percent for the middle age group, and 16.7 percent for the old age group. In comparison, the percent decrease in headlamp flux from the "high" to "low" position was 72 percent. Therefore, while the amount of headlamp flux was significant, and it was most evident with the older age group, its relationship with legibility performance is not a 1:1 scale. Using an overall average decrease in legibility performance (across all age groups) of 9.5 percent, and for the conditions studied herein, a trading ratio of approximately 7.5 results from the analysis of the data. This trading ratio means that for every 7.5 percent decrease in headlamp illumination, the resulting legibility decrease will be only 1 percent. This may be useful information in terms of determining the impacts of headlamp aiming and the need for mandatory aiming inspections as part of the state's annual vehicle inspection requirement.

The only statistically significant interaction was between the luminance level and the various combinations of retroreflective sheeting ($F = 4.94$, $p = 0.0011$). This interaction is shown in Figure 19 using the contrast ratio created by the use of different retroreflective sheetings for the legend versus the background.

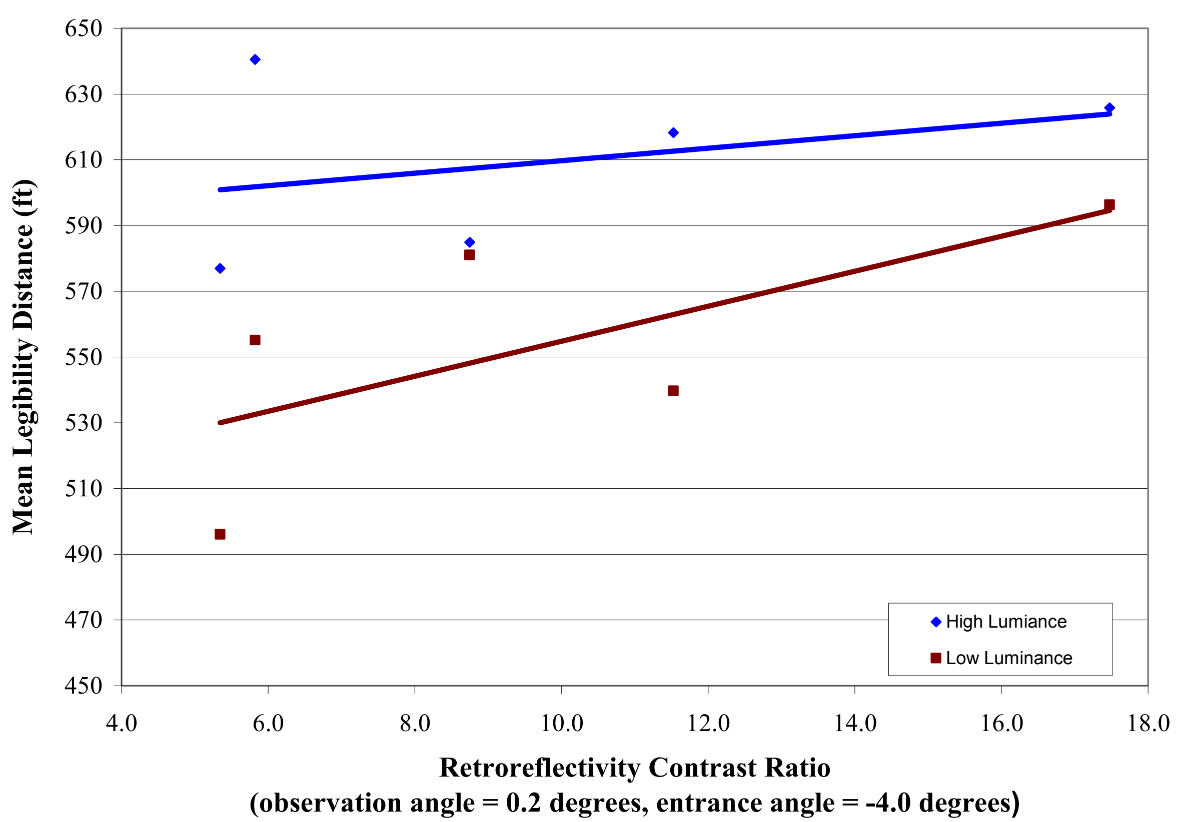

Figure 19. Interaction of Luminance with Sheeting Type for Freeway Guide Signs.

The contrast ratios for Figure 19 were created by dividing the retroreflectivity of the white legend by the retroreflectivity of the green background. They are based on the various retroreflective sheeting legend/background combinations used for the guide sign portion of this study. These combinations include (with each respective contrast ratio): Type III on Type III (5.3), Type IX on Type III (8.7), Type IX on Type IX (5.8), Type VIII on Type III (17.4), and Type VIII on Type IX (11.5). Figure 19 demonstrates the strong nature of the interaction.

However, possibly the most revealing finding is that under the high luminance conditions (i.e., normal low-beam illumination), the contrast ratio of the sign is less important than under low luminance conditions. Under low luminance conditions, higher contrast ratios clearly produce longer legibility distances. This correlates with a 1993 research study performed by Mace, Garvey, and Heckard (*9*). Mace observed no difference in the legibility of signs with ratios from 10:1 to approximately 40:1. The research also found that luminance levels could be increased without a negative effect on legibility as long as a "reasonable" contrast ratio was maintained. Mace suggests a contrast ratio of 4:1 to 15:1 for fully retroreflective positive contrast signs and indicates that a ratio as high as 1:50 is acceptable. The signs used in this study fall within the reasonable range. Mace also found that large contrast ratios (over 100) could have a negative effect on legibility.

One of the caveats of this analysis is that the combination of different retroreflective materials actually produces different contrast ratios as a function of distance to the sign. Therefore, one contrast ratio does not completely describe the range or variation in contrast ratio as the test subjects approached the signs. In order to keep this analysis relatively simple, the researchers based the contrast ratio on measurements made at 640 ft, equating to a legibility index of 40 ft/inch, which is suggested as a design parameter in the Manual on Uniform Traffic Control Devices (MUTCD). The criterion of 40 ft/inch is slightly higher than the grand overall performance mean of the subjects (36 ft/inch).

The researchers also recorded the luminance of the Type III legend material. Using an LMT1009, the researchers took several measurements from the driver's position while the test vehicle was parked 640 ft from the sign. Under the "high" condition the white Type III material measured 13.0 cd/m^2 and under the low condition the same material measured 3.6 cd/m^2.

The practicality of sign design, however, is that the headlamp illumination cannot be controlled beyond the boundaries set by National Highway Traffic Safety Association (NHTSA) in *FMVSS108* (*10*). Even so, *FMVSS108* allows for a wide variety of headlamp designs, which lead to a wide variety of headlamp performances. Research has also shown that there are a significant number of headlamps out of proper alignment (*11*, *12*). Zwahlen, Miller, and Yu determined an average horizontal misaim value of 0.23 inches (s = 4.2) for driver side, low beam lamps and -0.19 inches (s = 4.0) for passenger side, low beam lamps. Vertical misaim values were 0.62 (s = 4.7) and 0.91 inches (s = 4.7) for driver side and passenger side lamps, respectively (*12*). Zwahlen, Miller, and Yu also found that the detrimental effect of misaimed headlamps could be offset by the use of brighter reflective materials. The good news is that the font and sheeting are factors that the traffic engineer has some control over. Therefore, the natural question that a traffic engineer may ask is what font and sheeting provide the best overall performance? In order to move forward with this line of thinking, the next statistical test is based on the assumption that the Clearview 5WR font is chosen over the traditional Series E(Modified) because of the proven increased performance as shown above. The remaining issue would be what kind of sheeting could be used to get the maximum performance of the Clearview 5WR font. In order to determine the best sheeting combinations, the researchers eliminated all guide sign observations with Series E(Modified) words. They also collapsed the data across subject age and luminance level (factors beyond the control of the traffic engineer). The statistical test called the Duncan multiple range was then performed on the data. The results are shown in Table 17.

Table 17. Duncan Multiple Range Test for Sheeting.

Retroreflective Sheeting Combination	Mean Legibility (ft)	Duncan Grouping (α=0.05)	
VIII on IX	626.4	■	
IX on III	602.4	■	
IX on IX	595.4	■	■
VIII on III	591.5	■	■
III on III	549.9		■

The shaded cell groups on the columns labeled Duncan Grouping indicate legibility means that are not statistically different. The results show that signs with microprismatic legends (only Types VIII and IX were tested in this study) perform statistically better than the signs with Type III legends. They also show that the signs made with microprismatic backgrounds performed statistically similarly to signs made with high-intensity backgrounds. The results also show that there are no statistical differences between the legibility distances associated with any of the signs made with microprismatic legends. Therefore, in order to maximize guide sign legibility distances, the data show that the font style should be Clearview 5WR and the retroreflective sheeting for the green background should be Type III and for the white legend it should be a microprismatic material (Type D according to TxDOT specifications).

Series E(Modified) vs. Clvw 5W vs. Clvw 5WR vs. Clvw 5WR2

A small study was incorporated into the overall project design so that the legibility differences between three different versions of Clearview 5W could be compared to Series E(Modified). The versions of the 5W that were studied include the conventional 5W, a reduced letter spacing 5W equivalent to about a 6.4 percent reduction (called 5WR in this report), and an intermediate reduced letter spacing 5W equivalent to about a 3.2 percent reduction (called 5WR2 in this report). This portion of the study did not include mixed retroreflective sheeting. All of the signs were fabricated with Type IX legends and backgrounds. However, all 30 of the subjects viewed each font type twice, once with the test vehicle low beams at full power and again with the test vehicle low beams at 27 percent of full power. The order of the signs was randomized and so was the illumination order of the headlamps.

An ANOVA test showed that the type of font was not statistically significant in this part of the study ($F_{3,225} = 1.95$, $p = 0.1225$) using the standard significance criteria of alpha = 0.05. However, further testing using the Duncan multiple range test shows a difference between the fonts (see Table 18).

Table 18. Duncan Multiple Range Test for Font.

Font	Mean Legibility (ft)	Duncan Grouping (α=0.05)	
Clearview 5W	592.9	■	
Clearview 5WR	590.8	■	
Clearview 5WR2	578.2	■	■
Series E(Modified)	539.4		■

The results of the Duncan test show that all three versions of the Clearview font performed the same from a statistical viewpoint and that they all outperformed the traditional guide sign font, Series E(Modified). The widest version of the Clearview font (5W) performed the best with an overall average legibility distance of 593 ft and the narrowest version of the Clearview font (5WR) performed nearly the same, with an average legibility distance of 591 ft. Interestingly, the intermediate width version of the Clearview font (5WR2) was outperformed by the narrowest version (5WR) by 13 ft. However, these differences were not found to be statistically different and only amount to approximately a 2 percent difference. The main point is that the Clearview 5WR font outperformed the traditional guide sign font, Series E(Modified).

LEGIBILITY ANALYSIS FOR DESTINATION/DISTANCE SIGNS

As previously stated, three destination/distance signs were fabricated. Each sign held three words. The middle word on each sign was the test word for the study. The top and bottom words remained constant. A total of 929 sign observations were collected.

Results

Appendix B contains the descriptive statistics of the data used in the analysis for the destination and distance signs. Figure 20 and 21 are cumulative distribution plots of the data. Figure 20 compares the fonts evaluated in the study (across all ages, luminance levels, and sheeting combinations) and Figure 21 compares the sheeting combinations evaluated (across all ages, fonts, and luminance levels).

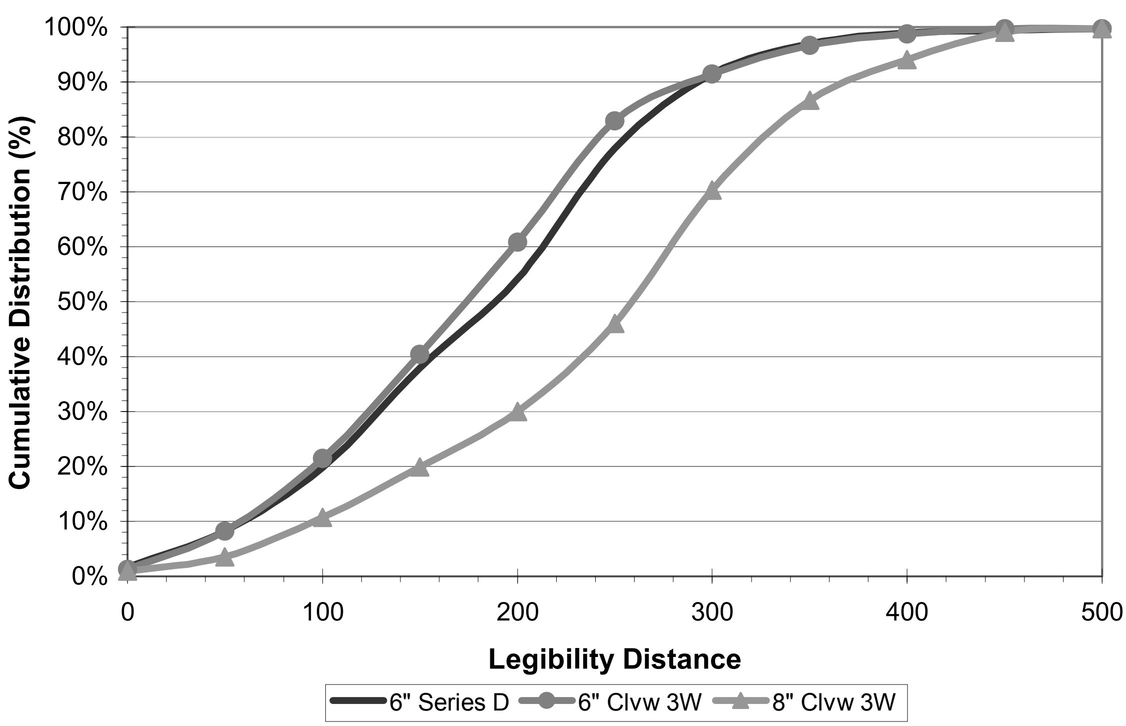

Figure 20. Cumulative Distribution Plot Comparing Fonts for Destination and Distance Signs.

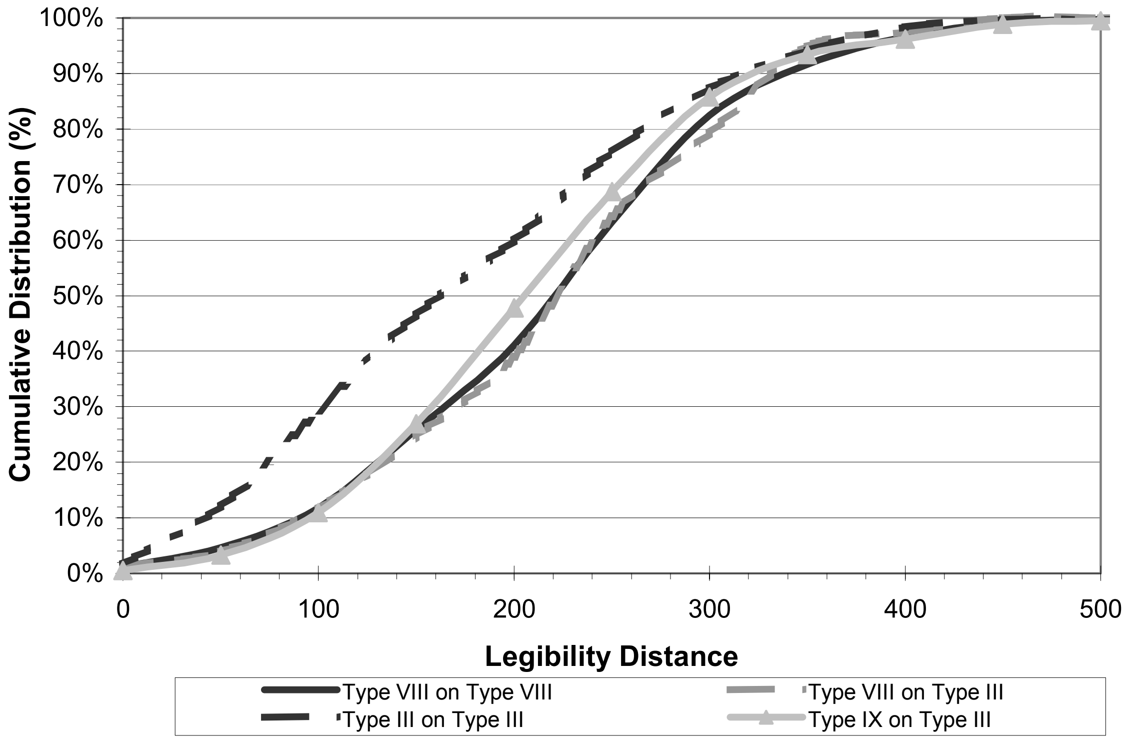

Figure 21. Cumulative Distribution Plot Comparing Sheeting Combinations for Destination and Distance Signs.

Destination Analysis

The data for the destination and distance signs were analyzed using the same approach as for the guide signs. One of the main objectives was a study of the impacts of the three different font styles. The mean legibility differences among the font styles were shown to be statistically significant (F = 112.37, $p \leq 0.0001$). The results are shown in Figure 22 by age group.

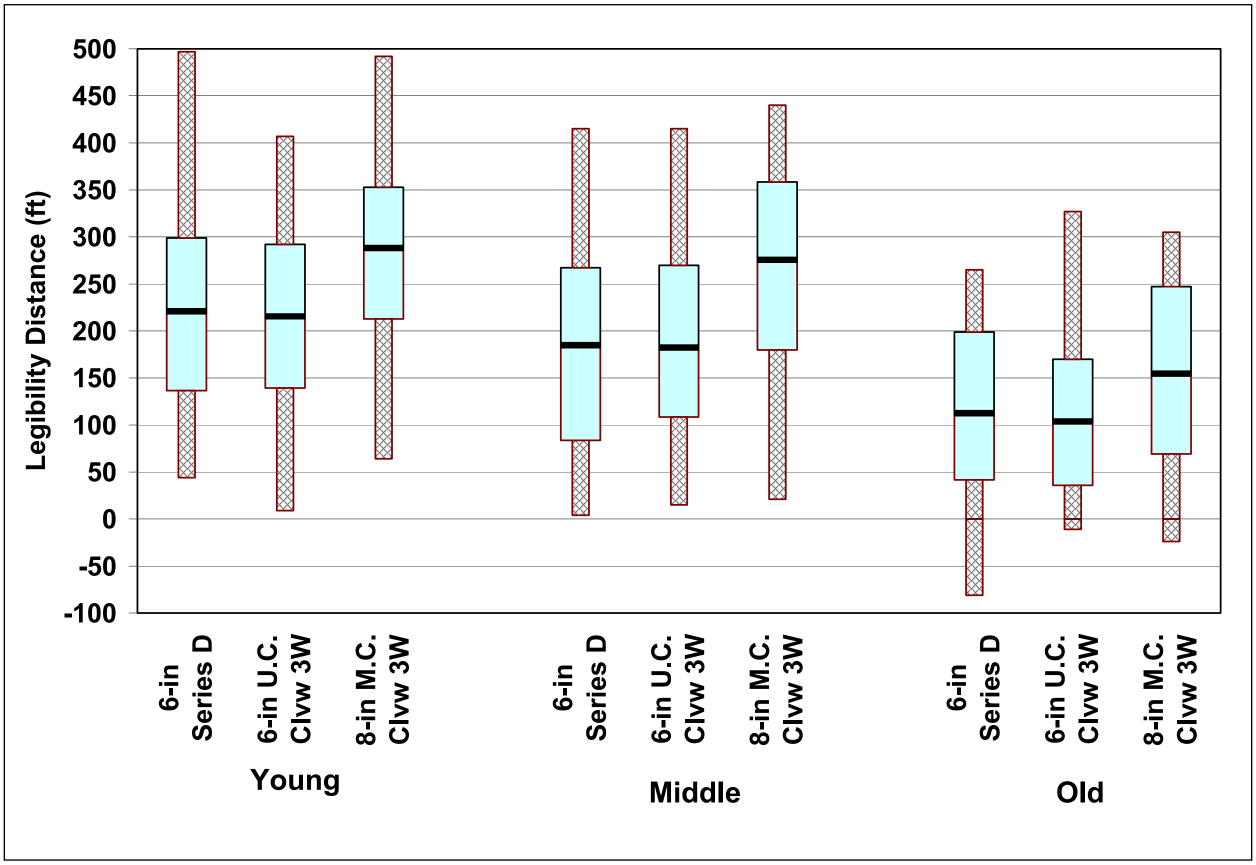

Figure 22. Box Plots Sheeting Results for Destination/Distance Signs.

The mean legibility distances show that legibility with the 6-inch uppercase Clearview 3W was slightly lower than the 6-inch Series D for each age group (215 to 211 ft for the young age group, 205 to 176 ft for the middle age group, and 104 to 113 ft for the young age group). The mean legibility distances of the 8-inch mixed-case Clearview 3W were much higher (288 ft for the young age group, 290 ft for the middle age group, and 155 for the old age group). These legibility distances equate to legibility indices of 36 ft/inch for the young age group, 34 ft/inch for the middle age group, and only 19 ft/inch for the older age group. The grand overall legibility index for the 8-inch mixed-case Clearview 3W was 30 ft/inch.

Additional statistical testing was completed using the Duncan multiple range test to determine the statistical differences between the mean legibility distances of the three font styles. Table 19 summarizes the results of this test.

Table 19. Duncan Multiple Range Test for Font.

Font	Mean Legibility (ft)	Duncan Grouping (α=0.05)	
8-inch mixed-case Clearview 3W	243.3	■	
6-inch Series D	180.3		■
6-inch uppercase Clearview 3W	173.1		■

The results of the Duncan multiple range test show that the 8-inch mixed-case Clearview 3W font significantly outperformed the other two font styles. This is not surprising because the font was 2 inches taller than the other two and was a mixed-case font, while the others were all uppercase. All three fonts produced approximately equal legibility indices of 30 ft/inch. However, if the testing protocol had emphasized recognition rather than legibility, it could be expected that the mixed-case font would show an increased performance over the all-uppercase fonts (because of word recognition aided by the footprint of words with descenders and ascenders) *(9)*. Because drivers search for particular destinations rather than reading unknown destinations as in the case of the study protocol used to obtain the data presented herein, and because there is no standardized legibility differences between the mixed-case and uppercase fonts, TxDOT should strive to use 8-inch mixed-case Clearview 3W where space permits and as a minimum TxDOT should use 8-inch mixed-case Clearview 3W on their destination and distance signs.

As with the guide sign portion of this study, the high and low luminance levels produced a statistically significant difference in the mean legibility distances ($F = 42.33$, $p \leq 0.0001$). The difference between the “low” and "high" positions remained the same as before (i.e., low = 27 percent of high). Like before, Figure 23 shows that the impact on legibility distance is not nearly as drastic as expected based on the difference in the headlamp illumination.

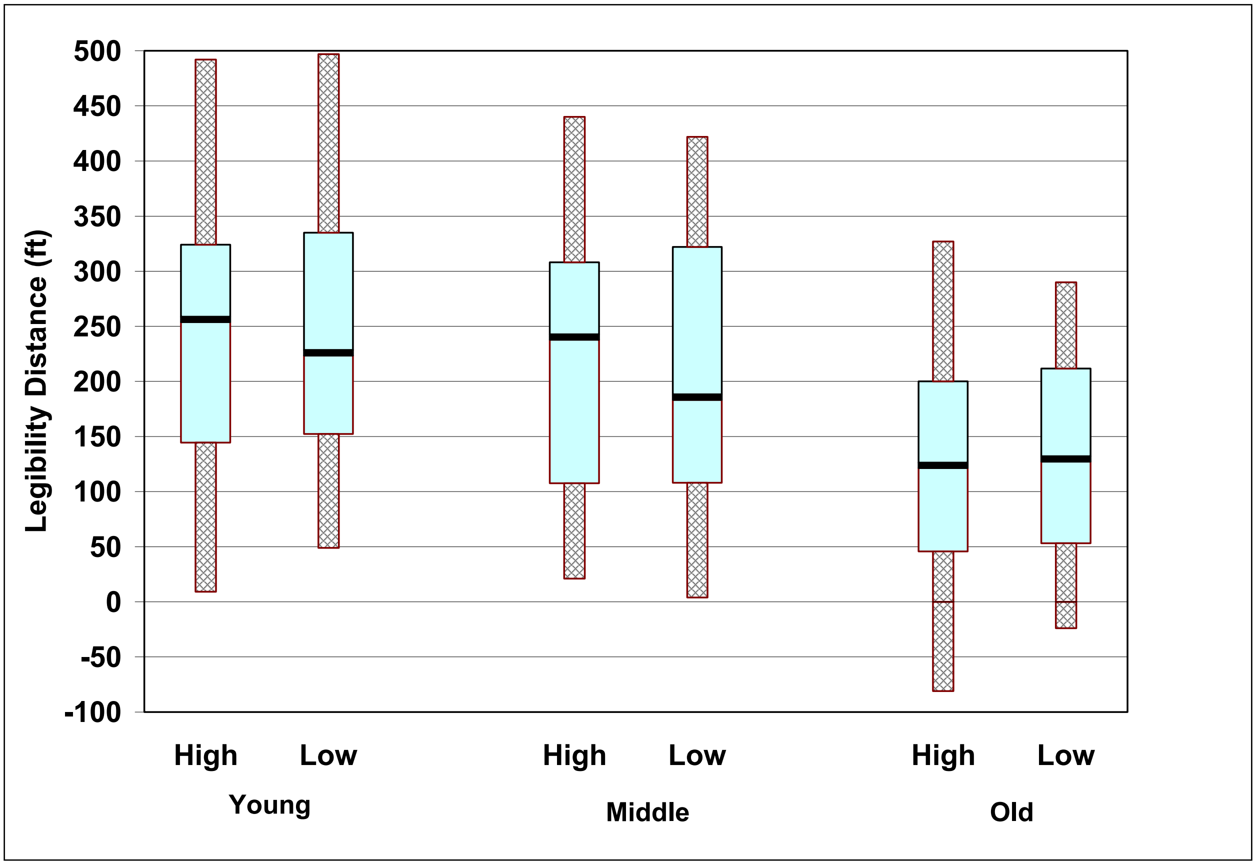

Figure 23. Box Plots Comparing Luminance for Destination and Distance Signs.

The mean legibility distances by age group for the "high" condition were 256 ft for the young age group, 240 ft for the middle age group, and 124 ft for the old age group. For the "low" condition, the mean legibility distances were 226 ft for the young age group, 186 ft for the middle age group, and 130 ft for the old age group. The percent decrease in mean legibility distance by age group equates to 11.8 percent for the young age group, 22.7 percent for the middle age group, and -4.6 percent for the old age group. In comparison, the percent decrease in headlamp flux from the "high" to "low" position was 72 percent. Therefore, while the amount of headlamp flux was significant, and it was most evident with the older age group, its relationship with legibility performance is not a 1:1 relationship. Using an overall average decrease in legibility performance (across all age groups) of 9.5 percent, and for the conditions studied herein, a trading ratio of approximately 7.5 results from the analysis of the data. This trading ratio means that for every 7.5 percent decrease in headlamp illumination, the resulting legibility decrease will be only 1 percent. This may be useful information in terms of determining the impacts of headlamp aiming and the need for mandatory aiming inspections as part of the states annual vehicle inspection requirement.

The combinations of retroreflective sheeting used on the destination and distance signs were also found to be significant ($F = 38.95$, $p \leq 0.0001$). Figure 24 shows the impact of sheeting on the legibility distances (categorized by age group).

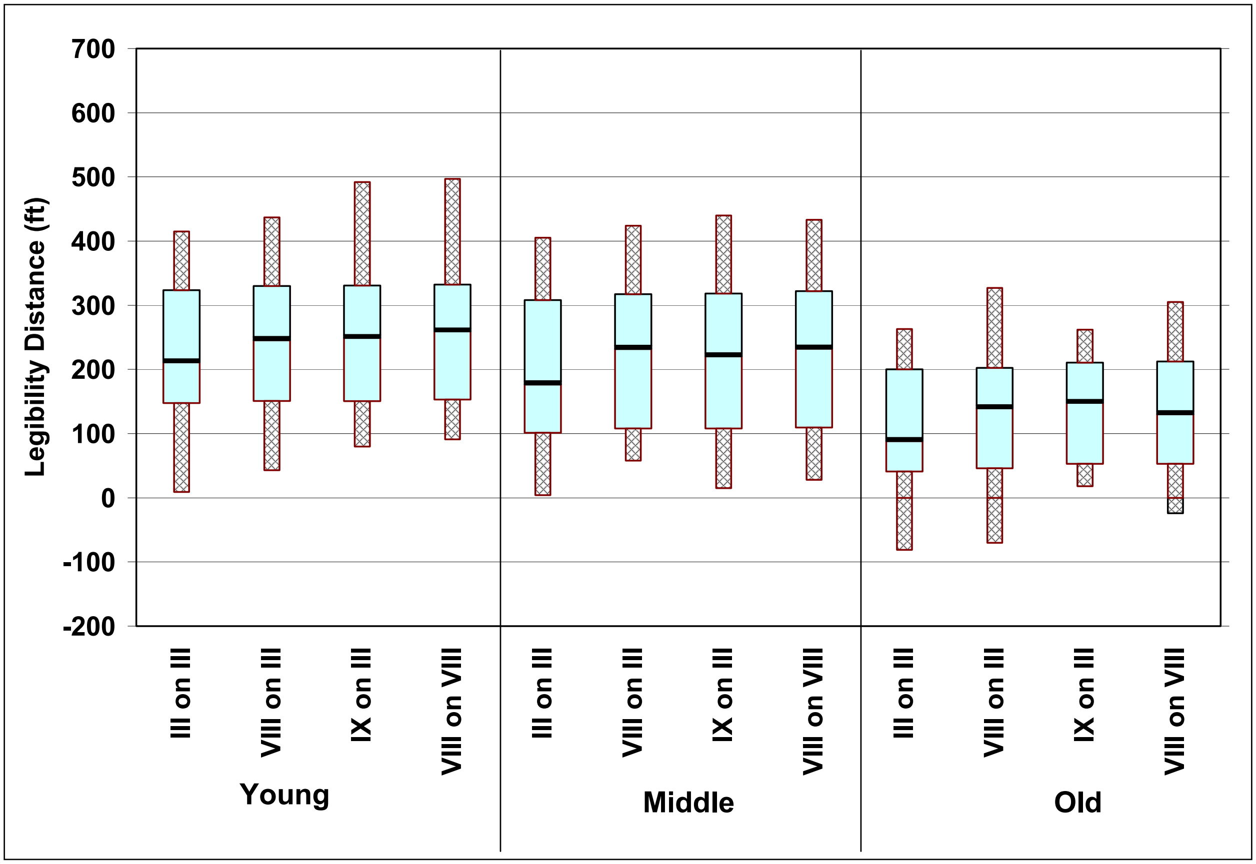

Figure 24. Box Plots for Sheeting Combination for Destination/Distance Signs.

Just as with the findings associated with the guide signs, one of the most evident findings revealed by Figure 24 is the increased legibility distances within each age group for all combinations of sheeting compared to Type III on Type III. The overall sheeting impacts were tested using the Duncan multiple range test and the results are shown in Table 20.

Table 20. Duncan Multiple Range Test for Sheeting Combination.

Retroreflective Sheeting Combination	Mean Legibility (ft)	Duncan Grouping (α=0.05)	
VIII on VIII	216.4	■	
VIII on III	215.2	■	
IX on III	208.4	■	
III on III	169.9		■

Overall, the results in Table 20 show that the destination signs made with prismatic legends produced significantly longer legibility distances than the destination signs made with Type III legends. The results also show that destination signs made with prismatic backgrounds and prismatic legends perform the same as destination signs made with Type III backgrounds and prismatic legends. This is an important finding as the cost of the prismatic retroreflective materials can be over twice the cost of Type III retroreflective materials. In this regard, the researchers caution against using combinations such as Type IX on Type VIII.

Interestingly, the only significant interaction ($F = 2.83$, $p = 0.0375$) among the main effect variables was sheeting by luminance level (just as before with the guide signs). The interaction is shown graphically in Figure 25.

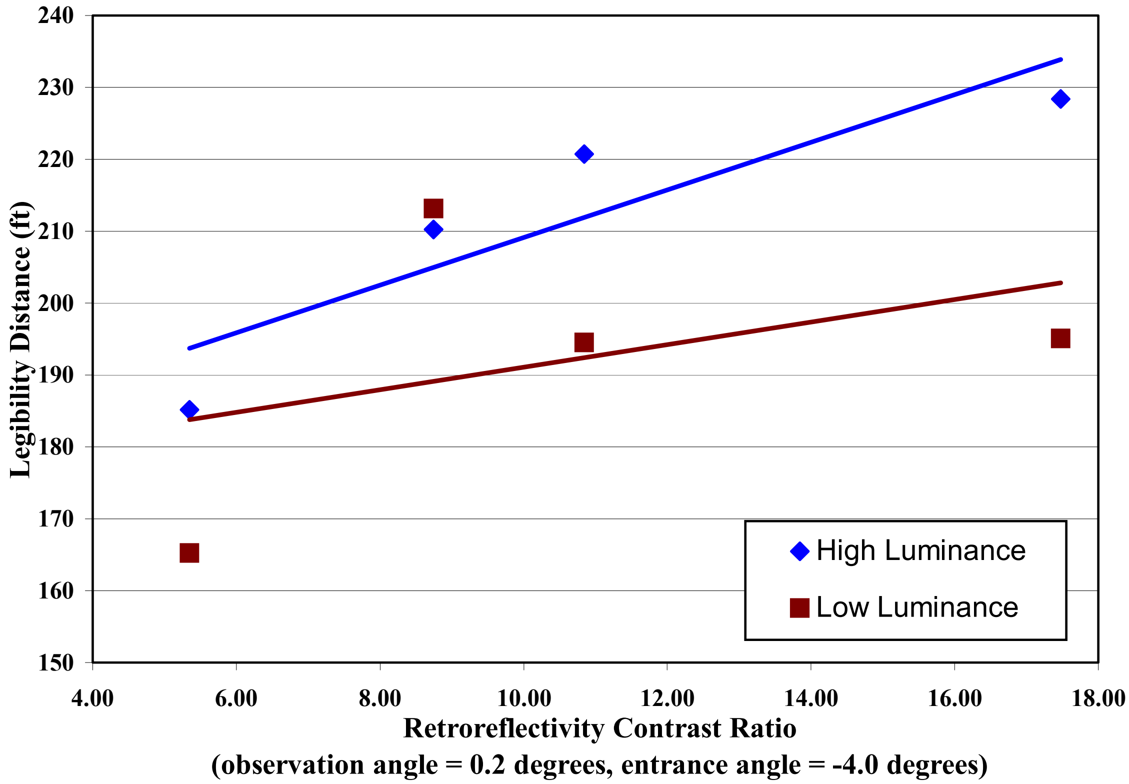

Figure 25. Luminance and Sheeting Type Interaction for Destination/Distance Signs.

The contrast ratios for Figure 25 were created by dividing the retroreflectivity of the white legend by the retroreflectivity of the green background. They are based on the various retroreflective sheeting legend/background combinations used for the destination sign portion of this study. These combinations include (with each respective contrast ratio): Type III on Type III (5.6), Type IX on Type III (8.4), Type VIII on Type VIII (10), and Type VIII on Type III (15.6). Like Figure 19, showing the results from the guide sign data, Figure 25 demonstrates the strong nature of the interaction and that under the high luminance conditions (i.e., normal low-beam illumination), the contrast ratio of the sign is less important than under low luminance conditions. Under low luminance conditions, higher contrast ratios clearly produce longer legibility distances.

LEGIBILITY ANALYSIS FOR COUNTY ROAD NAME SIGNS

The last type of sign tested was white-on-green county road name signs. TxDOT installs these signs on their roadways in advance of intersecting county roads. The current practice calls for a 4-inch Series D legend. TxDOT was interested in learning how different combinations of retroreflective sheeting might impact the legibility of these signs. Six county road name signs tested were made with Type III backgrounds and Type III, Type VIII, and Type IX legends (two signs of each retroreflective sheeting combination). A total of 170 observations were obtained using all 30 subjects. Missing observations occurred only with drivers 55 years and older and represent signs that could not be read before the test vehicle passed the sign. Note that each sheeting combination had missed data points for the older drivers.

Results

Appendix C contains the descriptive statistics of the data used in the analysis for the county road name signs. Figure 26 is a cumulative distribution plot of the data comparing the sheeting combinations evaluated (across all ages, fonts, and luminance levels) in the study.

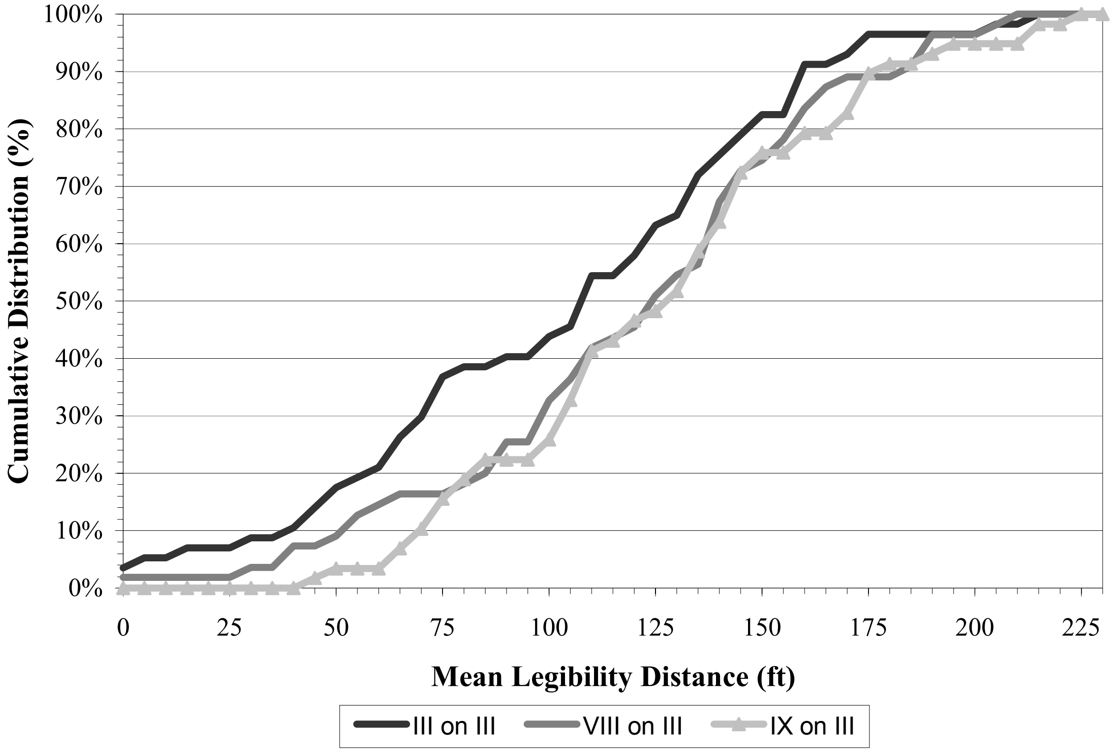

Figure 26. Cumulative Distribution Plot Comparing Sheeting Types for County Road Name Signs.

Analysis

Using the same approach as described above, a statistical analysis showed that the type of retroreflective sheeting used on the legends had a statistically significant impact on the legibility distance of these signs ($F = 6.74$, $p = 0.0016$). Figure 27 shows the results categorized by age group as before.

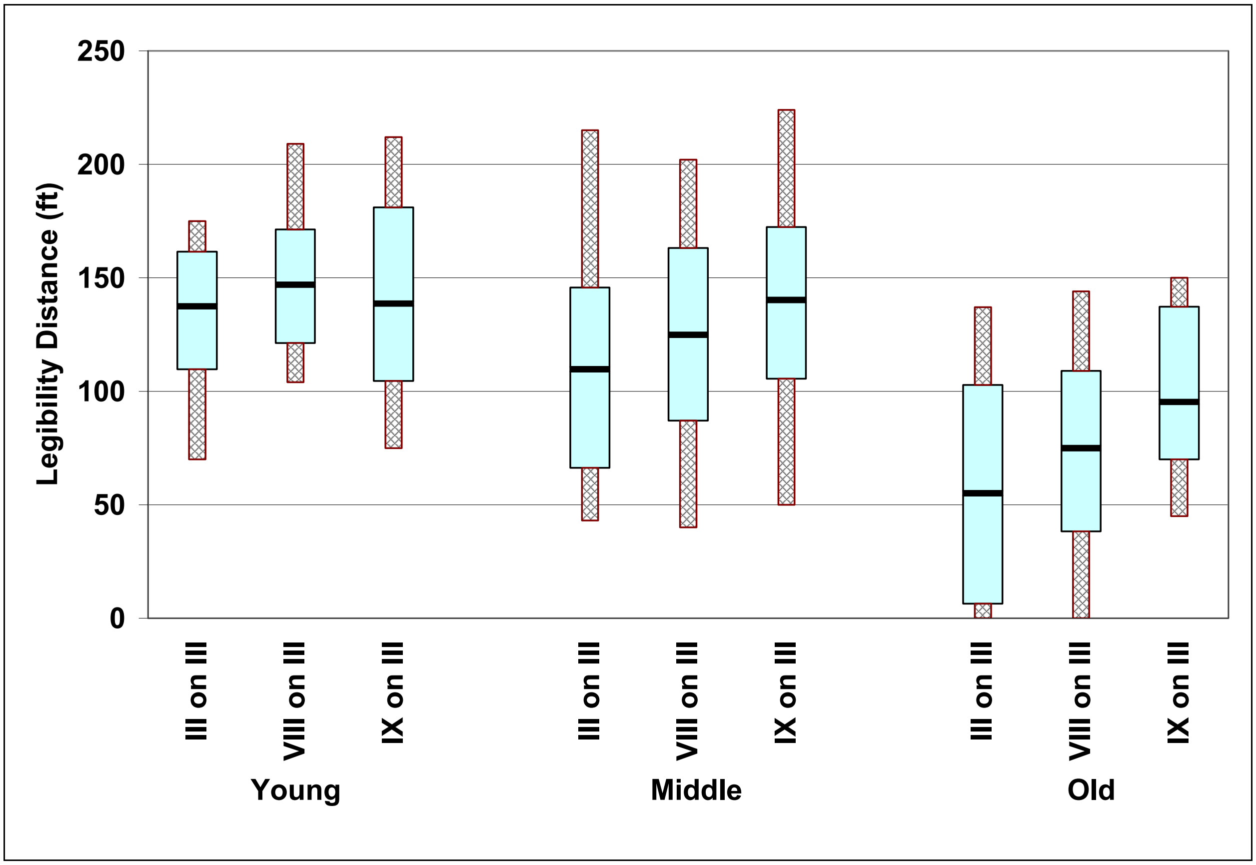

Figure 27. Box Plots for Material Combination for County Road Name Signs.

Figure 27 shows that the young age group read the county road name signs at approximately equal distances regardless of the sheeting used for the legend (mean legibility distances equate to 141 ft for Type III on Type III, 149 ft for Type VIII on Type III, and 140 ft for Type IX on Type III). However, the middle and old age groups, which both show the same trends, show different trends than the young age group. For the middle and old age groups, the mean legibility distances appear to depend on the type of sheeting used for the legend. The interaction between age group and sheeting was not significant (F = 1.73, $p = 0.1452$).

Statistical testing using the Duncan multiple range test was completed to determine the statistical differences between the mean legibility distances associated with each type of retroreflective sheeting but collapsed across age group. The results are shown in Table 21.

Table 21. Duncan Multiple Range Test for Sheeting Combination.

Retroreflective Sheeting Combination	Mean Legibility (ft)	Duncan Grouping (α=0.05)	
IX on III	125.8	■	
VIII on III	119.3	■	
III on III	103.2		■

Again, the findings show that prismatic legends produce statistically longer legibility distances than Type III legends. The overall mean legibility difference between the Type IX and Type VIII legend was only 6 ft and deemed not significant. However, the mean legibility difference between the Type IX and Type VIII legend for the middle age group was 15 ft and for the old age group the difference was 20 ft. These differences are somewhat intuitive given the nature of the Type IX material and the shorter legibility distances of the middle and old age groups.

SUMMARY

Shoulder-Mounted Freeway Guide Signs

The guide sign legibility results indicated that Clearview 5WR produces statistically longer legibility distances than Series E(Modified) while maintaining, on average, the same word length and therefore same size sign panels. The data also show that the best combination of retroreflective sheeting for guide signs made with Clearview 5WR would include microprismatic legends on Type III backgrounds. The all microprismatic signs do not provide a statistical advantage over the microprismatic legends on Type III backgrounds. However, microprismatic legends on Type III backgrounds produced mean legibility distances significantly longer than Type III legends on Type III backgrounds.

Destination and Distance Signs

The destination and distance sign legibility results indicated that the 6-inch Clearview 3W did not perform better than 6-inch Series D. However, the 8-inch Clearview, mixed-case font exhibited a substantial legibility increase over both the 6-inch Series D and 6-inch Clearview fonts.

The analysis of mixed sheeting again indicated that using microprismatic legend on glass-beaded background sheeting does increase the legibility distance for all drivers.

County Road Name Signs

The county road names signs were evaluated to obtain base level knowledge of how these particular signs perform. The standard signs use a Type III on Type III sheeting combination. The evaluation showed that the legibility of these signs could be increased for all drivers by using a mixed sheeting combination of a microprismatic legend and a glass-beaded background.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

The basic objective of this research was to compare the legibility of guide signs using combinations of microprismatic and glass-beaded sheeting. A secondary objective was to evaluate the Clearview fonts for guide signs as compared to the standard highway fonts. The research focused on destination and distance signs and shoulder-mounted freeway guide signs but also included a small sample of Texas county road name signs. The design of the study included 30 subjects categorized into three age groups: young (18-34), middle-aged (35-54), and older (55+). All 30 subjects conducted the study while driving a 2000 Ford Taurus.

CONCLUSIONS

Comparison with Previous TTI Clearview Project

Previous research (*1*) has found that freeway guide signs with Clearview font and microprismatic legend and background construction produce significantly longer legibility distances compared to the then-current TxDOT standard practice. The results showed that overall average legibility improvements of approximately 50 ft are possible for shoulder-mounted guide signs.

The current research discussed herein shows similar findings in that all microprismatic signs can produce between a 47 and 60 ft increase in the legibility distance of shoulder-mounted guide signs. The use of mixed sheeting signs can produce approximately an additional 30 ft of legibility over all microprismatic signs.

Clearview on Shoulder-Mounted Freeway Guide Signs

For shoulder-mounted guide signs manufactured with a combination of microprismatic and glass-beaded sheeting, the results show that the Clearview 5WR font provides longer legibility distances than Series E(Modified). The overall mean legibility distances were 26 ft greater with all Clearview 5WR fonts.

Clearview on Destination and Distance Signs

For destination and distance signs manufactured with a combination of microprismatic and glass-beaded sheeting, the results show that 6-inch Series D font provides the same or better legibility distance than 6-inch Clearview 3W. Overall mean legibility distances of Series D were 12 ft greater than 6-inch Clearview 3W.

The 8-inch Clearview, mixed-case font, however, produced significantly longer legibility distances than that of the 6-inch Series D and 6-inch Clearview 3W. Overall mean legibility distances were 50 and 62 ft greater, respectively.

RECOMMENDATIONS

For the guide sign conditions studied, the Clearview 5WR font outperformed the Series E(Modified) font. In terms of sheeting type, the combination of microprismatic and Type III sheeting consistently provided a longer legibility distance than either Type III or microprismatic sheeting only signs.

Therefore, based on the results discovered and presented herein, the researchers recommend that TxDOT begin using a microprismatic legend in combination with a Type III background and the Clearview 5WR font on all new and refurbished freeway guide signs.

Based on the results discovered and presented herein, the researchers also recommend the use of 8-inch Clearview 3W, initial capital letter font with microprismatic legend and Type III background.

The researchers further recommend that Texas county road name signs also be fabricated with a microprismatic legend and Type III background.

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APPENDIX A:
SHOULDER MOUNTED FREEWAY GUIDE SIGN DATA

Table A1 Freeway Guide Sign Font Performance by Subject Age

Font	Subject Age	N	Mean	Std. Dev.	95% Confidence Interval	
					Lower	Lower
Series E(m)	18-34	100	666	117.0	11.7	643.1
	35-54	100	604	160.0	16.0	572.6
	55+	100	440	137.0	13.7	413.1
Clvw 5W	18-34	20	671	119.0	26.6	618.8
	35-54	20	624	164.0	36.7	552.1
	55+	20	473	121.0	27.1	420.0
Clvw 5WR	18-34	100	694	123.0	12.3	669.9
	35-54	100	636	167.0	16.7	603.3
	55+	100	449	137.0	13.7	422.1
Clvw 5WR2	18-34	20	703	92.0	20.6	662.7
	35-54	20	611	160.0	35.8	540.9
	55+	20	429	112.0	25.0	379.9

Table A2 Comparison of Freeway Guide Sign Sheeting Combinations by Driver Age

Sheeting Combination	Subject Age	N	Mean	Std. Dev.	95% Confidence Interval	
					Lower	Lower
Type III on Type III	18-34	40	641	120.0	19.0	603.8
	35-54	40	590	160.0	25.3	540.4
	55+	40	379	134.0	21.2	337.5
Type VIII on Type III	18-34	40	681	108.0	17.1	647.5
	35-54	40	606	152.0	24.0	558.9
	55+	40	461	152.0	24.0	413.9
Type IX on Type III	18-34	40	695	133.0	21.0	653.8
	35-54	40	637	191.0	30.2	577.8
	55+	40	461	127.0	20.1	421.6
Type VIII on Type IX	18-34	40	710	106.0	16.8	677.2
	35-54	40	636	168.0	26.6	583.9
	55+	40	487	115.0	18.2	451.4

Table A3 Freeway Guide Sign Descriptive Statistics for Younger Drivers and High Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	10	641	140	44.3	554.2
		Type VIII	10	717	90	28.5	661.2
		Type IX	10	736	117	37.0	663.5
	Type IX	Type VIII	10	702	91	28.8	645.6
		Type IX	10	683	68	21.5	640.9
Clvw 5W	Type IX	Type IX	10	697	58	18.3	661.1
Clvw 5WR	Type III	Type III	10	753	103	32.6	689.2
		Type VIII	10	703	114	36.0	632.3
		Type IX	10	674	154	48.7	578.5
	Type IX	Type VIII	10	742	129	40.8	662.0
		Type IX	10	752	117	37.0	679.5
Clvw 5WR2	Type IX	Type IX	10	755	127	40.2	676.3

Table A4 Freeway Guide Sign Descriptive Statistics Middle-aged Drivers and High Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	10	632	163	51.5	531.0
		Type VIII	10	568	159	50.3	469.5
		Type IX	10	579	126	39.8	500.9
	Type IX	Type VIII	10	643	126	39.8	564.9
		Type IX	10	626	219	69.3	490.3
Clvw 5W	Type IX	Type IX	10	633	153	48.4	538.2
Clvw 5WR	Type III	Type III	10	647	185	58.5	532.3
		Type VIII	10	649	167	52.8	545.5
		Type IX	10	606	141	44.6	518.6
	Type IX	Type VIII	10	712	244	77.2	560.8
		Type IX	10	646	192	60.7	527.0
Clvw 5WR2	Type IX	Type IX	10	665	162	51.2	564.6

Table A5 Freeway Guide Sign descriptive Statistics for Older Drivers and High Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	10	390	131	41.4	308.8
		Type VIII	10	443	164	51.9	341.4
		Type IX	10	549	133	42.1	466.6
	Type IX	Type VIII	10	510	125	39.5	432.5
		Type IX	10	485	103	32.6	421.2
Clvw 5W	Type IX	Type IX	10	524	123	38.9	447.8
Clvw 5WR	Type III	Type III	10	454	114	36.0	383.3
		Type VIII	10	447	129	40.8	367.0
		Type IX	10	503	198	62.6	380.3
	Type IX	Type VIII	10	526	105	33.2	460.9
		Type IX	10	503	83	26.2	451.6
Clvw 5WR2	Type IX	Type IX	10	458	131	41.4	376.8

Table A6 Freeway Guide Sign Descriptive Statistics for Younger Drivers and Low Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	10	607	128	40.5	527.7
		Type VIII	10	650	57	18.0	614.7
		Type IX	10	672	125	39.5	594.5
	Type IX	Type VIII	10	659	101	31.9	596.4
		Type IX	10	590	172	54.4	483.4
Clvw 5W	Type IX	Type IX	10	646	158	50.0	548.1
Clvw 5WR	Type III	Type III	10	653	43	13.6	626.3
		Type VIII	10	613	85	26.9	560.3
		Type IX	10	684	112	35.4	614.6
	Type IX	Type VIII	10	630	144	45.5	540.7
		Type IX	10	728	108	34.2	661.1
Clvw 5WR2	Type IX	Type IX	10	662	66	20.9	621.1

Table A7 Freeway Guide Sign Descriptive Statistics for Middle-aged Drivers and Low Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	10	520	140.0	44.3	433.2
		Type VIII	10	620	170.0	53.8	514.6
		Type IX	10	645	200.0	63.2	521.0
	Type IX	Type VIII	10	600	204.0	0.0	0.0
		Type IX	10	610	74.0	23.4	564.1
Clvw 5W	Type IX	Type IX	10	615	183.0	57.9	501.6
Clvw 5WR	Type III	Type III	10	575	131.0	41.4	493.8
		Type VIII	10	559	156.0	49.3	462.3
		Type IX	10	632	155.0	49.0	535.9
	Type IX	Type VIII	10	611	181.0	57.2	498.8
		Type IX	10	657	162.0	51.2	556.6
Clvw 5WR2	Type IX	Type IX	10	621	117.0	37.0	548.5

Table A8 Freeway Guide Sign Descriptive Statistics for Older Drivers and Low Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	10	349	150	47.4	256.0
		Type VIII	10	451	149	47.1	358.6
		Type IX	10	378	87	27.5	324.1
	Type IX	Type VIII	10	461	118	37.3	387.9
		Type IX	10	380	100	31.6	318.0
Clvw 5W	Type IX	Type IX	10	423	100	31.6	361.0
Clvw 5WR	Type III	Type III	10	405	110	34.8	336.8
		Type VIII	10	329	115	36.4	257.7
		Type IX	10	449	92	29.1	392.0
	Type IX	Type VIII	10	393	89	28.1	337.8
		Type IX	10	473	139	44.0	386.8
Clvw 5WR2	Type IX	Type IX	10	375	161	50.9	275.2

Table A9 Freeway Guide Sign Descriptive Statistics for Younger Drivers and All Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	20	624	132	29.5	566.1
		Type VIII	20	683	81	18.1	647.5
		Type IX	20	704	123	27.5	650.1
	Type IX	Type VIII	20	680	96	21.5	637.9
		Type IX	20	637	136	30.4	577.4
Clvw 5W	Type IX	Type IX	20	671	119	26.6	618.8
Clvw 5WR	Type III	Type III	20	703	92	20.6	662.7
		Type VIII	20	658	108	24.1	610.7
		Type IX	20	679	132	29.5	621.1
	Type IX	Type VIII	20	686	145	32.4	622.5
		Type IX	20	740	110	24.6	691.8
Clvw 5WR2	Type IX	Type IX	20	708	110	24.6	659.8

Table A10 Freeway Guide Sign Descriptive Statistics for Middle-Aged Drivers and All Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	20	576	159.0	35.6	506.3
		Type VIII	20	594	162.0	36.2	523.0
		Type IX	20	613	166.0	37.1	540.2
	Type IX	Type VIII	20	622	165.0	0.0	0.0
		Type IX	20	618	159.0	35.6	548.3
Clvw 5W	Type IX	Type IX	20	624	164.0	36.7	552.1
Clvw 5WR	Type III	Type III	20	611	160.0	35.8	540.9
		Type VIII	20	604	164.0	36.7	532.1
		Type IX	20	619	145.0	32.4	555.5
	Type IX	Type VIII	20	661	215.0	48.1	566.8
		Type IX	20	651	173.0	38.7	575.2
Clvw 5WR2	Type IX	Type IX	20	643	140.0	31.3	581.6

Table A11 Freeway Guide Sign Descriptive Statistics for Older Drivers and All Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
E(M)	Type III	Type III	20	370	138.0	30.9	309.5
		Type VIII	20	447	153.0	34.2	379.9
		Type IX	20	464	140.0	31.3	402.6
	Type IX	Type VIII	20	485	121.0	27.1	432.0
		Type IX	20	433	112.0	25.0	383.9
Clvw 5W	Type IX	Type IX	20	473	121.0	27.1	420.0
Clvw 5WR	Type III	Type III	20	429	112.0	25.0	379.9
		Type VIII	20	388	134.0	30.0	329.3
		Type IX	20	476	153.0	34.2	408.9
	Type IX	Type VIII	20	459	117.0	26.2	407.7
		Type IX	20	488	112.0	25.0	438.9
Clvw 5WR2	Type IX	Type IX	20	435	156.0	34.9	366.6

APPENDIX B:
DESTINATION AND DISTANCE SIGN DATA

Table B1 Destination and Distance Sign Font Performance by Subject Age

Font	Subject Age	N	Mean	Std. Dev.	95% Confidence Interval	
					Lower	Lower
6 inch Series D	18-34	113	221	81.0	17.9	185.9
	35-54	112	185	87.0	8.5	168.4
	55+	75	113	75.0	6.7	99.9
6 inch Clvw 3W	18-34	116	215	80.0	11.6	192.3
	35-54	122	182	82.0	7.7	166.8
	55+	87	104	62.0	5.5	93.3
8 inch Clvw 3W	18-34	116	288	75.0	9.4	269.5
	35-54	118	276	88.0	8.2	259.9
	55+	102	155	78.0	7.3	140.6

Table B2 Comparison of Destination and Distance Sign Sheeting Combinations by Driver Age

Sheeting Combination	Subject Age	N	Mean	Std. Dev.	95% Confidence Interval	
					Lower	Lower
Type III on Type III	18-34	114	213	89.0	10.5	192.4
	35-54	116	179	102.0	7.3	164.7
	55+	76	91	72.0	7.5	76.2
Type VIII on Type III	18-34	54	248	85.0	5.4	237.4
	35-54	60	235	82.0	5.9	223.5
	55+	40	142	91.0	7.2	127.9
Type IX on Type III	18-34	62	251	80.0	7.8	235.7
	35-54	57	223	98.0	9.1	205.2
	55+	60	150	61.0	7.4	135.5
Type VIII on Type VIII	18-34	115	262	77.0	10.2	241.9
	35-54	119	235	87.0	5.6	224.1
	55+	88	133	68.0	6.4	120.5

Table B3 Destination and Distance Sign Descriptive Statistics for Younger Drivers and High Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	18	200	66	15.6	169.5
		Type VIII	7	234	76	28.7	177.7
		Type IX	9	240	65	21.7	197.5
	Type VIII	Type VIII	19	273	72	16.5	240.6
6 inch Clvw 3W	Type III	Type III	24	208	84	17.1	174.4
		Type VIII	9	264	104	34.7	196.1
		Type IX	11	229	63	19.0	191.8
	Type VIII	Type VIII	22	243	62	13.2	217.1
8 inch Clvw 3W.	Type III	Type III	18	296	74	17.4	261.8
		Type VIII	9	292	90	30.0	233.2
		Type IX	15	300	93	24.0	252.9
	Type VIII	Type VIII	19	308	85	19.5	269.8

Table B4 Destination and Distance Sign Descriptive Statistics for Middle-Aged Drivers and High Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	18	183	66	15.6	152.5
		Type VIII	8	227	78	27.6	172.9
		Type IX	7	220	65	24.6	171.8
	Type VIII	Type VIII	21	243	74	16.1	211.3
6 inch Clvw 3W	Type III	Type III	21	177	85	18.5	140.6
		Type VIII	15	223	52	13.4	196.7
		Type IX	9	210	66	22.0	166.9
	Type VIII	Type VIII	20	226	85	19.0	188.7
8 inch Clvw 3W	Type III	Type III	24	269	100	20.4	229.0
		Type VIII	7	273	112	42.3	190.0
		Type IX	14	317	74	19.8	278.2
	Type VIII	Type VIII	21	306	76	16.6	273.5

Table B5 Destination and Distance Sign Descriptive Statistics for Older Drivers and High Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	16	85	81	20.3	45.3
		Type VIII	9	80	96	32.0	17.3
		Type IX	8	137	42	14.8	107.9
	Type VIII	Type VIII	22	118	71	15.1	88.3
6 inch Clvw 3W	Type III	Type III	17	84	68	16.5	51.7
		Type VIII	9	128	89	29.7	69.9
		Type IX	14	138	45	12.0	114.4
	Type VIII	Type VIII	22	96	58	12.4	71.8
8 inch Clvw 3W	Type III	Type III	19	116	64	14.7	87.2
		Type VIII	8	180	91	32.2	116.9
		Type IX	9	205	61	20.3	165.1
	Type VIII	Type VIII	16	190	55	13.8	163.1

Table B6 Destination and Distance Sign Descriptive Statistics for Younger Drivers and Low Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	18	173	93	21.9	130.0
		Type VIII	11	189	65	19.6	150.6
		Type IX	12	237	76	21.9	194.0
	Type VIII	Type VIII	19	229	81	18.6	192.6
6 inch Clvw 3W	Type III	Type III	15	133	50	12.9	107.7
		Type VIII	10	232	62	19.6	193.6
		Type IX	9	203	64	21.3	161.2
	Type VIII	Type VIII	16	226	89	22.3	182.4
8 inch Clvw 3W	Type III	Type III	21	253	73	15.9	221.8
		Type VIII	8	296	76	26.9	243.3
		Type IX	6	290	70	28.6	234.0
	Type VIII	Type VIII	20	287	38	8.5	270.3

Table B7 Destination and Distance Sign Descriptive Statistics for Middle Aged Drivers and Low Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	20	95	74	16.5	62.6
		Type VIII	9	184	66	22.0	140.9
		Type IX	11	161	85	25.6	110.8
	Type VIII	Type VIII	18	201	79	18.6	164.5
6 inch Clvw 3W	Type III	Type III	18	117	61	14.4	88.8
		Type VIII	9	198	90	30.0	139.2
		Type IX	10	133	68	21.5	90.9
	Type VIII	Type VIII	20	178	75	16.8	145.1
8 inch Clvw 3W	Type III	Type III	15	219	99	25.6	168.9
		Type VIII	12	296	66	19.1	258.7
		Type IX	6	290	49	20.0	250.8
	Type VIII	Type VIII	19	249	78	17.9	213.9

Table B8 Destination and Distance Sign Descriptive Statistics for Older Drivers and Low Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	3	90	46	26.6	37.9
		Type VIII	2	233	46	32.5	169.2
		Type IX	9	130	73	24.3	82.3
	Type VIII	Type VIII	6	127	52	21.2	85.4
6 inch Clvw 3W	Type III	Type III	8	42	16	5.7	30.9
		Type VIII	5	133	55	24.6	84.8
		Type IX	6	100	20	8.2	84.0
	Type VIII	Type VIII	6	135	56	22.9	90.2
8 inch Clvw 3W	Type III	Type III	13	100	92	25.5	50.0
		Type VIII	7	176	80	30.2	116.7
		Type IX	14	169	64	17.1	135.5
	Type VIII	Type VIII	16	147	65	16.3	115.2

Table B9 Destination and Distance Sign Descriptive Statistics for Younger Drivers and All Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	36	186	81.0	13.5	159.5
		Type VIII	18	206	71.0	16.7	173.2
		Type IX	21	238	70.0	15.3	208.1
	Type VIII	Type VIII	38	251	79.0	12.8	225.9
6 inch Clvw 3W	Type III	Type III	39	179	81.0	13.0	153.6
		Type VIII	19	245	84.0	19.3	207.2
		Type IX	20	217	63.0	14.1	189.4
	Type VIII	Type VIII	38	236	79.0	12.8	210.9
8 inch Clvw 3W	Type III	Type III	39	273	76.0	12.2	249.1
		Type VIII	17	293	81.0	19.6	254.5
		Type IX	21	297	85.0	18.5	260.6
	Type VIII	Type VIII	39	297	65.0	10.4	276.6

Table B10 Destination and Distance Sign Descriptive Statistics for Middle-Aged Drivers and All Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	38	137	82.0	13.3	110.9
		Type VIII	17	205	73.0	17.7	170.3
		Type IX	18	104	81.0	19.1	66.6
	Type VIII	Type VIII	39	224	79.0	12.7	199.2
6 inch Clvw 3W	Type III	Type III	39	149	80.0	12.8	123.9
		Type VIII	24	214	68.0	13.9	186.8
		Type IX	19	169	76.0	17.4	134.8
	Type VIII	Type VIII	40	202	83.0	13.1	176.3
8 inch Clvw 3W	Type III	Type III	39	250	101.0	16.2	218.3
		Type VIII	19	207	84.0	19.3	169.2
		Type IX	20	309	67.0	15.0	279.6
	Type VIII	Type VIII	40	279	81.0	12.8	253.9

Table B11 Destination and Distance Sign Descriptive Statistics for Older Drivers and All Luminance

Font	Background Material	Legend Material	N	Mean Legibility Distance (ft)	Standard Deviation	95% Confidence Interval	
						Lower	Upper
6 inch Series D	Type III	Type III	19	86	75.0	17.2	52.3
		Type VIII	11	108	107.0	32.3	44.8
		Type IX	17	133	59.0	14.3	105.0
	Type VIII	Type VIII	28	120	67.0	12.7	95.2
6 inch Clvw 3W	Type III	Type III	25	70	59.0	11.8	46.9
		Type VIII	14	130	76.0	20.3	90.2
		Type IX	20	127	43.0	9.6	108.2
	Type VIII	Type VIII	28	104	59.0	11.1	82.1
8 inch Clvw 3W	Type III	Type III	32	110	76.0	13.4	83.7
		Type VIII	15	178	83.0	21.4	136.0
		Type IX	23	183	64.0	13.3	156.8
	Type VIII	Type VIII	32	168	63.0	11.1	146.2

APPENDIX C:
TEXAS COUNTY ROAD NAME SIGN DATA

TABLE C1 COUNTY ROAD NAME SIGN DESCRIPTIVE STATISTICS FOR SUBJECT AGE

Age Group	N	Mean Legibility Distance (ft)	Std. Dev.	95% Confidence Interval	
				Lower Bound	Upper Bound
18-34	60	141	31	4.0	133.2
35-54	60	125	45	5.8	113.6
55+	50	76	41	5.8	64.6
Total	170	116	47	3.6	108.9

Table C2 County Road Name Signs Descriptive Statistics for Sign Legend Material

Legend Sheeting Material	N	Mean Legibility Distance (ft)	Std. Dev.	95% Confidence Interval	
				Lower Bound	Upper Bound
Type III	57	103	51	6.8	89.8
Type VIII	55	119	46	6.2	106.8
Type IX	58	126	42	5.5	115.2
Total	170	116	47	3.6	108.9

Table C3 County Road Name Signs Descriptive Statistics: Subject Age and Sheeting in Combination

Subject Age	Legend Sheeting	N	Mean Legibility Distance (ft)	Std. Dev.	95% Confidence Interval	
					Lower Bound	Upper Bound
18-34	Type III	20	138	29.0	6.3	134.7
	Type VIII	20	147	28.0	6.5	124.8
	Type IX	20	139	36.0	8.0	122.9
35-54	Type III	20	110	45.0	9.4	106.5
	Type VIII	20	125	42.0	10.1	90.0
	Type IX	20	140	44.0	9.8	121.0
55+	Type III	17	55	42.0	10.2	35.0
	Type VIII	15	75	40.0	10.3	54.8
	Type IX	18	95	31.0	7.3	81.0

APPENDIX D:
CLEARVIEW 5W SPACING TABLES

Table D1. Clearview 5W Spacing (inches).

L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	Overall Length
	P			**u**			**t**			**t**			**e**			**r**		
3.20	11.68	1.92	3.04	10.88	3.04	1.44	7.84	1.76	1.44	7.84	1.76	2.40	11.84	2.40	3.04	7.36	1.60	79.68
		4.96			4.48			3.20			4.16			5.44				
	S			**e**			**n**			**i**			**o**			**r**		
1.92	11.52	2.08	2.40	11.84	2.40	3.04	11.04	3.04	2.72	3.68	2.72	2.40	12.32	2.40	3.04	7.36	1.60	84.00
		4.48			5.44			5.76			5.12			5.44				
	B			**a**			**t**			**t**			**l**			**e**		
3.20	12.16	2.40	2.08	11.84	2.08	1.44	7.84	1.76	1.44	7.84	1.76	3.04	5.12	1.76	2.40	11.84	2.40	76.80
		4.48			3.52			3.20			4.80			4.16				

TableD2. Clearview 5WR2 Spacing (inches).

L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	Overall Length
	P			**o**			**i**			**s**			**o**			**n**		
2.96	11.68	1.68	2.16	12.32	2.16	2.48	3.68	2.48	1.44	10.24	1.84	2.16	12.32	2.16	2.80	11.04	2.80	82.64
		3.84			4.64			3.92			4.00			4.96				
	E			**x**			**p**			**e**			**r**			**t**		
2.96	10.24	2.00	0.72	12.32	0.72	2.80	11.68	2.16	2.16	11.84	2.16	2.80	7.36	1.36	1.20	7.84	1.60	79.36
		2.72			3.52			4.32			4.96			2.56				
	C			**a**			**r**			**e**			**e**			**r**		
2.32	13.12	1.52	1.84	11.84	1.84	2.80	7.36	1.36	2.16	11.84	2.16	2.16	11.84	2.16	2.80	7.36	1.36	84.16
		3.36			4.64			3.52			4.32			4.96				

Table D3. Clearview 5WR Spacing (inches).

L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	Overall Length
	B			**a**			**n**			**n**			**e**			**r**		
2.72	12.16	1.92	1.60	11.84	1.60	2.56	11.04	2.56	2.56	11.04	2.56	1.92	11.84	1.92	2.56	7.36	1.12	87.04
		3.52			4.16			5.12			4.48			4.48				
	B			**a**			**s**			**k**			**e**			**t**		
2.72	12.16	1.92	1.60	11.84	1.60	1.12	10.24	1.60	2.56	11.36	0.64	1.92	11.84	1.92	0.96	7.84	1.44	81.12
		3.52			2.72			4.16			2.56			2.88				
	G			**a**			**r**			**d**			**e**			**n**		
2.08	13.92	2.08	1.60	11.84	1.60	2.56	7.36	1.12	1.92	11.68	2.56	1.92	11.84	1.92	2.56	11.04	2.56	87.52
		3.68			4.16			3.04			4.48			4.48				
	H			**o**			**u**			**s**			**e**			**s**		
3.20	12.32	3.20	1.92	12.32	1.92	2.56	10.88	2.56	1.12	10.24	1.60	1.92	11.84	1.92	1.12	10.24	1.60	87.68
		5.12			4.48			3.68			3.52			3.04				
	N			**e**			**r**			**v**			**e**			**s**		
2.72	13.28	2.72	1.92	11.84	1.92	2.56	7.36	1.12	0.64	12.16	0.64	1.92	11.84	1.92	1.12	10.24	1.60	83.20
		4.64			4.48			1.76			2.56			3.04				
	O			**c**			**e**			**a**			**n**			**s**		
2.08	14.88	2.08	1.92	10.88	1.12	1.92	11.84	1.92	1.60	11.84	1.60	2.56	11.04	2.56	1.12	10.24	1.60	89.12
		4.00			3.04			3.52			4.16			3.68				
	B			**a**			**t**			**t**			**e**			**r**		
2.72	12.16	1.92	1.60	11.84	1.60	0.96	7.84	1.44	0.96	7.84	1.44	1.92	11.84	1.92	2.56	7.36	1.12	75.20
		3.52			2.56			2.40			3.36			4.48				

Table D3. Clearview 5WR Spacing (inches) (continued).

L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	L	Letter	R	Overall Length
	S			**e**			**r**			**i**			**e**			**s**		
1.44	11.52	1.60	1.92	11.84	1.92	2.56	7.36	1.12	2.24	3.68	2.24	1.92	11.84	1.92	1.12	10.24	1.60	75.04
		3.52			4.48			3.36			4.16			3.04				
	R			**a**			**f**			**f**			**l**			**e**		
2.72	12.00	1.92	1.60	11.84	1.60	1.28	7.68	1.12	1.28	7.68	1.12	2.56	5.12	1.28	1.92	11.84	1.92	71.84
		3.52			2.88			2.40			3.68			3.20				
	G			**a**			**s**			**k**			**e**			**t**		
2.08	13.92	2.08	1.60	11.84	1.60	1.12	10.24	1.60	2.56	11.36	0.64	1.92	11.84	1.92	0.96	7.84	1.44	83.04
		3.68			2.72			4.16			2.56			2.88				
	P			**r**			**i**			**s**			**o**			**n**		
2.72	11.68	1.44	2.56	7.36	1.12	2.24	3.68	2.24	1.12	10.24	1.60	1.92	12.32	1.92	2.56	11.04	2.56	75.04
		4.00			3.36			3.36			3.52			4.48				
	R			**e**			**p**			**o**			**r**			**t**		
2.72	12.00	1.92	1.92	11.84	1.92	2.56	11.68	1.92	2.40	12.32	2.40	2.56	7.36	1.12	0.96	7.84	1.44	82.72
		3.84			4.48			4.32			4.96			2.08				
	C			**o**			**r**			**n**			**e**			**r**		
2.08	13.12	1.28	1.92	12.32	1.92	2.56	7.36	1.12	2.56	11.04	2.56	1.92	11.84	1.92	2.56	7.36	1.12	83.36
		3.20			4.48			3.68			4.48			4.48				
	B			**u**			**r**			**n**			**e**			**r**		
2.72	12.16	1.92	2.56	10.88	2.56	2.56	7.36	1.12	2.56	11.04	2.56	1.92	11.84	1.92	2.56	7.36	1.12	82.88
		4.48			5.12			3.68			4.48			4.48				
	G			**e**			**n**			**d**			**e**			**r**		
2.08	13.92	2.08	1.92	11.84	1.92	2.56	11.04	2.56	1.92	11.68	2.56	1.92	11.84	1.92	2.56	7.36	1.12	89.60
		4.00			4.48			4.48			4.48			4.48				