STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION
TECHNICAL REPORT DOCUMENTATION PAGE
TR0003 (REV 10/98)

1. REPORT NUMBER
CA15-2289

2. GOVERNMENT ASSOCIATION NUMBER

3. RECIPIENT'S CATALOG NUMBER

4. TITLE AND SUBTITLE
Evaluation of Guide Sign Fonts

5. REPORT DATE
April 2014

6. PERFORMING ORGANIZATION CODE

7. AUTHOR
Jeffrey D. Miles, Bari Kotwal, Sarah Hammond, and Fan Ye

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Texas A&M Transportation Institute
The Texas A&M University System
College Station, Texas 77843-3135

10. WORK UNIT NUMBER

11. CONTRACT OR GRANT NUMBER
TPF-5(262)

12. SPONSORING AGENCY AND ADDRESS
Minnesota Department of Transportation
Research Services Section
395 John Ireland Boulevard
Mail Stop 330
St. Paul, MN 55155

13. TYPE OF REPORT AND PERIOD COVERED
Final Report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT
Researchers at Texas A&M Transportation Institute completed a study of E-modified, Enhanced E-Modified, and Clearview 5W for overhead and shoulder-mounted guide signs. The overhead guide signed consisted of three six-letter words stacked over each other at a standard spacing. The test word was on the middle line and had a 16-inch tall leading uppercase letter followed by a combination of lowercase ascender and neutral letters, lowercase descender and neutral letters, or all lowercase neutral letters, of varying loop heights depending on letter style. The shoulder-mounted signs consisted of single two-digit numbers. Both the word and number legends were chosen to have similar footprints to minimize the likelihood of guessing based on recognition rather than legibility. Legibility distance data were recorded for each word read; however, the researchers completed the analysis based on the legibility index (LI) which is the legibility distance divided by the legend height. Clearview 5W and Enhanced E-Modified were not statistically different than E-Modified. The only statistically significant differences reported were with respect to subject age (e.g., 18-35 and 65+) and day versus night, and at night within Clearview 5W with respect to legend type. The mean LI were 68.9 and 45.2 for 18-35 versus 65+ participants in the daytime condition, respectively, and 50.2 and 36.4 for 18-35 versus 65+ participants in the nighttime condition, respectively. It was shown that the cost to implement Clearview 5W would be more expensive than E-Modified based on the cost of the license and the increased size of the signs versus E-Modified. Based on these findings, the researchers do not recommend using Clearview 5W. With drivers 65 years of age and older achieving nearly 81 percent of daytime legibility, it is questionable how much further improvement can be achieved, so it is recommended that only fonts or policies that reduce the costs of signs without reducing the safety be investigated in future studies. If further font evaluations are to be conducted that focus halation, the researchers recommend focusing on shoulder-mounted signs that have higher luminance values than overhead signs.

17. KEY WORDS
Overhead, Shoulder, Guide Sign, E-Modified, Enhanced E-Modified, Clearview 5W, Ascender, Descender, Neutral, Numbers, Nighttime, Daytime Legibility

18. DISTRIBUTION STATEMENT
No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. SECURITY CLASSIFICATION *(of this report)*
Unclassified

20. NUMBER OF PAGES
60

21. COST OF REPORT CHARGED

EVALUATION OF GUIDE SIGN FONTS

Final Report

Prepared by:

Jeffrey D. Miles, P.E.
Bari Kotwal
Sarah Hammond
Fan Ye

Texas A&M Transportation Institute
The Texas A&M University System
College Station, Texas 77843-3135

April 2014

Published by:

Minnesota Department of Transportation
Research Services Section
395 John Ireland Boulevard
Mail Stop 330
St. Paul, MN 55155

ACKNOWLEDGMENTS

This research study was made possible through the contribution of a number of organizations and individuals.

The research team would first like to acknowledge the Minnesota Department of Transportation as the leader in this pooled fund study. The significant efforts of Cory Johnson in leading the technical panel and providing project support are very much appreciated. Researchers are also very appreciative of the following Departments of Transportation for their financial support: Iowa, California, Florida, West Virginia, and Colorado.

The research team would also like to thank the members of the Technical Advisory Panel for their suggestions and feedback throughout the course of this research effort. Panel members include: Cory Johnson (MN), Tim Crouch (IA), Matt Hanson (CA), Gail Holley (FL), Ted Whitmore (WV), David Reeves (CO), as well as the project's Federal Highway Administration Liaison, Jim Shurbutt.

A special thank you is also extended to Nada Trout, Sandra Stone, and LuAnn Theiss with the Texas A&M Transportation Institute for their assistance in data collection efforts.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

EXECUTIVE SUMMARY

Researchers at the Texas A&M Transportation Institute (TTI) completed a pooled fund study for several state transportation agencies interested in completing a field evaluation of current and potential fonts for use on guide signs. In this study, TTI evaluated E-Modified, Clearview 5W, and Enhanced E-Modified. Clearview 5W and other Clearview fonts were designed by Meeker & Associates and revised over several different research projects [1]. Clearview was created using a thinner letter stroke width overall and increased the height of the lowercase letters to provide longer legibility distance. The designers of Clearview believed that the thinner, taller letters would mitigate the impact of halation being reported by drivers, in particular older drivers, with the use of newer retroreflective sign sheeting materials. Halation occurs when light reflected from a surface appears to exceed the boundaries of the surface and blend with an adjacent surface of a contrasting color. If halation occurs, a lowercase "e" could appear as an "a," "c," or "o." Enhanced E(Mod) was developed as a free font based on E(Mod), whereby staff at SignCAD® thinned the stroke width and increased lower-case loop height in a similar manner to Clearview.

For this study, three full-sized overhead guide signs and one full-sized shoulder-mounted guide sign were placed along a closed-course roadway, and participants were asked to view these signs while driving an instrumented vehicle during both daytime and nighttime conditions. E(Mod), Enhanced E(Mod), and Clearview 5W were the three fonts studied. Each overhead guide sign was constructed to present one of the fonts, while the shoulder-mounted guide sign allowed for all three fonts to be presented at one location. With the three overhead guide signs, participants saw an ascender, descender, or neutral word on each sign, and the shoulder-mounted guide sign contained a number. Participants saw each of the three overhead and the shoulder-mounted sign on each lap, which created four different conditions per lap. The overhead guide signs were set 18.5 ft above the pavement from the bottom of the sign with a 12-ft lateral offset. The shoulder-mounted sign was set at 7 ft to the bottom of the sign with a 12-ft lateral offset. The overhead guide signs were on mobile platforms that allowed researchers to randomize their placement with respect to the course; however, the shoulder-mounted number sign location was fixed because all three fonts could be presented at one location. None of the signs were equipped with sign lighting, and there was no roadway lighting.

Male and female participants with valid Texas driver licenses were recruited from two age groups (18–35 years old, 65+ years old) from within a 25-mile radius of Bryan/College Station, Texas, to drive the closed-course test track. Participants drove in a TTI instrumented Dodge Caravan with low-beam headlights. The resulting study design had three fonts, four sign conditions, and two lighting conditions: a $3 \times 4 \times 2$ factor design requiring at least 24 treatments for participants who ran in both day and night conditions. Some participants only saw the signs at night, for which only 12 different treatments were required. Legibility distance was recorded during the study, but it was converted to legibility index so that the results could be better compared to other studies independent of legend height.

All data collection was conducted at the Texas A&M Riverside Campus. Figure 3.1 shows the 2000-acre former U.S. Air Force base. This facility allowed TTI to create a closed-course route that was geometrically designed like a typical highway, while at the same time providing an atmosphere free from other roadway traffic. In all, two two-lane, two-way roadways were striped with 12-ft-wide lanes along the runways with standard 4-inch-wide white and yellow pavement markings. The roadways were connected at each end by horizontal curves. The curves allowed the drivers to avoid having to stop except at the beginning of each lap, which reduced the overall time required for data collection. One stop was required at the beginning of each lap to allow time for the field personnel to change the words and numbers on the test signs. There was over 1,800 ft of viewing distance to the first sign on each tangent section, and there was at least 1,000 ft between the first sign and the next adjacent sign.

The initial hypothesis by the researchers was that the thinner stroke width and increased lowercase loop height provided by Clearview 5W and/or Enhanced E(Mod) would provide higher legibility than E(Mod) based on the belief that halation may occur with newer brighter retroreflective sign sheeting materials. While there were instances where Clearview 5W and Enhanced E(Mod) appeared to perform better with respect to LI than E(Mod), the results were inconsistent and never statistically significant. The researchers believe that the large observation angle between the overhead guide sign and the headlights resulted in luminance levels that would not create a halation effect. However, the luminance levels are representative of real world conditions, and therefore, this maybe an indication that the halation effect is either not occurring or not negatively impacting legibility for the given fonts and sign position.

The luminance levels for the shoulder-mounted guide sign were higher than the overhead guide sign, but the font was not statistically significant. It is believed that the luminance of the shoulder-mounted sign under low-beam headlight illumination was still not bright enough to cause impairment. It is also possible that numbers in general are more difficult to read than mixed-case words. The researchers currently believe that it was the latter possible option because the overall legibility distance for the shoulder-mounted number condition was lower than the guide sign condition.

The researchers believe that the data do not support the use of Clearview 5W as a replacement for E(Mod), and that Enhanced E(Mod) requires further testing prior to making any recommendations for FHWA approval or experimentation. Based on the two questions above, Clearview 5W did not provide a statistically significant improvement in legibility and it is more expensive that E(Mod), so it is neither an improvement to safety nor a reduction in cost. Enhanced E(Mod) did not provide statistically significant improvement in legibility, but it does not add any cost if used on a replacement basis. With the overall mean legibility distance for the drivers in the study achieving 80 percent of the daytime legibility at night, should states invest in trying to improve legibility distance, or should states shift to putting a greater emphasis on reducing the cost in signing while maintaining or improving legibility?

With the findings of this report and when considering the question posed above, the researchers developed a list of potential future research that could help provide better guidance on the use of different types of fonts as well as improvements in signing policies in general.

- Font Evaluations:
  - As E(Mod) appears to provide around 80 percent of the daytime legibility distance at night, it is believed that future research should focus on fonts that

reduce the size of the sign while maintaining or providing better nighttime legibility than E(Mod).
    - Develop a tool that allows practitioners to design signs and predict expected performance based on font type, font size, sign type, vehicle speed, roadway geometry, message content, and driver age.
    - Develop a laboratory technique to quickly and inexpensively test candidate fonts prior human factors driving evaluations.
- Signing Policy:
    - Develop improved guidance to address the use of redundant signs with respect to quantity, placement, size, and in some cases whether signs are even needed such as route signs on low volume roadways.
    - Develop improved guidance on sign placement to improve driver expectancy.

CHAPTER 1
INTRODUCTION

In the last 50 years, retroreflective sheeting materials used for highway signs have improved dramatically; however, the basic design and fonts used on these signs have remained relatively unchanged. Where this is of particular interest is with the brighter prismatic retroreflective sign sheeting materials that are replacing beaded retroreflective sign sheeting materials. These brighter materials can cause a halation effect (or overglow) under certain conditions. The halation effect results in the blurring of the edges of letters and can cause, for instance, a "c" or an "e" to appear as an "o." Various other letters can get confused as a result of halation, and halation is especially a problem for older drivers and others with reduced contrast sensitivity. While using beaded retroreflective sign sheeting avoids this problem, these sign sheeting materials may not be efficient enough under certain conditions, such as for drivers in vehicles with large observation angles (e.g., tractor trailers) or drivers viewing signs with large entrance angles (e.g., overhead guide signs). One consideration to counteract the halation effect is to modify existing fonts or create new fonts with thinner stroke widths and increase lowercase loop heights, such as ClearviewHwy® or Enhanced E-Modified.

Series E-Modified is one of the Standard Alphabets for Highway Signs fonts and has long been the standard font for positive-contrast highway guide signs. However, in the 1990s a new highway sign font, ClearviewHwy®, was developed and tested and is now in use as well. In this report, ClearviewHwy® and Series E-Modified will be referred to as Clearview and E(Mod), respectively. Clearview 5W is considered the comparable font within the Clearview font library to E(Mod). In 2004, the Federal Highway Administration (FHWA) issued an Interim Approval for the optional use of the Clearview font for positive-contrast legends on guide signs [2]. The newly released 2009 FHWA Manual on Uniform Traffic Control Devices (MUTCD) did not include Clearview but left the Interim Approval in force because more definitive research is needed [3]. While the interim approval has been in place since 2004, not all states have adopted the use of Clearview for at least three reasons: (1) the results of research studies have not definitively shown that Clearview is superior to E(Mod); (2) Clearview 5W produces wider footprint words, which result in wider, more expensive signs; and (3) Clearview is a patented font that requires purchasing, and E(Mod) is free of charge.

Several studies to date have evaluated Clearview and E(Mod), specifically in relation to guide sign legibility [4,5,6,7,8,9]. More recent studies have specifically compared Clearview 5WR versus E(Mod) for guide sign fonts and found longer legibility distances with the use of the Clearview font [8,9]. Clearview 5WR, a modified version of Clearview 5W, was designed to produce, on average, the same footprint as E(Mod) while allowing for increased legibility distance. Researchers, however, found that the majority of states are currently using Clearview 5W rather than the modified Clearview 5WR, except in cases where the sign has limited space, warranting the use of Clearview 5WR. It is not known how Clearview 5W and E(Mod) compare when modifications are made to E(Mod) similar to those made to Clearview, including varying stroke width and letter spacing.

Objectives

The objectives of this study were threefold:

- Investigate whether Clearview 5W provides greater legibility than E(Mod) for overhead guide signs.

- Investigate whether a new font developed by reducing the stroke width of E(Mod) would provide greater legibility than E(Mod) for overhead guide signs.

- Investigate the performance of E(Mod), Enhanced E(Mod), and Clearview 5W with respect to whole numbers for shoulder-mounted signs.

Project Overview

TTI conducted the research detailed in this report from October 1, 2012, to August 30, 2013. A discussion of the research activities, as well as an overview of the organization of the report, follows:

- Background—The researchers conducted a topic investigation reviewing pertinent research on legibility as it relates to overhead guide signs, sign sheeting retroreflectivity, and fonts including Clearview. Chapter 2 summarizes this information.
- Research approvals—Prior to data collection, the researchers were required to obtain multiple approvals to conduct the study:
  - Once the scope of work and project objectives were refined, an experimental plan was submitted to the project director and panel members for approval.
  - After obtaining consensus and approval for the planned study, the experimental plan was submitted to the Texas A&M University Institutional Review Board for approval, as is required for any TTI research involving human subjects.
- Study preparation—Once all approvals were obtained, the researchers began the following preparations for conducting the study:
  - Runways were reserved at the Texas A&M Riverside Campus for use as the closed-course roadway, and all necessary associated roadway markings (paint and raised pavement markers) were planned and approved.
  - Full-size signs and test word and number panels were ordered, and sign support structures were fabricated.
  - Forklifts for use in raising and lowering the signs were identified and reserved.
  - Data collection equipment was readied.
  - Participant packets were prepared, including consent forms, an explanation of the study, word display order randomized for each participant, and blank data collection forms. These forms can be found in Appendix A.
- Data collection—Data were collected under daytime and nighttime driving conditions from mid-April 2013 through the end of May. A total of 64 participants were recruited. More detailed information about the data collection portion of the study is provided in Chapter 3.

- Data analysis—After field evaluation was completed, the resulting data were evaluated using appropriate statistical analysis techniques. The analyses and results are presented in Chapter 4.
- Conclusions and recommendations—Based on the analyses and results, the researchers have provided a cost-benefit analysis with recommendations, as well as suggestions for future research, in Chapter 5.

CHAPTER 2
BACKGROUND

Researchers conducted a comprehensive review of relevant research. The scope of the reviewed material included sign sheeting retroreflectivity, halation, fonts and font characteristics, and overhead guide signs.

Retroreflective Sign Sheeting

Retroreflective sign sheeting is a material that is designed to reflect light from a source back to that source. The American Society of Testing and Materials (ASTM) has specified up to 11 different classifications as stated in ASTM D4956-11a [10]. Of note, ASTM Type VII and Type X have been reclassified as Type VIII and discontinued. The 11 classifications are:

- "4.2.1 Type I—A retroreflective sheeting referred to as "engineering grade" that is typically an enclosed lens glass-bead sheeting. Applications for this material include permanent highway signing, construction zone devices, and delineators.
- 4.2.2 Type II—A retroreflective sheeting referred to as "super engineer grade" that is typically an enclosed lens glass-bead sheeting. Applications for this material include permanent highway signing, construction zone devices, and delineators.
- 4.2.3 Type III—A retroreflective sheeting referred to as "high-intensity" that is typically manufactured as an encapsulated glass-bead retroreflective material or as an unmetalized microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.
- 4.2.4 Type IV—A retroreflective sheeting referred to as "high-intensity" that is typically an unmetalized microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.
- 4.2.5 Type V—A retroreflective sheeting referred to as "super high-intensity" that is typically a metalized microprismatic retroreflective element material. This sheeting is typically used for delineators.
- 4.2.6 Type VI—An elastomeric retroreflective sheeting without adhesive. This sheeting is typically a vinyl microprismatic retroreflective material. Applications include orange temporary roll-up warning signs, traffic cone collars, and post bands.
- 4.2.7 Type VII—Retroreflective sheeting materials previously classified as Type VII have been reclassified as Type VIII. The use of a designation as Type VII has been discontinued.
- 4.2.8 Type VIII—A retroreflective sheeting typically manufactured as an unmetalized cube corner microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.
- 4.2.9 Type IX—A retroreflective sheeting typically manufactured as an unmetalized cube corner microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators.
- 4.2.10 Type X—Retroreflective sheeting materials previously classified as Type X have been reclassified as Type VIII. The use of a designation as Type X has been discontinued.

- 4.2.11 Type XI—A retroreflective sheeting typically manufactured as an unmetalized cube corner microprismatic retroreflective element material. Applications for this material include permanent highway signing, construction zone devices, and delineators” [10].

This specification can be useful for quality controls along a production line, but these different classifications do not always correlate to improved performance for drivers with regard to increased legibility distance [6,7]. As a case in point, researchers used the software ERGO 2001 to plot some of the typical sign sheeting materials for overhead guide sign (see the black lines in Figure 2.1) and shoulder-mounted guide sign (see the gray lines in Figure 2.1) geometry. The researchers then plotted average legibility data from another research project that used internally illuminated signs to create specific luminance profiles [11]. The average legibility distance data plotted are for an overhead guide sign with 12-inch-tall words in the Clearview 5WR font with fixed luminance values at 1, 30, and 80 cd/m^2 (see the black dots in Figure 2.1). Figure 2.1 shows that there is little benefit from sign sheeting materials after exceeding luminance values above 30 cd/m^2. There is a question of whether this case of diminishing returns is attributed to the human response being logarithmic, the maximum threshold being reached, or halation occurring at the brighter luminance levels.

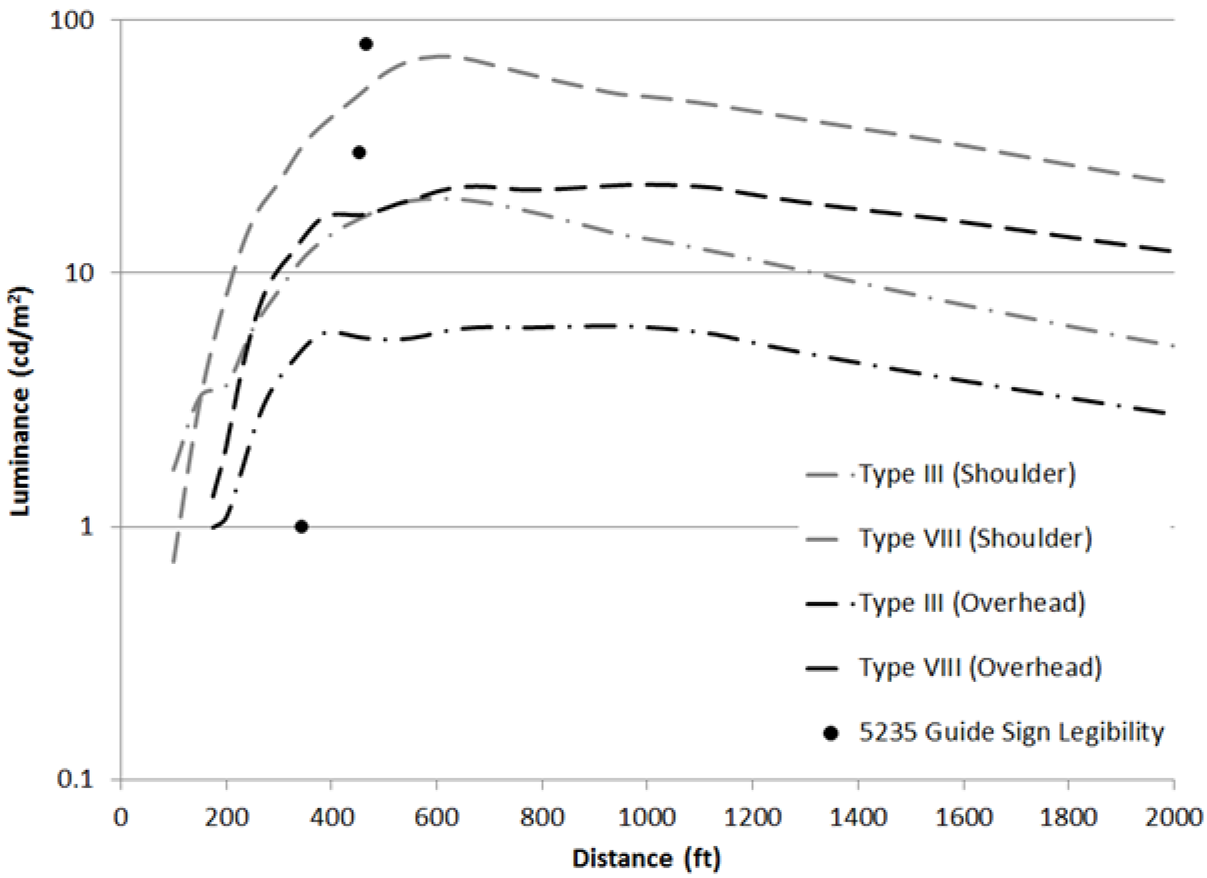


Figure 2.1. ASTM Type and Legibility Distance versus Luminance.

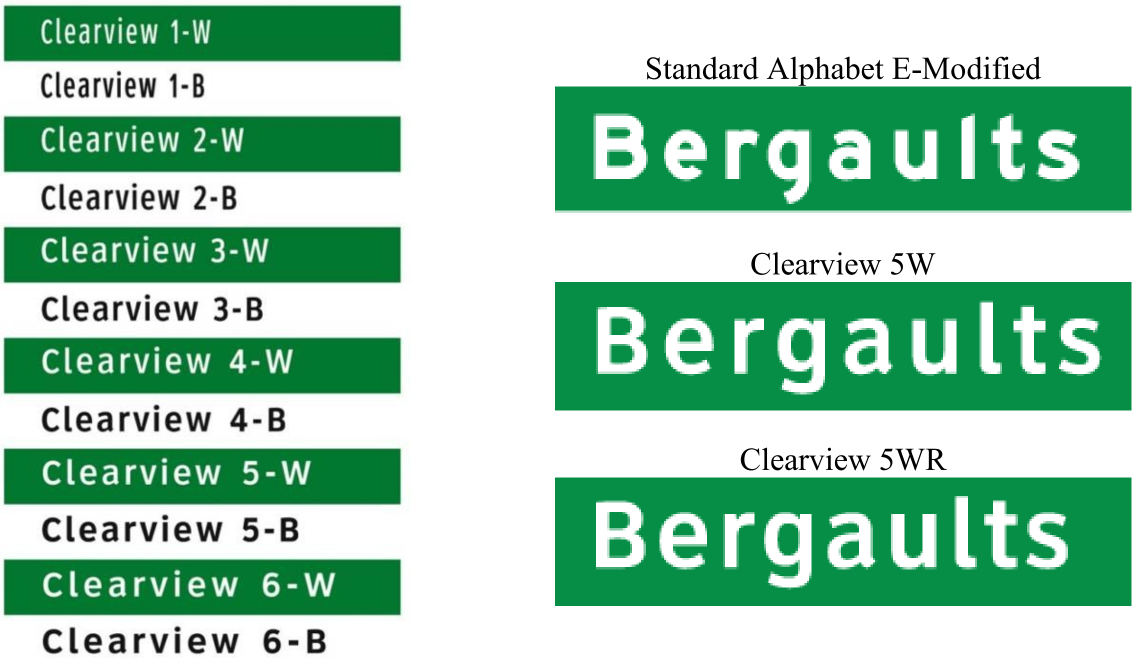
Another specification by the American Association of State Highway and Transportation Officials (AASHTO) that is similar to ASTM D4956-11a is M268-10 [12]. This specification has only four classifications of retroreflective sign sheeting material, with Type A for beaded materials and Type B through D for different performance levels of microprismatic materials. The four classifications are detailed below.

- "4.2.1. Type A – Retroreflective sheeting materials meeting Type A are typically constructed of encapsulated microscopic glass bead lens construction.
- 4.2.2. Type B – Retroreflective sheeting materials meeting Type B are typically constructed of unmetalized microprismatic optics. These triangular microprismatic materials do not have a significant 1-degree observation angle performance.
- 4.2.3. Type C – Retroreflective sheeting materials meeting Type C are typically constructed of unmetalized microprismatic optics. These triangular microprismatic materials have a significant 1-degree observation angle performance.
- 4.2.4. Type D – Retroreflective sheeting materials meeting Type D are typically constructed of unmetalized microprismatic optics. These materials have 0.5- and 1-degree observation angle performance approximately two times greater than Type C materials."

Clearview Font Types

Several renditions of the Clearview font have been developed over the years, but the current visual structure of Clearview fonts differ from Standard Alphabets for Highway Signs fonts in three primary ways: Clearview has thinner stroke widths; lowercase letters have increased loop heights; and the letter spacing for the lowercase Clearview is more open. Clearview is available in six weights, with each weight based on use for positive-contrast signs (e.g., white letters on a darker background) or negative-contrast signs (e.g., black letters on a lighter background). These fonts are shown in Figure 2.2a. The positive-contrast Clearview fonts are "W" fonts and the negative-contrast Clearview fonts are "B" fonts.

The version of the Clearview font designed to substitute for E(Mod) is Clearview 5W, which has been shown to provide a statistically significantly longer legibility distance over E(Mod) [7]. However, this improvement initially came at a cost of an increased footprint (i.e., requiring more sign space), as shown in Figure 2.2b. To address this issue, the developers of Clearview created a modified version, Clearview 5WR, and subsequent research completed at TTI found that Clearview 5WR provided, on average, the similar footprint as E(Mod) and with statistically significantly longer legibility distances [7].



(a) Clearview Fonts [1] (b) Footprint Comparison [1]

Figure 2.2. Clearview Positive- and Negative-Contrast Fonts.

Previous Research

Clearview was developed for traffic signs by a design team that included Donald Meeker and Christopher O'Hara of Meeker and Associates, Inc.; James Montalbano of Terminal Design, Inc.; and Martin Pietrucha, Ph.D., and Philip Garvey of the Pennsylvania Transportation Institute (PTI). Gene Hawkins, Ph.D., and Paul Carlson, Ph.D., of TTI provided supporting research, and Susan Chrysler, Ph.D., of TTI gave advice on research design.

The Clearview font was developed with a focus on increasing legibility and ease of recognition of positive-contrast sign legends and at the same time reducing the effects of halation or overglow, which are thought to decrease legibility distance. The halation effect has resulted from improvements in retroreflective sign sheeting materials, which are designed more efficiently using microprisms. Halation is especially a problem for older drivers and drivers with reduced contrast sensitivity.

With this in mind, PTI conducted the first nighttime research on Clearview in the 1990s demonstrating its efficacy. Researchers focused specifically on fonts used for destination legends on freeway guide signs, looking at ways to create a font that would provide greater legibility than E(Mod) [4]. The study also looked at comparing the ease of recognition of mixed-case legends (i.e., uppercase and lowercase letters) versus those with all uppercase letters (Series D), and also comparing the required size for the letters and resulting sign based on the lettering used. Results showed that similar to printed text, accuracy, viewing distance, and reaction time were all better for the mixed-case lettering, but this result included a case with an increase in the font size.

When the legibility distances were normalized by dividing by the font size, the change was not significant.

Prior studies have also shown that the Clearview font provides increased nighttime legibility for positive-contrast overhead and ground-mounted guide signs when compared to existing fonts [5,6,7,8,9,11]. As mentioned previously, researchers at PTI performed the first Clearview study [4]. Since then, several studies sponsored by the Texas Department of Transportation (TxDOT) have been completed at TTI [6,7,8,9,11]. The research has focused mainly on positive-contrast signs (mostly a white legend on a green background), although the 2006 study evaluated the effectiveness of the Clearview font on negative-contrast signs of various colors [9]. In this negative-contrast study, it was shown that Clearview did not outperform E(Mod), and it was recommended not to use the Clearview fonts for negative contrast signs in Texas.

Table 2.1 contains a summary of the previous studies that evaluated shoulder-mounted and overhead guide signs with mixed-case fonts, with participants driving a sedan with low-beam headlights. The table shows that the average legibility index (LI) for guide signs is approximately 50 ft/in for daytime conditions and 40 ft/in for nighttime conditions. In general, Clearview in its many forms has not really improved daytime legibility, but it has improved nighttime visibility. Note that the change with legibility distance was not always significant, and when it was, it was an improvement of about 3 to 12 percent, which would equate to an additional 19 to 77 ft for a guide sign with 16-inch letter height and assuming 40 ft/in of LI.

Table 2.1. Summary of Previous Research.

Study	Day/Night	Sign Position	Legend Sheeting (ASTM)[a]	Font	LI (ft/in)
PTI [4]	Day	Shoulder	III, IV	E(Mod)	44.6
				Clearview[b]	36.7–43.3
	Night	Shoulder	III, IV	E(Mod)	39.4
				Clearview[b]	30.2–43.4
TTI [5]	Day	Shoulder	III	E(Mod)	52.3
				BTM	51.3
				Clearview[c]	50.3
		Overhead	III	E(Mod)	54.1
				BTM	52.4
				Clearview[c]	55.3
	Night	Shoulder	III	E(Mod)	40.8
				BTM[c]	40.2
				Clearview[c]	40.9
		Overhead	III	E(Mod)	40.6
				BTM[c]	39.0
				Clearview[c]	41.4
TTI [6]	Night	Shoulder	VIII/III	E(Mod)	42.3
				Clearview[d]	43.3
			IX/III	E(Mod)	38.6
				Clearview[d]	42.2
		Overhead	IX/III	E(Mod)	39.0
				Clearview[d]	42.4
TTI [7]	Night	Shoulder	III/III	E(Mod)	34.9
				Clearview 5WR[e]	38.6
			VIII/III	E(Mod)	36.0
				Clearview 5WR[e]	37.5
			IX/III	E(Mod)	38.8
				Clearview 5WR[e]	37.1
			VIII/IX	E(Mod)	38.6
				Clearview 5WR[e]	41.3
			IX/IX	E(Mod)	37.4
				Clearview 5WR[e]	39.6
				Clearview 5WR2[e]	39.1
				Clearview 5W[e]	38.6

a. The sheeting designation is based on ASTM D4956-11a, and the comma indicates that multiple retroreflective sheeting materials were tested but the materials were not found to be significant. The forward slash indicates the study used mixed retroreflective materials between legend and background. First material listed was the legend.
b. There were four different Clearview fonts evaluated. The one with a statistically significant increase in legibility distance was for a taller font, so in terms of LI, this change was not significant.
c. There were initially three Clearview fonts considered, but the researchers used what was called Clearview 5.7. E(Mod) was either statistically better or not statistically different from Clearview. British Transport Medium (BTM)
d. The same Clearview was used as in the previous TTI project [5]; however, this time Clearview provided statistically significant longer legibility distances by, on average, about 6.8 percent over E(Mod).
e. Clearview 5W, 5WR, and 5WR2 were evaluated, and it was found that both 5W and 5WR provided statistically significant longer legibility distances with 5WR, on average—about 3.2 percent better than E(Mod).

CHAPTER 3
FIELD EVALUATION

The objective of the field evaluation was to determine the legibility of overhead guide signs for three fonts: E(Mod), Enhanced E(Mod), and Clearview 5W. Researchers also conducted a preliminary investigation of the impact of the font on the legibility of numbers. The numbers were presented in a shoulder-mounted guide sign condition. All signs were fabricated using ASTM Type XI white 16-inch letters on ASTM Type IV green background retroreflective sign sheeting. The study was conducted on a closed-course roadway and included both daytime and nighttime conditions, with participants in two distinct age groups.

Study Design

Three full-size overhead guide signs and one full-size shoulder-mounted guide sign were placed along the closed-course roadway, and participants were asked to view these signs while driving an instrumented vehicle. E(Mod), Enhanced E(Mod), and Clearview 5W were the three fonts studied. Each overhead guide sign was constructed to present one of the fonts, while the shoulder-mounted guide sign presented all three fonts at one location. Participants saw an ascender, descender, or neutral word on each of the overhead guide signs, and they saw one number on the shoulder-mounted guide sign on each lap. This created four different conditions for each lap. The shoulder-mounted number sign location was fixed because all three fonts could be presented at one location, but the overhead guide signs were on mobile platforms that allowed researchers to randomize their placement with respect to the course.

Testing was conducted under both daytime and nighttime conditions, and all night testing was conducted under low-beam headlight illumination, without sign lighting and with no fixed roadway lighting. Male and female participants with valid Texas driver licenses were recruited from two age groups from within a 25-mile radius of Bryan/College Station, Texas. Gender has not been a factor in legibility studies, but researchers sought to balance the gender across age groups and treatments. The resulting study design had three fonts, four sign conditions, and two lighting conditions: a $3 \times 4 \times 2$ factor design requiring at least 24 treatments for participants who ran in both daytime and nighttime conditions. Some participants only saw the signs at night, for which only 12 different treatments were required. Table 3.1 contains a list of the independent variables. Age was not included in the calculation of the number of treatments because each participant saw all of the necessary number of treatments for a full-factorial design study. Legibility distance was recorded during the study, but this was converted to LI so that the results could be better compared to other studies independent of legend height.

Table 3.1. Independent Variables.

Font	Condition	Time of Day	Age Group
E(Mod) Clearview 5W Enhanced E(Mod)	Ascender Descender Neutral Number	Daytime (baseline) Nighttime	21–35 years of age 65+ years of age

Researchers weighted the study with two-thirds of the participants being older drivers and one-third of the participants being younger drivers. This enabled the research team to document the performance of younger drivers, who are acknowledged to be able to read signs at longer distances than older drivers, while providing greater statistical power to evaluate the impact of the fonts on older driver legibility. Table 3.2 contains the breakdown of the intended study population with respect to demographics for age, gender, and time of day.

Table 3.2. Number of Participants.

Age Group	Both Daytime & Nighttime		Nighttime Only	Totals		TOTAL
	Daytime	Nighttime		Daytime	Nighttime	
21–35	6	6	12	6	18	24
65+	10	10	20	10	30	40
Totals	**16**	**16**	**32**	**16**	**48**	**64**

Course Setup

All data collection was conducted at the Texas A&M Riverside Campus. Figure 3.1 shows the 2000-acre former U.S. Air Force base. This facility allowed TTI to create a closed-course route that was geometrically designed like a typical highway, while at the same time providing an atmosphere free from other roadway traffic. In all, two 2-lane, 2-way roadways were striped with 12-ft-wide lanes along the runway marked in Figure 3.1. The roadways were connected at each end by horizontal curves. The curves allowed the drivers to avoid having to stop except at the beginning of each lap, which reduced the overall time required for data collection. One stop was required at the beginning of each lap to allow time for the field personnel to change the words and numbers on the test signs. A scaled drawing of the closed course showing the location of the signs and the start/stop point is shown in Figure 3.2. There was over 1800 ft of viewing distance on the tangent approach to signs 1 and 3, and at least 1000 ft between signs 1 and 2 and between signs 3 and 4. The edge lines consisted of 4-inch white retroreflective pavement markings, and the centerline consisted of 4-inch yellow retroreflective pavement markings.

Figure 3.1. Texas A&M Riverside Campus.

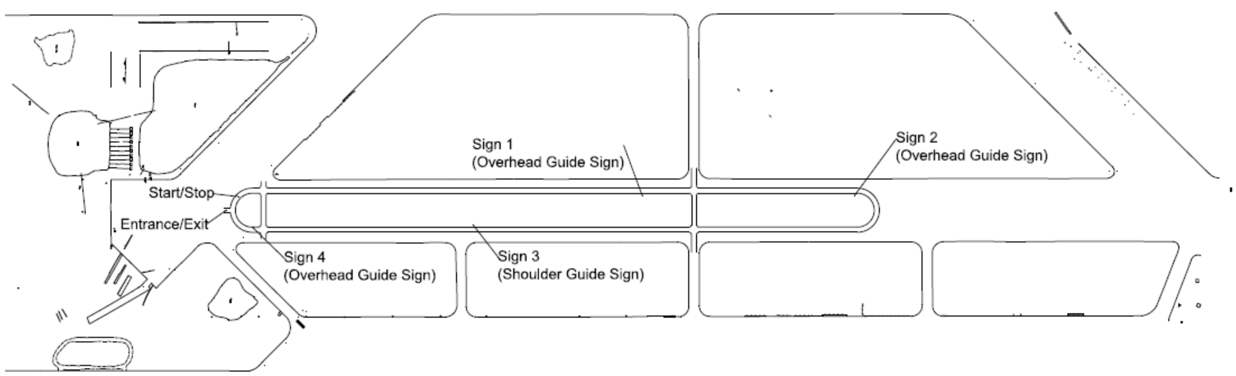


Figure 3.2. Closed-Course Layout.

Overhead Guide Signs

Each overhead guide sign consisted of an 8-ft × 10-ft surface made from extruded aluminum covered with ASTM Type IV green retroreflective sheeting. Figure 3.3 shows one of the assembled overhead guide signs. The extruded aluminum panels are shown in the expanded image on the left of the figure. The legends and sign borders were constructed with ASTM Type XI white retroreflective sheeting. These sheeting types were used because they are the materials currently in use. The ASTM Type IV retroreflective sheeting used for the background was oriented 90 degrees to its optimal efficiency as measured using an alpha observation angle of 0.2 degrees and an entrance angle of −4 degrees. Each word in the study was mounted on two pieces of 4-ft × 2.5-ft aluminum substrate and mounted on the background panels. Two panels were used for each individual target word for safety reasons because it was deemed difficult and dangerous for one staff member to lift a single 4-ft × 2.5-ft panel. Using two smaller, more manageable panels also helped reduce the time required to change words.

Figure 3.3. Overhead Guide Sign Construction.

The top and the bottom words remained unchanged throughout the study. These two words were "Paying" on the upper line, which contains descenders, and "Likely" on the lower line, which contains ascenders. These words were chosen to evaluate the impact of interline spacing. While the interline spacing was kept constant at 12 inches and set according to current prescribed standard spacing, it was believed that the presence of a word with descenders above a word of interest and the presence of a word with ascenders below a word of interest could impact the legibility of the word of interest. As stated previously, researchers designed the study to explore this idea further by having test words that contained three conditions—neutral and ascender letters (e.g., "Finish"), neutral and descender letters (e.g., "Hungry"), and neutral letters only (e.g., "Season"). The uppercase letters are not considered ascenders because all uppercase letters have the same vertical footprint within a given letter height. Some examples of the finished signs, as rendered in SignCAD, are shown in Appendix B.

The word on the middle line was the test word. Panels containing these words were mounted on the sign background by sliding them in a slot created by the bottom of the top word panel and the top of the bottom word panel. The top and bottom words were mounted approximately ¼ inch away from the background surface to create the slot for the test words to slide into. This design allowed for a quick change of each word throughout the study. The slot overlap is depicted in Figure 3.3 in the expanded image on the right.

The overhead guide signs were tested at 18.5 ft from the surface of the pavement to the bottom of the sign. The signs were also laterally offset 12 ft from the right edge line of the roadway to the left edge of the sign. The three signs were raised and lowered using three forklifts, one for each sign structure. Each extruded background panel was secured to a metal structural support, which was designed so that it could be readily accessed, raised, and lowered using the forklift (see Figure 3.4a). Figure 3.4b depicts the nighttime condition, in which the forklift was not visible to the participant until after he/she read the sign. The use of the forklifts to move the signs enabled the presentation of the three fonts to be more readily randomized throughout the study.

(a) Daytime (b) Nighttime

Figure 3.4. Overhead Guide Signs in the Daytime and Nighttime Raised Position.

Researchers installed a weighted cable on the bottom of each overhead guide sign to ensure consistency between laps and participants. The cable is outlined in the tall rectangular dotted box in Figure 3.4a. Field personnel raised a sign until the weight was just touching the ground. This put the sign at approximately the same height every time. A staff member then verified the vertical alignment of the sign by checking to see if the cable was parallel to the vertical plane of the sign background. One of the field boxes used to hold the test words is also shown in Figure 3.4a, outlined by the dotted box in the lower right corner. The field boxes were built to carry the signs from one location to another on a forklift and to ensure that the different test words and fonts did not get interchanged.

Shoulder-Mounted Guide Signs

The shoulder-mounted guide signs for testing numbers were created in the same manner as the test words, except they consisted of a single flat 4-ft × 2.5-ft extruded aluminum panel. ASTM Type IV green retroreflective sheeting was used for the background, and ASTM Type XI white retroreflective sheeting was used for the border and numbers. The signs were supported on a metal post at a height of 7 ft from the ground to the bottom of the sign, and the sign was also laterally offset 12 ft from the right edge line of the roadway to the left edge of the sign. To help reduce the change time between laps, a special bracket system was developed so that only one person was needed to change the shoulder-mounted sign. Figure 3.5 shows the number sign setup, with the test sign storage box in the bottom right corner, outlined by a dotted box. Examples of some of the signs rendered in SignCAD, prior to the construction of the signs, are shown in Appendix B.

Figure 3.5. Shoulder-Mounted Number Sign.

Test Words and Numbers

The test words consisted of a single six-letter word, and the number legends consisted of a two-digit number. A total of 15 words and 5 numbers were generated, and each participant saw every word and every number, but not for every font condition. Each participant saw each word and number only once. Words and numbers were randomized for each participant among each of the three fonts being tested, and font types for the guide signs were randomly assigned to different positions along the driving course throughout the study.

Words were selected that were common but had no relation to roadway terminology and that were thought to not be easily recognized so participants would have to actually read them. For instance, the word "Senior" was avoided because the younger driving group typically consisted of new or recent high school and college graduates that would easily relate to that word. This particular word might also be easily identified by older drivers that are close to or already associated with the term "senior citizen." While all of the words consisted of six letters, effort was also taken to ensure that the words had similar footprints. For example, the word "Common" was initially considered, but it had a footprint that was too large to fit on an 8-ft-wide sign.

In addition, researchers designed the letter legend signs to investigate potential problems with interline spacing. It was believed that the occurrence of descending letters above another word, or ascending letters below a word, might interfere with reading the adjacent word and negatively impact legibility. This is an area of research that previous studies have not addressed. Researchers incorporated this by placing three words stacked vertically on each overhead guide sign. The top word and the bottom word remained the same throughout the study; the middle word was the only word that was changed. The top word contained descending letters, and the bottom word contained ascending letters. The middle words were either ascenders, descenders, or neutral (i.e., contained neither ascenders nor descenders). Number legends were selected so that they contained similarly shaped characters. Interline spacing was not investigated for the numbers, so only one two-digit number was presented on the sign. The study words and numbers are shown in Table 3.3.

Table 3.3. Test Words and Numbers.

Neutral	Ascenders	Descenders	Numbers
Honors	Buffer	Grapes	31
Houses	Rubber	Hungry	38
Season	Dishes	Orange	52
Sensor	Finish	Jogger	73
Series	Punish	Supper	85

Instrumented Vehicle

Two Dodge Caravans were instrumented for data collection. They were both 2005 year model minivans but with different trim packages and mileage. Figure 3.6 shows one of the instrumented vehicles, with inset images of the data collection equipment. The seating and handling were identical in the two vehicles with respect to the requirements of this study. Also, headlights were replaced for both vehicles and appropriately aimed by researchers to ensure that the headlights had similar illuminance distributions. Each vehicle was instrumented with a 10-Hz 66-channel global positioning system (GPS) receiver and laptop. TTI used proprietary distance measuring instrument (DMI) software with the data from the GPS to geocode every response by the participants.

Figure 3.6. Instrumented Vehicle.

Study Procedure

Researchers recruited and scheduled each participant to drive through the closed course route at the Texas A&M Riverside Campus. The participants were met at the entrance to the Riverside Campus by TTI staff and then escorted to an office where they completed an informed consent form, a demographics questionnaire, a Snellen visual-acuity test, and a color blindness test. Prior to starting the study, the participants completed a few additional tasks. First, they were given some brief instructions about what was required of them. Provided they did not have any reservations about conducting the tasks described to them, participants were then escorted to an instrumented vehicle.

The participant was seated in the driver seat of the instrumented vehicle, and the experimenter was seated in the middle-row passenger seat. Once in the vehicle, each participant was given an opportunity to familiarize him-/herself with the vehicle controls (i.e., climate control, lights, and mirrors) and adjust the vehicle to individual preferences. Participants were instructed to wear a seatbelt at all times during the testing and to alert the researcher to any concerns throughout the study. Participants were also instructed to stop the vehicle at any point that they felt it was necessary. While on the course, the participants were instructed to drive 35 mph and not to exceed 40 mph. As the GPS DMI provided real-time speed information, the researcher alerted the driver if he/she was going too fast or too slow, but these comments were kept to the end of each lap to avoid compromising the data.

The researcher guided each participant throughout the closed course. This primarily consisted of providing directions as they drove from the main building to the course, instructions on when to start and stop driving, and a reminder about the driver's task prior to each lap. Again, the task was for the participant to read only the middle word on each overhead guide sign and to read the number on the shoulder-mounted guide sign. At the start of each lap, each participant was instructed to let the researcher know when he/she could clearly read the sign immediately in front of him/her as it became clearly legible. Participants were discouraged from guessing, and if they realized they had misread a sign, they were asked to correct their response as soon as they were certain of the word. The researcher recorded all responses based on sign order, so the input values were 1 through 4. If multiple responses were provided for a sign, there were multiple button presses for a single sign, and the researcher recorded on a paper data sheet the reason for the additional responses, such as an incorrect response by the participant or an accidental button press by a researcher.

Two participants were run at the same time, with one participant in each instrumented vehicle, so the procedure was designed to ensure that one participant did not interfere with or influence the other. The vehicles were staggered so that only one vehicle drove on the course at a time for each lap. This avoided the problem of the headlights of one vehicle impacting the other participant. After completing each lap, participants were instructed to stop at a designated position on the roadway. The stop/start point was strategically placed in a horizontal curve to avoid a participant seeing signs being changed. In addition, researchers asked the participant in the trailing vehicle to turn off his/her headlights as he/she approached the rear of the stopped lead vehicle waiting to start the next lap. The participant in the trailing vehicle did not turn on his/her headlights until the lead vehicle had started the next lap. The total time required to complete one lap and to change signs took approximately 8 minutes.

After the fifth and final lap, the participants were directed back to the main building. The entire driving portion of the study took approximately 45 minutes to complete, with a maximum of another 45 minutes for each participant to complete the required pre-study paperwork and eye exams. On average, most participants left within 1 hour and 15 minutes of arriving. Each participant was paid $50 in cash for completing the study and was then escorted back to the main gate.

CHAPTER 4
ANALYSIS AND RESULTS

Researchers worked to recruit a balance of gender within the age groups and between daytime versus nighttime conditions. Because of weather delays and other unforeseen issues, the final demographic breakdown of participants was not fully achieved as originally intended. Table 4.1 shows the distribution of final participants for which the research team was able to fully reduce and analyze their data. The distribution by gender differed by one or two participants for any given condition, and the final total was within four persons of the original goal. Each participant saw more treatments than were required for a full factorial design. The remainder of this chapter discusses the data reduction and analysis.

Table 4.1. Demographics of Participants Included in the Data Analysis.

Age Group	Daytime[a]		Nighttime		Totals
	Male	Female	Male	Female	
21–35	4	2	4 (3)	8 (2)	23
65+	4	6	13 (2)	11 (5)	41
Totals	**8**	**8**	**22**	**26**	**64**

a. All of the daytime participants were scheduled to return for the nighttime portion of the study, but scheduling conflicts occurred. The actual number of participants that returned for the nighttime study is in parentheses.

Data Reduction

The data reduction consisted of four steps. The first step was to convert the comma-delimited text files generated from the GPS DMI program during data collection. In this step, the data were imported into Microsoft® Excel using a macro. The original files recorded continuous GPS data at 10 Hz, and any response data were saved with the specific GPS point at which a button press was made. Subsequently, any line of GPS data that did not include a button press was removed from the data. In general, there were 20 responses for each participant for the day or night condition.

In the second step, researchers incorporated the data collected on the paper data sheets. This data included the demographic data, and the files were set up to make sure that the demographic data did not include any specific identifiers that could be used to identify the actual participant. For instance, the actual age devoid of the date of birth, gender, and visual acuity were all that were reported. Next, the sign data were recorded for each response. Also included in the paper data sheets were any reasons for additional responses, and these reasons were used to code each data point as either good (G), missed (M), or error (E). Good indicated when a given data point represented the legibility distance for the correct identification of a test word or number. Missed indicated if a participant incorrectly identified a word, and these data were used to evaluate whether a particular word or number was more difficult than others to correctly identify. The error data response was used to purge incorrect responses by the researcher from inadvertent button presses or wrong button presses.

The third step of data reduction was focused on calculating the LI. The GPS location of each sign was added to a tab, and these data were used to calculate the legibility response distance. These values were then divided by the legend height of 16 inches to calculate the LI in feet per inch.

In the fourth and final step prior to analysis, researchers combined all of the individual data from each participant into one master file, and the data were reviewed in detail to purge data that would not be used in the LI analysis. All formulas and links that were created during the first two steps were stripped as the data were input into the master file. In the first pass over the data, all of the error data were removed. Then researchers sorted the data by time of day, age, and LI. Quartiles were calculated ±1.5 times the inner quartile and were applied to the upper and lower quartiles as appropriate to assess and remove outliers. It was believed that any values outside of this range were not typical of the driving population or resulted from either a guess or an unreported inadvertent button press by the researcher. This decreased the final data set by less than 10 percent. The breakdown of the number of data points available in the analysis after the four steps of the data reduction is shown in Table 4.2.

Table 4.2. Demographic Breakdown by Gender and Age with Respect to Data.

Group	Male	Female
Ages 18–35	241 (17%)	254 (18%)
Ages 65+	424 (30%)	486 (35%)

Analysis

Three font types were included for study on the overhead guide signs and shoulder-mounted guide signs. These three fonts, along with their associated abbreviations that will be used throughout the analysis, are:

- Series E(Mod) [E].
- Enhanced E(Mod) [S].
- Clearview 5W [C].

Prior to starting the analysis, researchers made some assumptions, which are discussed in the next section.

Assumptions

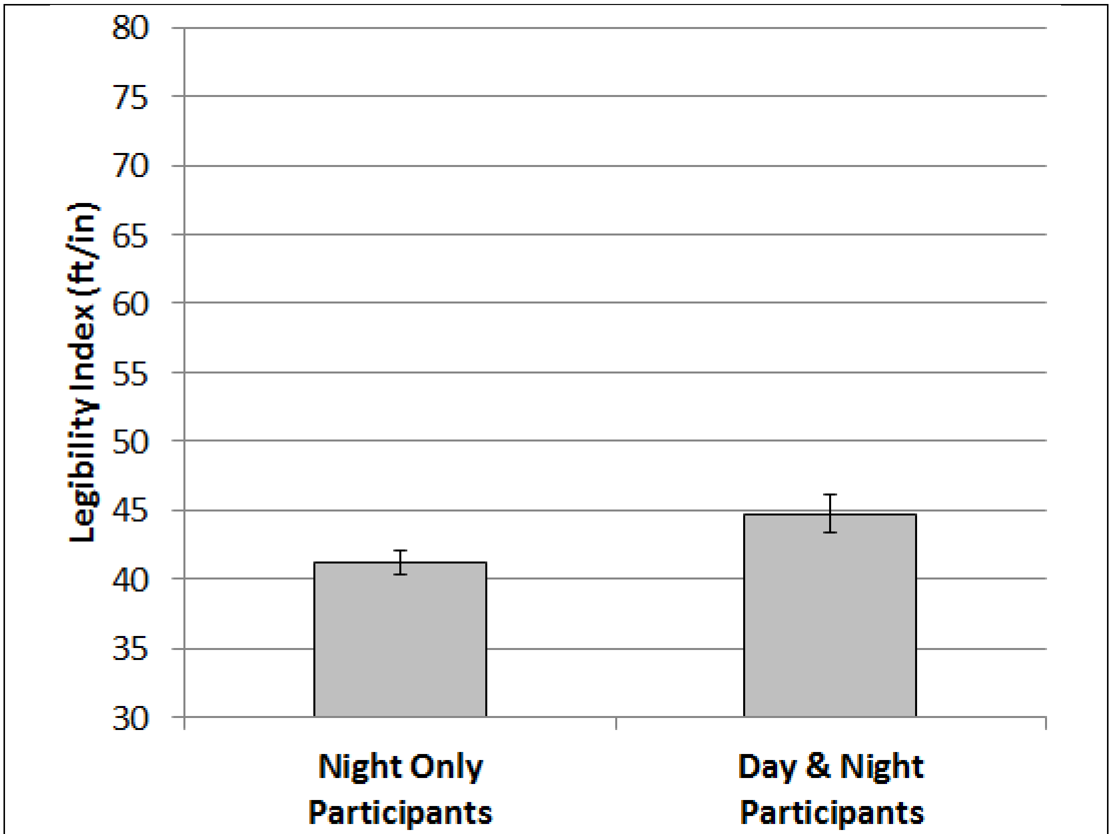
During the course of the study, each participant was presented with every word and every number, and he/she saw each only once. One concern for researchers was the chance that some words might be read incorrectly more often than others, thus possibly skewing the results. Table 4.3 shows a breakdown of the number of incorrect responses by word or number and font. Researchers felt that if a particular word or number was difficult to read, this would be evident in similar proportions across fonts and that a large percentage of the responses would be incorrect. Only about 10 percent of the data collected resulted from incorrect responses. The variability associated with the incorrect responses across the numbers, words, and fonts also appeared to be unique to the fonts. Subsequently, researchers concluded that the words and numbers used in the study were appropriate for including in the remainder of the analysis.

Table 4.3. Number of Incorrect Responses by Legend and Font Type.

Legend	Font			Total
	C	E	S	
31	2	0	3	5
38	2	0	3	5
52	1	1	0	2
73	2	3	5	10
85	4	0	8	12
Buffer	2	**10**	7	19
Dishes	0	1	3	4
Finish	2	0	3	5
Grapes	0	0	1	1
Honors	3	2	2	7
Houses	7	1	1	9
Hungry	0	3	0	3
Jogger	0	**9**	5	14
Orange	0	5	1	6
Punish	0	0	2	2
Rubber	1	0	2	3
Season	1	4	1	6
Sensor	3	1	1	5
Series	5	2	1	8
Supper	7	3	**11**	21
Total	42	45	60	147

Note: The three legends most often read incorrectly are shown in **bold**.

The next assumption was that there was not a learning effect for the participants who viewed the signs in both the daytime and nighttime conditions. This assumption is necessary to combine and analyze all nighttime data together. While 16 participants completed daytime data collection, only 12 of those participants returned for the nighttime portion of the study. The data from those 12 participants were used to evaluate whether the researchers' assumption regarding the learning effect could be held valid by comparing the mean nighttime LI of those 12 participants to that of the other nighttime participants. Data showed that participants who participated in both day and night runs did have a slightly lower mean LI than subjects who only participated in the night study (see Figure 4.1). In fact, the difference was statistically significant, which indicated that the learning effect did occur and nighttime data needed to be purged for the 12 participants that saw the signs in the daytime first.

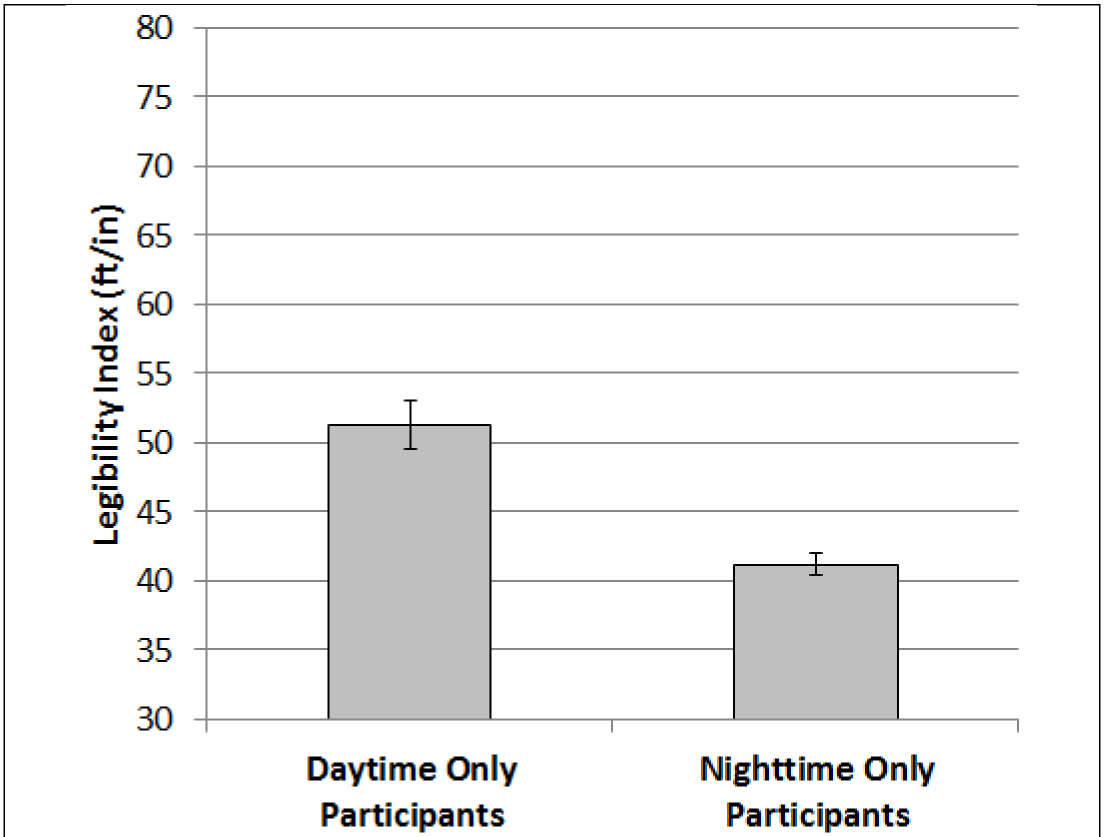


Group	Sample Size	Mean	Standard Deviation	Standard Error Mean	t-Statistic
Night-Only Participants	658	41.2	11.0792	0.4319	−4.163
Day & Night Participants	220	44.7	10.4192	0.7025	

Figure 4.1. Nighttime Legibility Evaluation.

Daytime versus Nighttime Driving

A basic analysis was initially done to compare the LI during the daytime and nighttime driving conditions. With a t-statistic of 11.455, the LI for daytime driving was significantly larger than for nighttime driving, with mean values of 51.3 and 41.2 for daytime and nighttime conditions, respectively (see Figure 4.2). These numbers are also representative of previous studies, as shown in Table 2.1. Researchers subdivide the analysis between daytime and nighttime in the next subsections.



Group	Sample Size	Mean	Standard Deviation	Standard Error Mean	t-Statistic
Daytime Only Participants	254	51.3	13.8343	0.8680	11.455
Nighttime Only Participants	658	41.2	11.0792	0.4319	

Figure 4.2. Daytime versus Nighttime Legibility Evaluation.

Daytime Driving

Using the statistical software SPSS, researchers ran a general linear model univariate analysis on the daytime data, and the results are shown in Table 4.4. A full factorial model was run, but both main effects and interaction effects were found to be statistically significant. Note that all statistical significance in this report refers to findings with a significance level of $\alpha = 0.05$ if not otherwise specified. Legend type as a main effect did not significantly affect the LI, but age group and font type did. The mean LIs for younger and older participants were 68.9 and 45.2, respectively. Researchers highlight these differences because age had the greatest influence in the analysis.

Subsequently, researchers broke the analysis into smaller focused analyses with legend and font within age groups. Figure 4.3 through Figure 4.4 were created to visually look at what was happening with the data. These figures contain the mean LI values and the confidence intervals with respect to two different independent variables, and are followed by single-variable analysis of variance (ANOVA) tests.

Table 4.4. Daytime Analysis.

Source	Type III Sum of Squares	df[a]	Mean Square	F[a]	Sig.[a]
Corrected Model	30,366.553[b]	23	1,320.285	16.819	0.000
Intercept	550,808.4	1	550,808.4	7,016.843	0.000
Font	541.656	2	270.828	3.450	0.033
Legend Type (A, D, N, #)[c]	182.831	3	60.944	0.776	0.508
Age Group	23,428.662	1	23,428.662	298.462	0.000
Font*Legend	1,060.877	6	176.813	2.252	0.039
Font*Age	248.896	2	124.448	1.585	0.207
Legend*Age	1,028.220	3	342.740	4.366	0.005
Font*Legend*Age	421.080	6	70.180	0.894	0.500
Error	18,054.547	230	78.498		
Total	715,800.2	254			
Corrected Total	48,421.100	253			

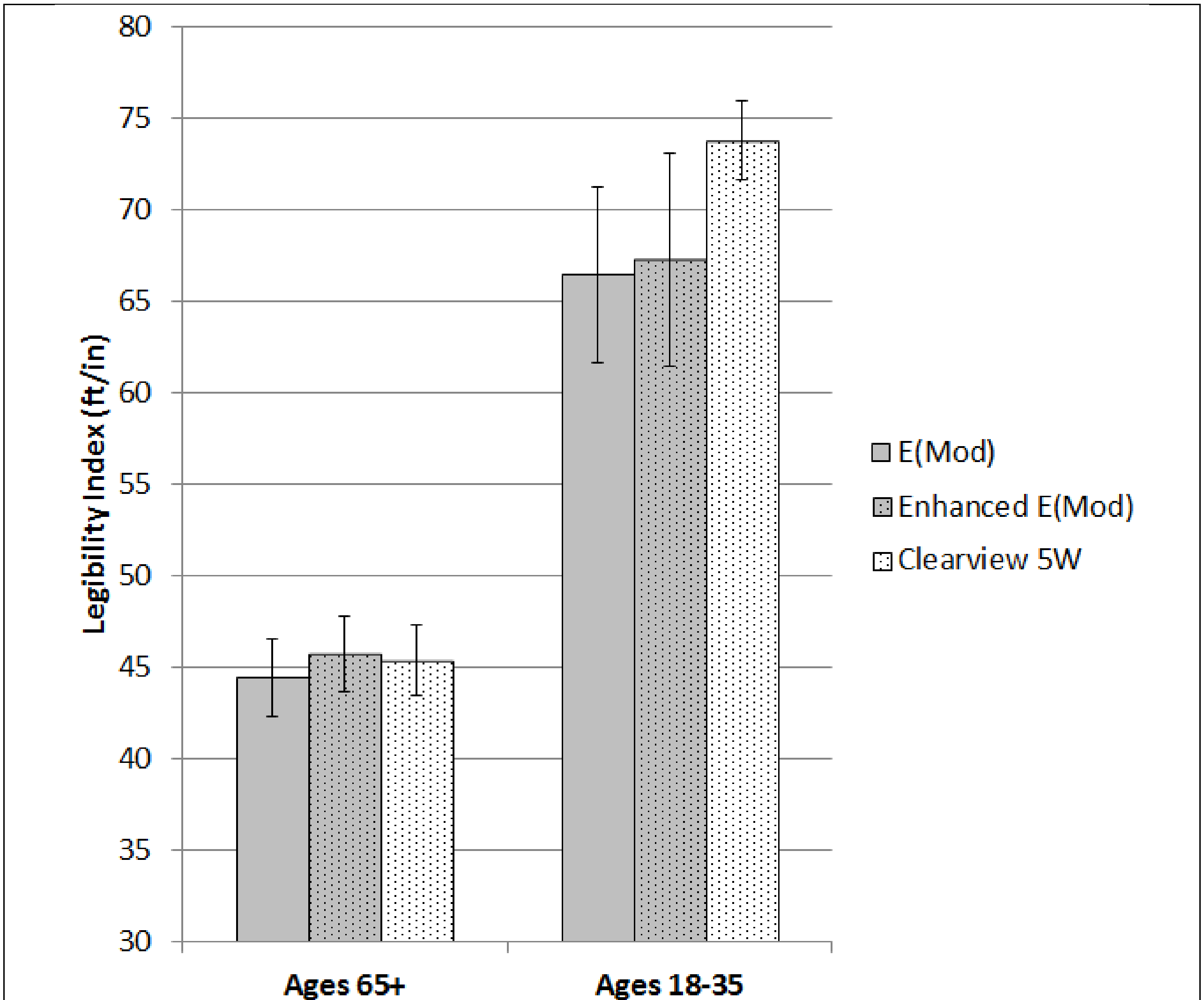
a. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.
b. R Squared = 0.627 (Adjusted R Squared = 0.590), and assumes statistical significance at α = 0.05.
c. Word with ascenders (A), descenders (D), or Neutral (N) for the overhead guide sign, or number (#) for shoulder guide sign.

Figure 4.3 shows that younger drivers were able to read the signs approximately 50 percent farther away than the older drivers. That said, Table 4.4 shows that there was not an interaction between age and font. The researchers reran the analysis by age group and the results are shown at the bottom of Figure 4.3. The single-variable ANOVA was focused on the word legend data only. While age is statistically significant in the overall model of the daytime data, font is not statistically significant within either age group.

Age and legend were shown to have an interaction (see Table 4.4), so the researchers graphed age and legend and ran a separate single-variable ANOVA. In this analysis, the number legends were excluded. Figure 4.4 shows that word legend is almost statistically significant at α = 0.05 in the new model for the older age group; however, word legend type was not significantly different within either age group.

The researchers then focused further on font and legend. The results are presented in Figure 4.5, and the ANOVA shown excludes the number legends. This is the first time for the daytime data where font is shown to be statistically significant, but it is only for Clearview 5W within the font with respect to ascender, descender, and neutral. A Tukey's b post hoc test showed that both the ascender and the descender condition provided over 10 LI greater legibility over the neutral case, or approximately 160 feet for the 16-inch letters used in this study. This does not necessarily mean that Clearview 5W has improved performance over E(Mod) or Enhanced E(Mod).

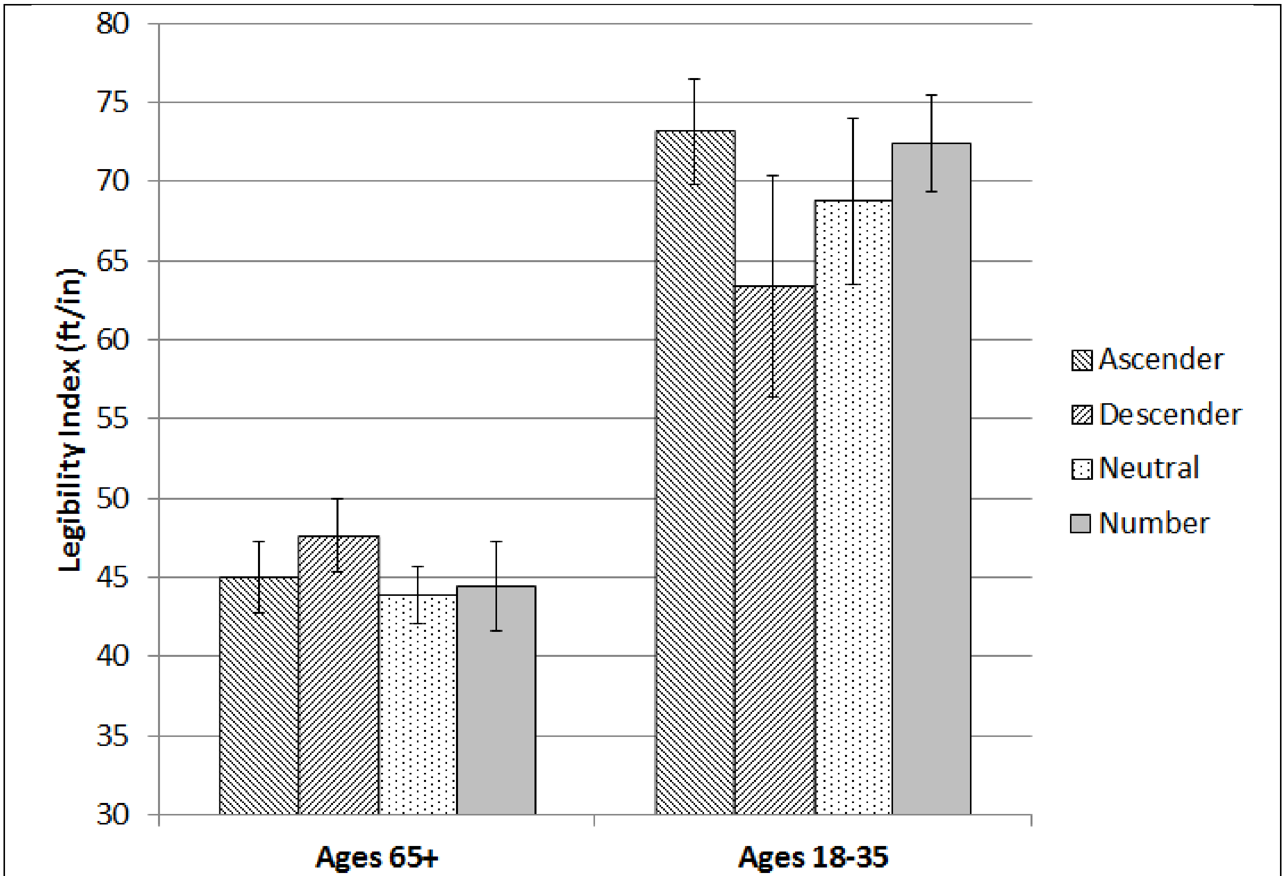
A separate ANOVA was run on the number legends with respect to font (see Table 4.5), and results show that number legends were not significantly different across font.



Age Group	Font	Sum of Squares	df[a]	Mean Square	F[a]	Sig.[a]
65+	Between Groups	59.880	2	29.940	0.448	0.640
	Within Groups	12,441.569	186	66.890		
	Total	12,501.450	188			
18–35	Between Groups	647.392	2	323.696	2.437	0.096
	Within Groups	8,236.207	62	132.842		
	Total	8,883.599	64			

a. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.

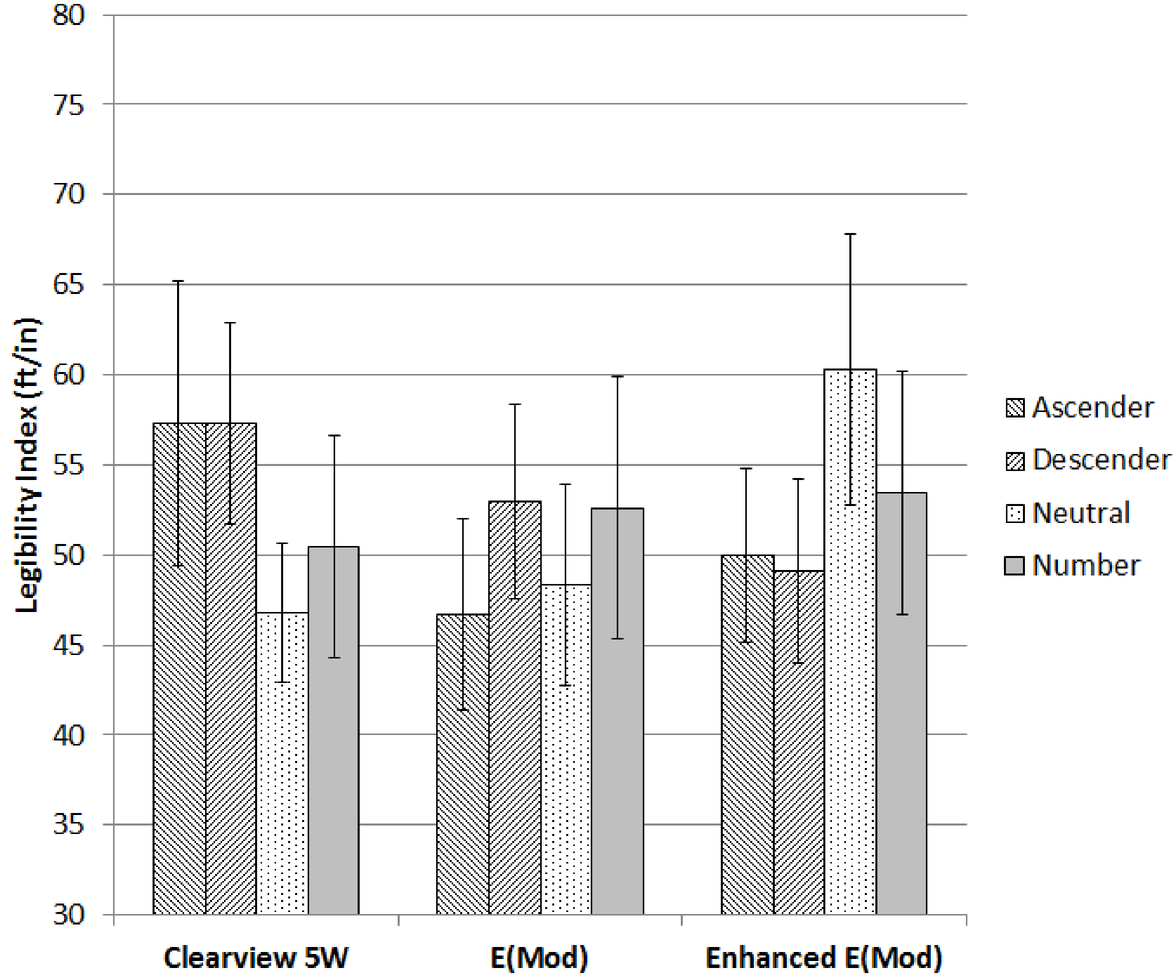
Figure 4.3. LI for Age and Font.



Age Group	Legend Type[a]	Sum of Squares	df[b]	Mean Square	F[b]	Sig.[b]
65+	Between Groups	344.494	2	172.247	3.037	.051
	Within Groups	7996.998	141	56.716		
	Total	8341.492	143			
18–35	Between Groups	798.213	2	399.107	2.520	.092
	Within Groups	7127.789	45	158.395		
	Total	7926.003	47			

a. Numbers were excluded from this single variable ANOVA.
b. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.

Figure 4.4. Daytime LI for Age and Legend Interaction.



Font	Legend[a]	Sum of Squares	Df[b]	Mean Square	F[b]	Sig.[b]
Clearview 5W	Between Groups	1,693.675	2	846.838	5.592	0.006
	Within Groups	8,783.544	58	151.440		
	Total	10,477.219	60			
E(Mod)	Between Groups	457.396	2	228.698	1.357	0.265
	Within Groups	10,114.986	60	168.583		
	Total	10,572.382	62			
Enhanced E(Mod)	Between Groups	985.236	2	492.618	2.743	0.072
	Within Groups	11,675.117	65	179.617		
	Total	12,660.353	67			

a. Numbers were excluded from this single variable ANOVA.
b. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.

Figure 4.5. Daytime LI for Font and Legend Interaction.

Table 4.5. ANOVA Results for LI for Number Legend and Font.

Source	Type III Sum of Squares	df[a]	Mean Square	F[a]	Sig.[a]
Corrected Model	111.014[b]	2	55.507	0.228	0.797
Intercept	161,139.646	1	161,139.646	661.590	0.000
Font (E,S,C)	111.014	2	55.507	0.228	0.797
Error	14,370.298	59	243.564		
Total	182,502.856	62			
Corrected Total	14,481.312	61			

a. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.
b. R Squared = 0.008 (Adjusted R Squared = -0.026), and assumes statistical significance at α = 0.05.

The researchers did not see the trends in the reduced ANOVAs that they anticipated from the model in Table 4.4, so they decided to investigate whether age was impacting the initial model more than the other variables. A separate model was developed for the older and the younger age groups that included both font and legend type. Again, only the word legends were evaluated. Table 4.6 and Table 4.7 show that font, legend, and their interaction were not statistically significant.

Table 4.6. ANOVA for LI for Word Legend and Font (Older Age Group Only).

Source	Type III Sum of Squares	df[a]	Mean Square	F[a]	Sig.[a]
Corrected Model	830.448[b]	8	103.806	1.866	0.070
Intercept	242300.273	1	242300.273	4354.992	0.000
Legend Type (A, D, N)[c]	215.160	2	107.580	1.934	0.149
Font Type (E, S, C)	276.124	2	138.062	2.481	0.087
Legend*Font Type	308.282	4	77.070	1.385	0.242
Error	7511.044	135	55.637		
Total	306065.543	144			
Corrected Total	8341.492	143			

a. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.
b. R Squared = 0.100 (Adjusted R Squared = 0.046), and assumes statistical significance at α = 0.05.
c. Word with ascenders (A), descenders (D), or Neutral (N) for the overhead guide sign.

Table 4.7. ANOVA for LI for Word Legend and Font (Younger Age Group Only).

Source	Type III Sum of Squares	df[a]	Mean Square	F[a]	Sig.[a]
Corrected Model	1954.792c	8	244.349	1.596	0.158
Intercept	189624.090	1	189624.090	1238.499	0.000
Legend Type (A, D, N)[c]	488.623	2	244.312	1.596	0.216
Font Type (E, S, C)	460.426	2	230.213	1.504	0.235
Legend*Font Type	620.843	4	155.211	1.014	0.412
Error	5971.211	39	153.108		
Total	227231.844	48			
Corrected Total	7926.003	47			

a. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.
b. R Squared = 0.247 (Adjusted R Squared = 0.092), and assumes statistical significance at α = 0.05.
c. Word with ascenders (A), descenders (D), or Neutral (N) for the overhead guide sign.

Nighttime Driving

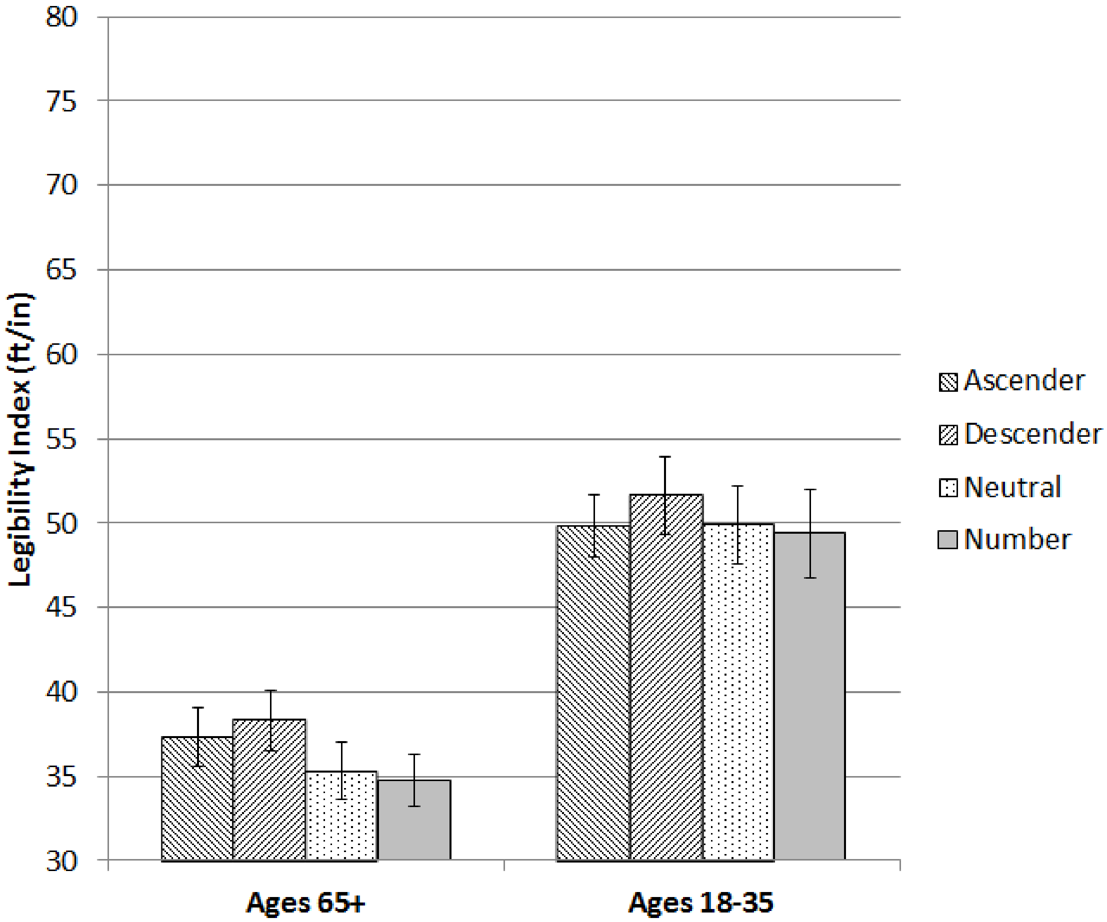
Again using SPSS, a full factorial general linear model univariate analysis was run on the nighttime data, but no interactions were found, so researchers reran the analysis just for the main effects (see Table 4.8). Font type did not significantly affect the LI, but age group and legend type did. The mean LI values and the confidence intervals are shown in Figure 4.6. The mean LIs for younger and older drivers were 50.2 and 36.4, respectively.

Table 4.8. Nighttime Analysis.

Source	Type III Sum of Squares	df[a]	Mean Square	F[a]	Sig.[a]
Corrected Model	29,469.982[b]	6	4,911.664	62.480	0.000
Intercept	1,115,135.656	1	1,115,135.656	14,185.456	0.000
Font	169.294	2	84.647	1.077	0.341
Legend Type (A, D, N, #)[c]	1,036.304	3	345.435	4.394	0.005
Age Group	28,187.718	1	28,187.718	358.571	0.000
Error	51,175.889	651	78.611		
Total	1,196,535.325	658			
Corrected Total	80,645.871	657			

a. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.
b. R Squared = 0.365 (Adjusted R Squared = 0.360), and assumes statistical significance at α = 0.05.
c. Word with ascenders (A), descenders (D), or Neutral (N) for the overhead guide sign, or number (#) for shoulder guide sign.

The researchers reran the analysis within age groups. It was found that legend type was only significant for the older age group, as seen in Figure 4.6. A single variable ANOVA was completed for word legend type within each age group, and older participants were significantly impacted by legend type while younger participants were not. Older participants had statistically significant improvement in their LI when reading descenders rather than neutral words, but had no difference for ascenders. The number legends only differed with respect to age group.



Age Group	Legend Type[a]	Sum of Squares	df[b]	Mean Square	F[b]	Sig.[b]
65+	Between Groups	913.097	3	304.366	3.804	0.010
	Within Groups	34,080.707	426	80.002		
	Total	34,993.804	429			
18–35	Between Groups	167.235	3	55.745	0.728	0.536
	Within Groups	17,142.099	224	76.527		
	Total	17,309.334	227			

a. Numbers were excluded from this single variable ANOVA.
b. Degrees of freedom (df). F-statistic (F). Test result for significance with values less than or equal to α as statistically significant in the model.

Figure 4.6. ANOVA for Nighttime LI by Legend and Age Group.

While font was not significant (see Table 4.8), the researchers decided to graph the data with respect to age and font for reporting purposes. Figure 4.7 shows, as stated in Table 4.8, that font was not significantly different within age groups.

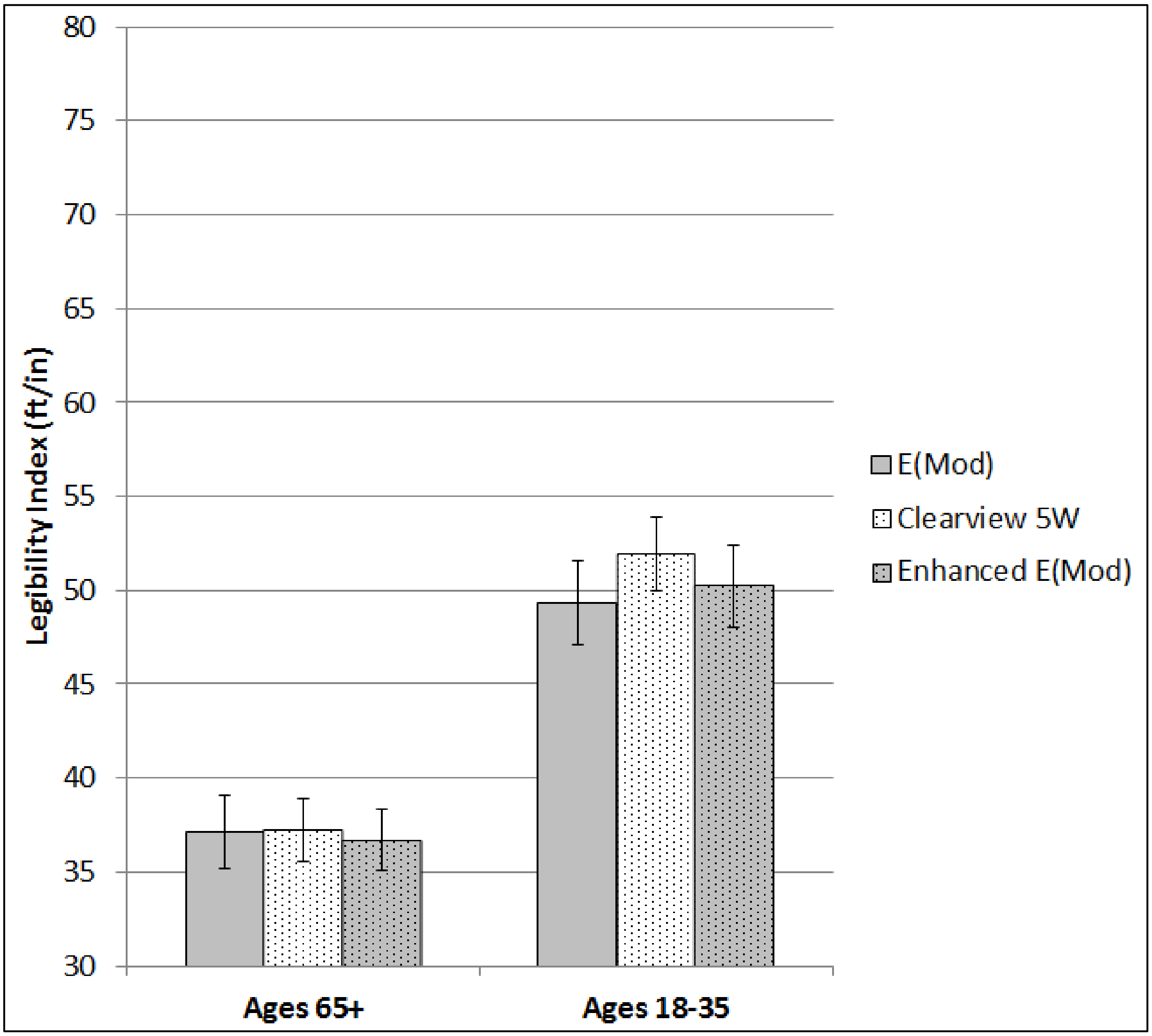


Figure 4.7. Nighttime LI for Age and Font.

CHAPTER 5
COST-BENEFIT ANALYSIS

Researchers conducted a preliminary cost analysis on the impacts of the findings of this research. In any such analysis, the resulting safety benefits must be weighed against factors including material costs, installation costs and time requirements, and any costs associated with use of a particular font. Regarding font costs, of the three fonts tested, Clearview is the only font that requires purchase; E(Mod) and Enhanced E(Mod) are free of charge. The cost of Clearview is currently about $191 per font for a single license (the price includes tax) [12]. As with many bulk purchases, there are discounts for multiple licenses purchased at one time. Depending on the agency's needs, at approximately $2700 for licenses for one font for up to 100 workstations, this can lower the cost to under $30 per workstation. Further discounts are provided if a group buys all available fonts to the point that if that group needed all of the fonts installed on 100 workstations, it would cost approximately $12,000. With the general cost of owning the font addressed, transportation agencies would need to consider several additional factors: material costs for new and/or larger signs, costs associated with removing old signs and installing new ones, potential costs being passed on from consultants that may be required to use the font, and safety benefits and cost savings from lives saved and/or reductions in congestion.

The potential additional cost from using Clearview with respect to a larger sign or other hidden costs are relatively easy to approximate. The Clearview font has a somewhat larger footprint overall than either the E(Mod) font when considering individual words. In an ongoing project, National Cooperative Highway Research Program (NCHRP) 5-20, researchers evaluated overhead guide signs from three different cities. The cities involved in the analysis are Bryan/College Station, Texas; San Antonio, Texas; and Orlando, Florida. A few of the words evaluated are listed in Table 5.1, along with their total width in inches, comparing the E(Mod) and Clearview 5W fonts. The spacing was evaluated using SignCAD® software and 16-inch-tall legends. Researchers estimated the cost for using Clearview 5W over E(Mod) based on a cost of $9.31 per square foot per sign spent for the study documented by this report. Signs were assumed to have ASTM Type XI retroreflective white legend sheeting on ASTM Type IV retroreflective green background sheeting on aluminum extruded panels.

Table 5.1. Word Size[a] Comparison Based on Font.

Legend	E(Mod) (Inches)	Clearview 5W (Inches)	Difference	Estimated Cost
George Bush	157.4	171.6	9.0%	$36.72
Old Reliance	159.2	172.2	8.2%	$33.62
Military Dr	141.8	141.6	−0.1%	$(0.52)
San Antonio	159	164	3.1%	$12.93
Leon Valley	149.6	157.2	5.1%	$19.65
Callaghan Rd	168.6	178.2	5.7%	$24.83
Fairbanks Ave	185.8	188.2	1.3%	$6.21
Amelia St	126.8	129.8	2.4%	$7.76

a. The words were created using 16-inch-tall legends in SignCAD software. Each sign assumed a 12-inch border above and below the word. The standard spacing for E(Mod) 2000 U.S. 2009 was used.

Based on this sample, the differences in the footprints between the fonts would be approximately a 4 percent increase in the width of the sign when switching from E(Mod) to Clearview 5W. When looking at individual words, Clearview 5W does consistently have a wider footprint. One potential advantage of Clearview is that the spacing between words is adjusted according to the words, rather than the spacing between words being fixed as in E(Mod). There is only one instance where that results in a smaller legend footprint than with E(Mod). Clearview 5WR was designed like Clearview 5W, but it was designed to be closer to the footprint of E(Mod). So, the researchers rendered the same words in Clearview 5WR and saw an overall reduction of 2 percent in the size of the signs when using Clearview 5WR over E(Mod). With an average new sign cost of around $500 for the example signs, this would equate to approximately a $10 savings per sign. This does not account for any potential savings from the potential reduction in the size of the sign structures needed to mount the sign. Even if the potential cost savings was seen as significant to an agency, it would be beneficial to conduct at least one more study focusing on the effectiveness of Clearview 5WR versus at least E(Mod).

The last component to be considered is the potential savings associated with shifting to Clearview from a safety and/or congestion aspect. With respect to safety, researchers would need to assess whether fewer crashes occur with the use of E(Mod) or Clearview 5W. Researchers in this study did not conduct a safety analysis, but improvement in legibility distances has been used as a surrogate for improved safety. At 60 mph, there would be 1 additional second of perception reaction time for every additional 88 ft of legibility distance. With respect to LI and the 16-inch letters used in this study, an increase of 5.5 LI would equate to this change. There are a few instances where this level of change in the mean values occurred, but it was either not statistically significant different versus other fonts or the change occurred within a font. So, the researchers believe these findings to be inconclusive. Further research is recommended. On this point, there is a project scheduled to start in the fall of 2013 in Michigan in which the researchers will select changes implemented by the state to evaluate with respect to safety, and the request for proposal specifically mentions the Clearview font.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

The initial hypothesis by the researchers was that the thinner stroke width provided by Clearview 5W and/or Enhanced E(Mod) would provide higher legibility than E(Mod) based on the belief that halation may occur with newer brighter retroreflective sign sheeting materials. While there were instances where Clearview 5W and Enhanced E(Mod) appeared to perform better with respect to LI than E(Mod), the results were inconsistent and never statistically significant. When considering the graph shown in Figure 2.1, the researchers believe that the overhead guide signs never achieved the level of luminance required to create halation and the same may have occurred for the shoulder-mounted sign. Another consideration is that the shoulder-mounted signs were two-digit numbers. Subsequently, it is questionable whether the potential benefits of a thinner stroke width would be captured in the data. That stated, the level of luminance achieved is representative of real world conditions and the participants achieved approximately 80 percent of the daytime performance, so practitioners need to ask a few questions.

- Does a suggested change in policy improve safety and/or reduce cost?
- What is a practical change that is needed in the safety and/or reduction in cost to justify the change in policy?

The researchers believe that the data does not support the use of Clearview 5W as a replacement for E(Mod), and that Enhanced E(Mod) requires further testing prior to making any recommendations for FHWA approval or experimentation. Based on the two questions above, Clearview 5W did not provide a statistically significant improvement in legibility and it is more expensive that E(Mod), so it is neither an improvement to safety or a reduction in cost. Enhanced E(Mod) did not provide statistically significant improvement in legibility, but it does not add any cost if used on a replacement basis.

When considering the practical change in safety and/or cost needed to justify a policy change, the researchers direct the reader back to Figure 4.2. With the overall mean legibility distance for the drivers in the study achieving 80 percent of the daytime legibility at night, should states invest in trying to improve legibility distance, or should states shift to putting a greater emphasis on reducing the cost in signing while maintaining or improving legibility?

Recommendations

One of the many goals of transportation engineers is to implement practices that promote uniformity to meet driver expectancy. Subsequently, the researchers believe changes in that uniformity should only take place if the proposed changes improve safety or reduce cost without reducing safety.

Taking this into consideration, the findings can be applied in at least two ways. One group could say that practitioners should stop the use of Clearview 5W, and there is no reason to pursue the use of Enhanced E(Mod) because it is not better than E(Mod). The other group could say that Clearview 5W and Enhanced E(Mod) have similar performance to E(Mod) and should be allowed for use. The researchers of this report see both sides and recommend the following:

- The data do not support the change to Clearview 5W, because they do not provide a statistically or practically significant improvement in legibility or a reduction in cost for positive contrast overhead guide signs. Furthermore, data from previous research [7] did not show a practically significant improvement for Clearview 5W for shoulder-mounted signs either.

- It is not recommended for practitioners to seek approval for the use of or field experimentation with Enhanced E(Mod), but it should not be excluded from consideration of future font related research.

Future Research

The researchers have developed a list of potential future research that could help provide better guidance on when and how to evaluate other fonts. In addition, the list includes ideas developed from summary discussions that have resulted from the initial review of this report in its draft form and a webinar that was hosted by the research team on February 20, 2014.

- Font Evaluations:
    - As E(Mod) appears to provide around 80 percent of the daytime legibility distance at night, it is believed that future research should focus on fonts that reduce the size of the sign while maintaining or providing better nighttime legibility than E(Mod).
    - Develop a tool that allows practitioners to design signs and predict expected performance based on font type, font size, sign type, vehicle speed, roadway geometry, message content, and driver age.
    - Develop a laboratory technique to quickly and inexpensively test candidate fonts prior human factors driving evaluations.
- Signing Policy:
    - Develop improved guidance to address the use of redundant signs with respect to quantity, placement, size, and in some cases whether signs are even needed such as route signs on low volume roadways.
    - Develop improved guidance on sign placement to improve driver expectancy.
- Develop a national pooled-fund accelerated weathering durability retroreflective sign sheeting evaluation program that could be used by states for predicting normal and premature end-of-life performance.

REFERENCES

1. Meeker and Associates. ClearviewHwy®. http://clearviewhwy.com. Accessed on September 26, 2013.

2. Federal Highway Administration. MUTCD—Interim Approval for Use of Clearview Font for Positive Contrast Legends on Guide Signs. Memorandum. http://mutcd.fhwa.dot.gov/res-ia_clearview_font.htm. Accessed on September 26, 2013.

3. Federal Highway Administration. *Manual on Uniform Traffic Control Devices*. Washington, D.C., 2009.

4. P.M. Garvey, M.T. Pietrucha, and D. Meeker. "Effects of Font and Capitalization on Legibility of Guide Signs." *Transportation Research Record 1605*, TRB, National Research Council, Washington, D.C., pp. 73–79, 1997.

5. H.G. Hawkins, M.D. Wooldridge, A.B. Kelly, D.L. Picha, and F.K. Greene. *Legibility Comparison of Three Freeway Guide Sign Alphabets.* TxDOT Report 1276-1F, Texas Transportation Institute, College Station, Texas, 1999.

6. P. Carlson. *Evaluation of Clearview Alphabet with Microprismatic Retroreflective Sheeting*. TxDOT Report 0-4049-1, Texas Transportation Institute, College Station, Texas, August 2001.

7. A. Holick and P. Carlson. *Nighttime Guide Sign Legibility for Microprismatic Clearview Legend on High Intensity Background*. TxDOT Report 0-1796-4, Texas Transportation Institute, College Station, Texas, September 2003.

8. P.J. Carlson and A.J. Holick. "Maximizing Legibility of Unlit Freeway Guide Signs with Clearview Font and Combinations of Retroreflective Sheeting Materials." *Transportation Research Record 1918*, TRB, National Research Council, Washington, D.C., pp. 26–34, 2005.

9. A. Holick, S. Chrysler, E. Park, and P. Carlson. *Evaluation of the Clearview Font for Negative Contrast Traffic Signs*. TxDOT Report 0-4984-1, Texas Transportation Institute, College Station, Texas, 2006.

10. ASTM International. D4956—11a: Standard Specification for Retroreflective Sheeting for Traffic Control. West Conshohocken, Pennsylvania. March 30, 2011.

11. P. Carlson, J. Miles, E. Park, S. Young, S. Chrysler, and J. Clark. *Development of a Model Performance-Based Sign Sheeting Specification Based on the Evaluation of Nighttime Traffic Signs Using Legibility and Eye-Tracker Data*. TxDOT Report 0-5235-1, Vol. 1, Texas Transportation Institute, College Station, Texas, September 2010.

12. AASHTO. M268—10: Standard Specification for Retroreflective Sheeting for Flat and Vertical Traffic Control Applications. Washington, D.C. 2010.

13. F. Schieber. “Using the ‘Blur Tolerance’ Technique to Predict and Optimize the Legibility Distance of Symbol Highway Signs.” *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Vol. 38*, Nashville, Tennessee, pp. 912–915, October 1994.

14. F. Schieber, D.W. Kline, and R. Dewar. “Optimizing Symbol Highway Signs for Older Drivers.” *Proceedings of the 12th Triennial Congress of the International Ergonomics Association, Vol. 6*, Toronto, Canada, pp. 199–202, 1994.

15. R. McCall and F. Schieber. “Validating the Effectiveness of Recursive Blur Enhancement of Symbol Signs Using Static and Dynamic Protocols.” *Proceedings of the Human Factors and Ergonomics Society 54th Annual Meeting*. Human Factors and Ergonomics Society, San Francisco, California, 2010.

APPENDIX A
STUDY FORMS

Project #99-479520-001 Evaluation of Guide Sign Fonts

You are being invited to take part in a research study being conducted by Bari Kotwal and Sarah Hammond, researchers from the Texas A&M Transportation Institute which is part of the Texas A&M University System. The study is being sponsored by the Minnesota Department of Transportation (MnDOT). You are being asked to read this form so that you know about this research study. The information in this form is provided to help you decide whether or not to take part in the study. If you decide to take part in the study, you will be asked to sign this consent form. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefit you normally would have.

WHY IS THIS STUDY BEING DONE?
The purpose of this study is to determine the legibility distances of guide signs used on roadways.

WHY AM I BEING ASKED TO BE IN THIS STUDY?
You are being asked to be in this study because you have a current driver's license without any nighttime restrictions, age 18 or older, able to speak and understand English, and have a minimal level of acceptable vision.

HOW MANY PEOPLE WILL BE ASKED TO BE IN THIS STUDY?
A maximum of 60 participants will be invited to participate in this study locally. The first 20 participants will be asked to participate in both a day and night-time condition study. The remaining 40 will be invited to participate in the night-time condition study only.

WHAT ARE THE ALTERNATIVES TO BEING IN THIS STUDY?
The alternative to being in this study is not to participate.

WHAT WILL I BE ASKED TO DO IN THIS STUDY?
There will be two groups: The group that you have been selected to participate is circled below:
GROUP 1 **GROUP 2**

Group 1 – will be the first 20 participants, your participation in this study will last up to 3 hours for one night and 3 hours for one day. So you will be participating for a total of 6 hours.

Group 2 – will be the next 40 participants, your participation will last up to 3 hours for one night only.

For both groups, upon arrival, you will be given a verbal briefing and will be asked to read and sign an informed consent document. You will be asked to show your driver's license to assure that it is current with no nighttime restrictions. For safety reasons, a standard visual acuity, a vision contrast, and a color blind screening will be conducted to ensure that you have at least the minimal levels of acceptable vision. If you do not meet these standards, you will be compensated $10.00 for your time.

IRB NUMBER: IRB2012-0674
Initials
IRB APPROVAL DATE: 12/04/2012
IRB EXPIRATION DATE: 11/30/2013

You will be driving a state-owned passenger vehicle on a closed course at the Texas A&M Riverside Campus. The study vehicle is specially equipped to record and measure various driving characteristics, but drives just like a normal car. You will be accompanied at all times by a study administrator who will provide verbal directions to you. You are to obey all traffic laws at all times. You will not be asked to exceed the posted speed limit at any time. You must agree to wear a safety belt at all times.

At various points within the driving task, you will be asked to tell the study researcher when you can correctly read the words on the various guide signs. A researcher will be in the vehicle with you at all times and will tell you what information is needed for each treatment you view. At the end of each test area, you may be asked to indicate if you have any general or specific comments with respect to the treatment that you just viewed. Upon completion of the driving task, you will return here to be debriefed on the study and complete the paper work necessary to receive your compensation.

ARE THERE ANY RISKS TO ME?

The things that you will be doing have no more risk than you would come across in everyday life. The risks associated with this study are minimal and you will be exposed to the general types of risks associated with driving a motor vehicle on closed course roadways located at the Riverside Campus. While there should not be any other vehicles on the runways/roadways, if you do encounter other vehicles at any time during the driving task, you are to drive and react as you normally would on any other roadway. When driving the state-owned vehicle, you will have physical control of the vehicle at all times and will be responsible for ensuring it is operated safely. The study procedure has been designed to minimize the risk from your surroundings including the other motor vehicles. All steps have been taken to ensure your safety in the event of an accident. The motor vehicle is equipped with standard airbags for supplemental occupant protection. You will be given time for you to get familiar with the vehicle before the experiment begins. If at any time you feel uncomfortable or unsafe performing any of the tasks asked of you, you have the right to refuse to perform the task.

A cellular telephone will be available to the researcher at all times. In case of an accident or medical emergency, appropriate emergency medical services will be called. However, neither MnDOT, TTI nor Texas A&M University will assume financial responsibility for any medical costs incurred due to your participation in this study. Continuing medical care and/or hospitalization for research-related injury will not be provided free of charge nor will financial compensation be available or provided by Minnesota Department of Transportation, TTI, TAMU or the investigators.

WILL THERE BE ANY COSTS TO ME?

Aside from your time, there are no costs for taking part in the study.

WILL I BE PAID TO BE IN THIS STUDY?

At the end of your participation for each study you will be compensated $50.00. If you are uncomfortable with any part of the procedure, do not hesitate to make it known to the researcher. If you choose not to continue to participate in the research for any reason, you are free to quit at any time. After the practice drive you will be asked if you'd like to continue. If you would like to quit at this time, or any time before the end of the study, you will receive compensation of

$10.00. Unforeseen circumstances such as equipment breakdown may cause the researcher to excuse you from further participation on the project. In that event, you will be compensated at least $20.00. Other than the compensation, there are no special benefits for the participants.

WILL INFORMATION FROM THIS STUDY BE KEPT PRIVATE?

The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only Bari Kotwal and/or Sarah Hammond as well as the other researchers on the project will have access to the records.

Once the data is entered into electronic format, a code linking individual participants to the research will be used. Information about you will be stored in the TTI Gibb Gilchrist Building. Hard copy data with confidential information will be kept until the project has been completed, after which it will be destroyed. Electronic research data will be stored with no identifying links for a minimum of 7 years. Information forms of those participants that would like to be added to the TTI previous subject list, will be taken from the project file and placed into the subject list data base, at which time the hard copy will be destroyed. The data base is restricted and can only be accessed with the appropriate password.

Information about you will be kept confidential to the extent permitted or required by law. This consent form will be filed securely in an official area.

People who have access to your information include the Principal Investigators and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly.

WHOM CAN I CONTACT FOR MORE INFORMATION?

You can call the Principal Investigators to tell them about a concern or complaint about this research study. The Principal Investigators can be called or emailed at: Bari Kotwal at 979-862-3699, b-kotwal@tamu.edu and/or Sarah Hammond at 979-862-6300, s-hammond@tamu.edu. For questions about your rights as a research participant, or if you have questions, complaints, or concerns about the research and cannot reach the Principal Investigator or want to talk to someone other than the Investigator, you may call the Texas A&M Human Subjects Protection Program office.

- Phone number: (979) 458-4067
- Email: irb@tamu.edu

MAY I CHANGE MY MIND ABOUT PARTICIPATING?

This research is voluntary and you have the choice whether or not to be in this research study. You may decide not to participate or stop participating at any time. If you choose not to be in this study or stop being in the study, there will be no effect on your relationship with MnDOT, TTI, or TAMU. If you do quit before the end of the study, you will receive compensation of $10.00 for your time.

STATEMENT OF CONSENT

I agree to be in this study and know that I am not giving up any legal rights by signing this form. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I know that new information about this research study will be provided to me as it becomes available and that the researcher will tell me if I must be removed from the study. I can ask more questions if I want. A copy of this entire, signed consent form will be given to me.

______________________________	______________________________
Participant's Signature	Date
______________________________	______________________________
Printed Name	Date

INVESTIGATOR'S AFFIDAVIT:
Either I have or my agent has carefully explained to the participant the nature of the above project. I hereby certify that to the best of my knowledge the person who signed this consent form was informed of the nature, demands, benefits, and risks involved in his/her participation.

______________________________	______________________________
Signature of Presenter	Date
______________________________	______________________________
Printed Name	Date

IRB NUMBER: IRB2012-0674
IRB APPROVAL DATE: 12/04/2012
IRB EXPIRATION DATE: 11/30/2013
Initials

Texas Transportation Institute

SUBJECT INFORMATION

Project: ____________

Name: ______________________________ City: ______________

Phone (Home): ______________ Phone (Alternate): ______________

E-mail Address: ____

General / Vision		Driving Experience	Years	Education	(✓)
Age		Passenger Vehicle		Some High School	
Gender	M / F	Motorcycle		K-12 / GED	
Visual Acuity	20 /	RV		Some College	
Contrast Sensitivity	20 /	Personal Trailer		Associates / Equivalent	
Corrected Vision	Y / N	Work Trailer		Bachelor	
Contacts	Y / N	Tractor Trailer		Master	
Glasses	Si/Bi/Tri	Bus		PhD	
Transition	Y / N	Other:__________		Currently Student	Y / N
Color Blind	Y / N				

Have you had any previous eye surgery? Yes No
If yes, please explain: ____

____

Do you currently have any visual concerns ? Yes No
If yes, please explain: ____

____

Do you have any motion sickness problems? Yes No

I have voluntarily given my personal information to a TTI researcher so that I may be contacted to participate in future TTI research studies.

Signature: ______________________________

Section below the solid line to be completed by Administrator

Project #99-479520-001 October, 2012

ATM
IRB NUMBER: IRB2012-0674
IRB APPROVAL DATE: 12/04/2012
IRB EXPIRATION DATE: 11/30/2013

Prior to Study - Verbal Instructions to Subjects

My name is ______________________________. I work for the Texas A&M Transportation Institute, which is part of the Texas A&M University System. I would first like to thank you for volunteering to participate in this study. The study is being sponsored by the Minnesota Department of Transportation. The purpose of this study is to determine the detection and legibility of roadway guide signs.

This study has been reviewed and approved by the Texas A&M Institutional Review Board for the use of human subjects in research. Before we can begin you will need to read, understand, and sign this document. *(Hand the subject the consent form.)* This is an informed consent document that confirms that you are volunteering to participate in this study and that you understand what is being asked of you. If you have any questions, please let me know. *(Allow the participant to read the consent form, ask questions, and sign the form. Then give a copy of a signed form to the subject*

First, for safety reasons, a standard visual acuity, vision contrast sensitivity, and a color blind eye screening will be conducted to ensure that you have at least the minimal levels of acceptable vision.

Conduct visual acuity screening test using the Snellen Acuity eye chart. *Binocular only. Record acuity based on last line of which the participant reads all letters correctly. If the participant misses only one or two letters, have them try to read the next larger line. If they get all letters correct, continue to the next line down. If they cannot read the smaller line, go back to the previous line. If they still make errors, use the last all-correct line to determine acuity.*

Conduct contrast sensitivity screening test using the Vistech chart. *Binocular only. First point out the sample patches at the bottom of the chart with the three possible responses (left, right, or straight up). Start with Row A and ask the participant to identify the last patch in which lines can be seen and tell you which direction they tilt. If a response is incorrect, have them describe the preceding patch. Once the participant has correctly identified a patch, have them guess which way the lines tilt in the next patch to the right. Record the last patch the participant correctly identifies in each row by marking the corresponding dot on the Evaluation Form. Record the lowest acuity that the line falls through; highest number is lowest acuity.*

Conduct color blind screening. *Binocular only. Have participants read the numbers on the chart of five color vision dots (A through E). People with normal color vision will have no problem seeing the numbers on the chart, but those who have color vision limitations will have difficulty seeing the numbers in the color vision dots B through E. They will see only random colored dots.*

Now, let me tell you a little about your task. You will drive in a state-owned passenger vehicle on a closed course we have set up here at the Riverside Campus. The vehicle is specially equipped to record and measure various driving characteristics, but it drives just like a normal car. A researcher will be in the vehicle with you at all times and will direct you when, where, and how fast you will need to drive. However, you will not be asked to drive over 40 mph.

While you are driving you will encounter various roadway signs which will be explained in detail when we are in the test vehicle. For each sign, you will be asked to tell the researcher when you can detect the

IRB NUMBER: IRB2012-0674
IRB APPROVAL DATE: 12/04/2012

Verbal Instructions to Participants in Test Vehicle

- *Make sure participants fasten their seat belt.*
- *Make sure the participant is wearing glasses if required on driver's license.*
- *During the day time condition make sure the participants are not wearing sun glasses.*
- *At night, make sure the headlights are on dim (low beam) at all times.*

Before we start, I would like for you to get familiar with the vehicle. Please check your mirrors and adjust your seat so that you are comfortable. Now, we will drive to the starting point on the study course, which will give you a few minutes to get adjusted to the vehicle. When you feel comfortable, let me know and we will begin.

Now, if you remember, you will be asked to drive a predetermined route here on the Riverside Campus. While you are driving you will encounter several guide signs on the roadway. You are to focus on the guide signs and please read the words out loud when you feel you can clearly correctly read the words. If you read the wrong word, please let me know what the corrected word or words are as soon as possible.

Okay, when you are ready let me know and I will direct you to the starting point.

Project #99-479520-001
October 2012

Age:________		Gender: F	M
Visual Acuity Test:	20/________		
Contrast Sensitivity Test:	20/________		
Color Blind:	Yes	No	

DATA FORM

NIGHTTIME or DAYTIME condition (*Circle One*)

Subject No: ____________	Date: _________
Weather Conditions: __________	Researcher: __________
Study Order: ______________	Time:____________

Remember, As soon as you feel you can correctly read the word or words on the sign, read them aloud. If you realize that you did not read the words correctly, please read them correctly at that point.

Please feel free to comment on the signs if there is something that stands out in a particularly good or bad way. We are interested in your feedback.

Lap	Word(s) on Sign	Correct Word(s) (✓)	Incorrect Word(s)		Comments
			Extra tag (✓)	Word(s) Spoken	
1A					
1B					
2A					
2B					
3A					
3B					
4A					
4B					
...					
12A					
12B					

A|M
IRB NUMBER: IRB2012-0674
IRB APPROVAL DATE: 12/04/2012

APPENDIX B
STUDY SIGN EXAMPLE LAYOUTS

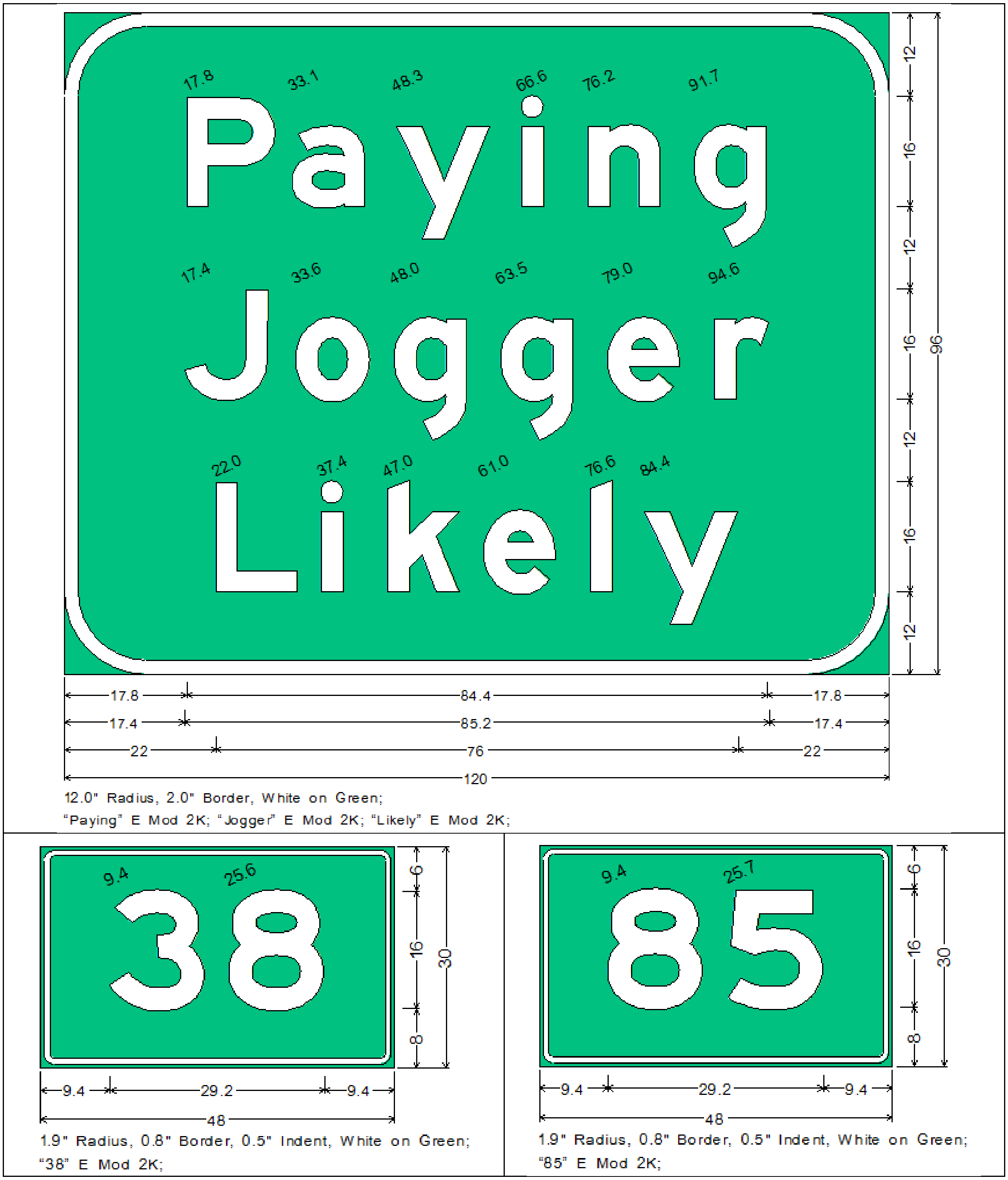


Figure B.1. E(Mod) Sign Layouts.

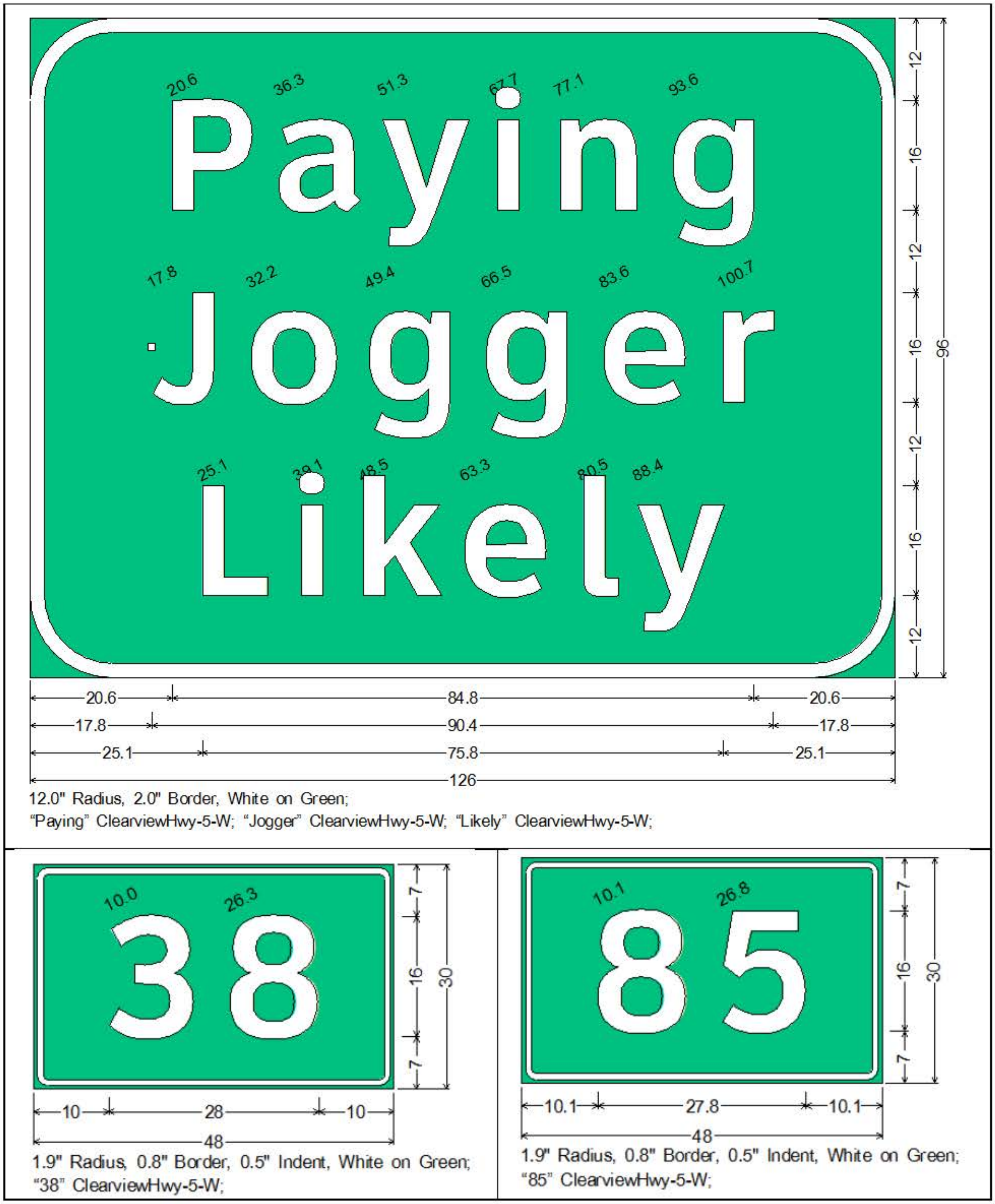


Figure B.2. Clearview 5W Sign Layouts.

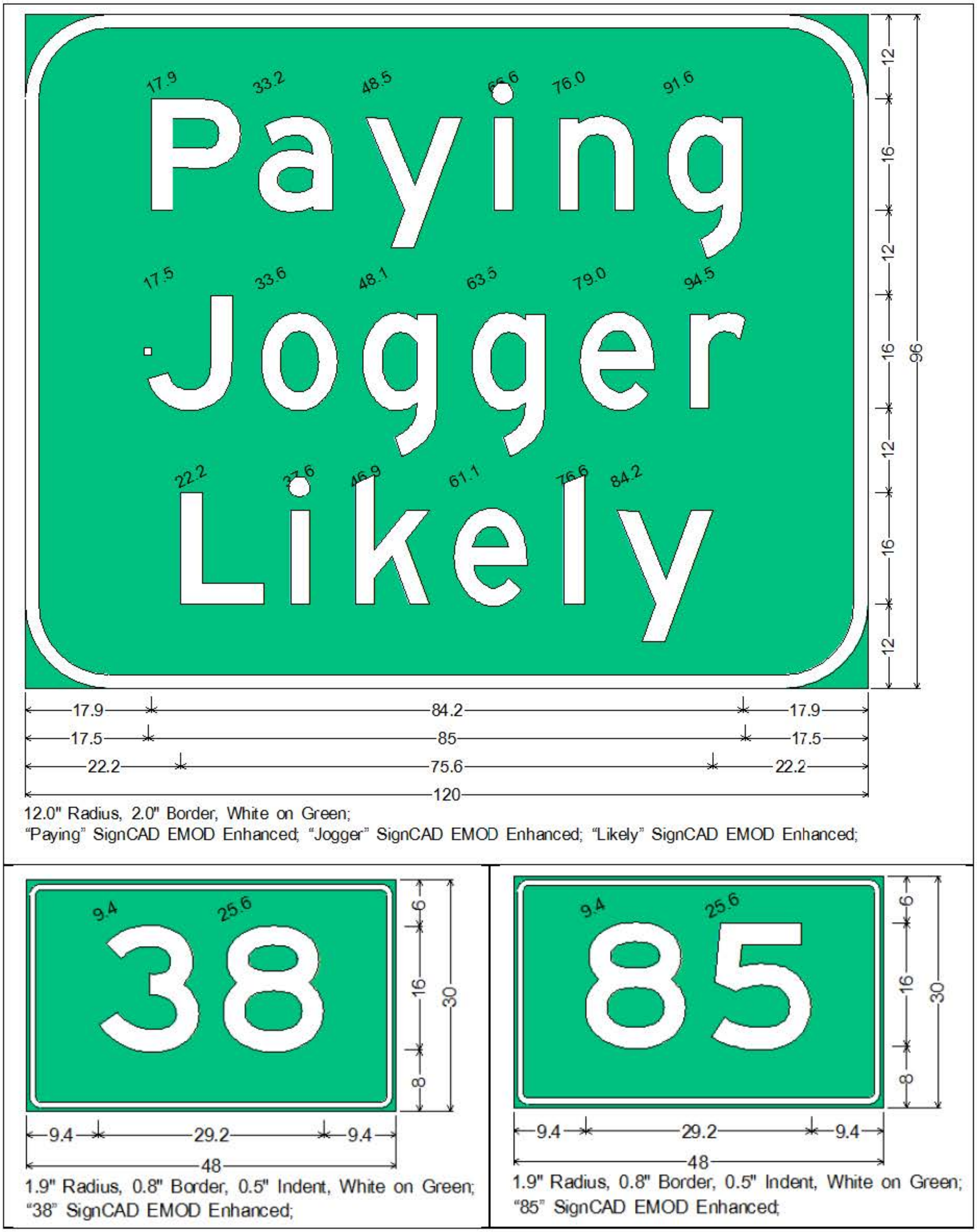


Figure B.3. Enhanced E(Mod) Sign Layouts.