I-95 Corridor Coalition

Reference Location Sign Study

Phase II – Survey, TarVIP Analysis, and Field Validation

April 2008

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Prepared for:

I-95 Corridor Coalition

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1. ABSTRACT

Mile marker signs on interstates are both a convenience and a safety measure in that they provide travel progress information to motorists and essential location information for 911 emergency procedures. Motorists who report accidents need to be able to identify the location of a crash so that first responders will be able to deploy help from the appropriate facility as fast as possible. Providing crash location information becomes more difficult on complex urban highway interchanges. Inadequate ramp designation signing may lead to incorrect locations being called into the 911 dispatcher. This may cause delays in providing aid. The goal of the research performed in this study was to determine mile marker and ramp designation sign effectiveness using (1) a computer model of human nighttime legibility with a program called Tarvip, (2) a computer-based sign comprehension analysis, and (3) a road test validation. Tarvip provided the letter height and the legibility distance of the mile marker and ramp signs, while the comprehension analysis provided the design, content, and layout of the signs. The road test validated the results from Tarvip and the comprehension analysis.

2. INTRODUCTION

The purpose of this research project was to (1) find the best design/deployment of mile markers and (2) find the best design for ramp designation signs so that motorists can pinpoint locations along the freeway and relay it to first responders, if needed.

A pilot study was conducted in 2006 by KMJ Consulting, Inc. [1] on behalf of the I-95 Corridor Coalition to evaluate all of the types of signs that are currently being used. The study also covered the following items:

- cost considerations
- deployment policy and spacing
- cluttering of the highways
- Enhanced Reference Location Signs continued relevance given E911's role.

The findings of the KMJ report were that the anticipated adoptions as of January 2006 were:

- Four states with a State MUTCD were in substantial conformance with the National MUTCD.
- 22 States adopting the National MUTCD with a State supplement.
- 26 States plus Puerto Rico and the District of Columbia adopting the national MUTCD without a supplement.

The KMJ study compared the mile marker signs from Florida, Indiana, Iowa, Kentucky, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Vermont, West Virginia, and Wisconsin and to the 2003 MUTCD Standard layout. The previous study also compared ramp signs from Kentucky and New Jersey. From this previous study, some mile marker and ramp signs where chosen to be further investigated in more detail, which is covered in this report. The previous study also discussed an earlier study conducted by Pigman [2] from the Kentucky Transportation Center at the University of Kentucky, which evaluated reference location signs. The Pigman recommendation was to space the mile markers every 0.2 miles, with an exception to curved sections having the spacing be every 0.1 miles. Pigman also found that white on blue mile markers performed slightly better than the white on green mile markers. Pigman proposed the use of white on blue mile marker signs and the layout of the content on the sign look like the Indiana mile marker sign.

The study described within this report was conducted to determine how to maximize legibility and comprehension during nighttime driving with low beams only, which is important because the sign is only illuminated by the headlamps of the vehicle approaching the sign. Also if the sign performs adequately during nighttime driving, the sign will likely perform better during daytime because of ambient illumination provided by the sunlight and the daytime adaptation of the observer visual system. A number of parameters that affect mile marker and ramp sign legibility are available/required preview time, recognition distance, and legibility distance. In this study, there were three phases (Figure 1): Phase I - Tarvip Analysis, Phase II - Comprehension Analysis, Phase III - Road Test Validation. The first and second phases of this study were conducted inside a laboratory at The University of Iowa. The third phase was conducted on a public county road.

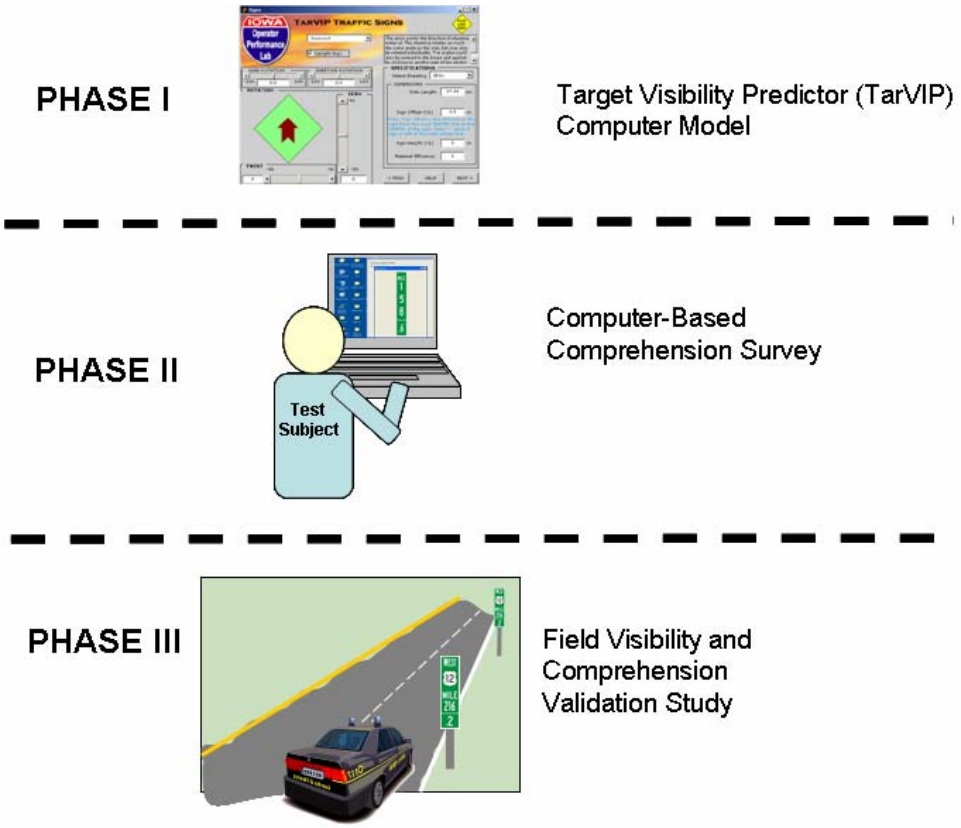


Figure 1. Diagram of Three Phases

In the first phase, a Tarvip model was built to compare the nighttime legibility performance of American Society for Testing and Materials (ASTM) Type III and full cube corner sheeting materials under automobile low-beam headlamp illumination. Tarvip is a traffic sign legibility modeling program that simulates visibility from an automobile with specified headlamps driving toward a sign at a specified speed, and for specified driver characteristics such as driver eye position and driver age. The program also incorporates the sign size, letter height, font, background and legend sheeting materials. Parameters for the driver eye position in relation to the sign and headlamp locations were obtained from a previous study performed by Zwahlen and Schnell [3]. The benchmark for the minimum required legibility distance (MRLD) was obtained from a study done by Zwahlen [4]. The results generated with Tarvip were legibility distance estimates for the different sign designs.

The second phase of this study was a traffic sign comprehension analysis to evaluate the information motorists were able to recall about a simulated sign shown on a computer screen for three seconds. The conceptual idea is that a motorist might have to recall the last mile marker or ramp designation sign when making a call to first responders. After viewing each sign on a computer screen, the subjects were asked a series of questions probing on sign comprehension. The three second presentation time for the sign stimuli was selected using a pilot run based on an 85th-percentile correct response level. An 85th-percentile was chosen since it is an engineering

traditional set point and related to available viewing times while driving. Participants were seated in front of a computer while the program ran through the presentation and answer sequence.

The third phase, the road test study, was used to validate what was found from the Tarvip model and comprehension analysis. This phase of the study was only run during nighttime with low beam headlamp illumination. Participants drove at 15 mph throughout the study. A Ford Taurus SE (2000) instrumented car was equipped with an audio and video recorder and a Distance Measurement Instrument (DMI) system to measure the legibility distance to the signs, which is shown in **Figure 2**. Participants were asked to identify the color of the sign and to read out loud whatever they could read when the sign's legend would come into view. After the participants were done driving through the test section, a post-survey was administered to evaluate the comprehension of the signs and to rank the quality of the information presented on the signs.

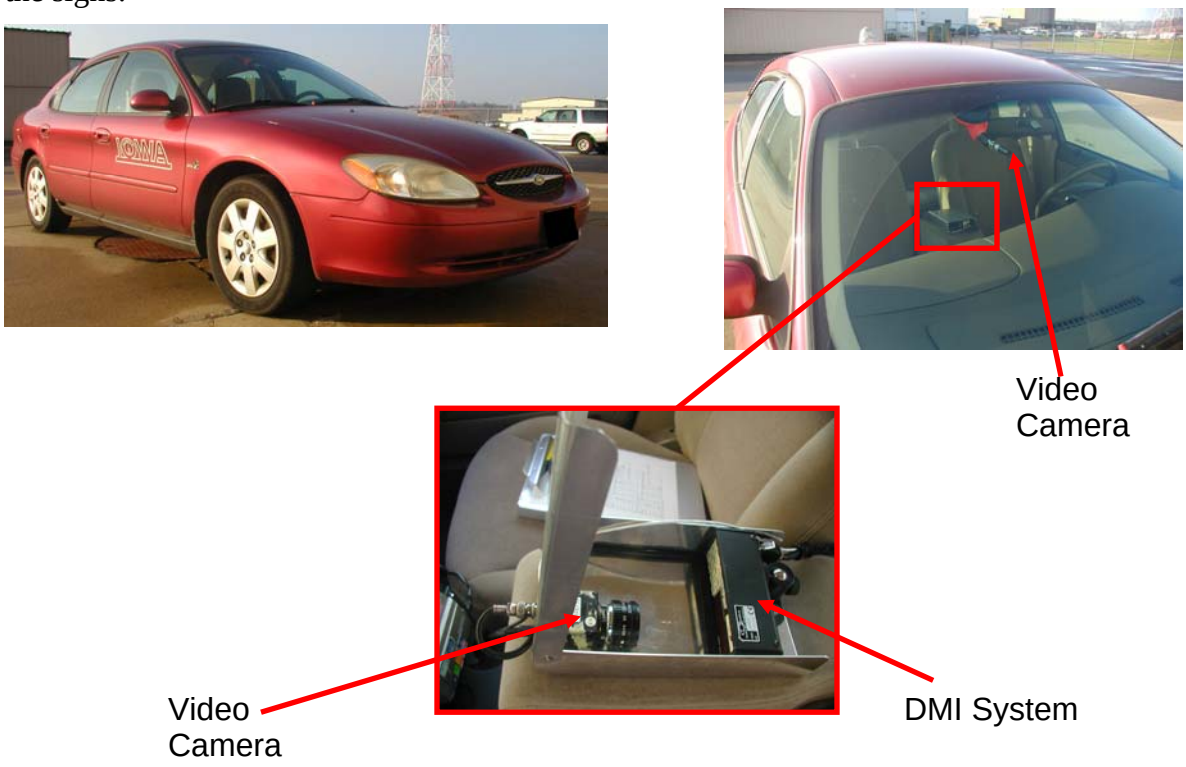


Figure 2. Instrumented Vehicle

3. Phase I--TARVIP ANALYSIS

In the first phase, the Tarvip model was set up to simulate a scenario involving a 62-year-old motorist driving during nighttime using low-beam headlamps. A 62 year old motorist was chosen because a previous study conducted by Carlson and Hawkins determined that drivers of age 55 and older accurately represented the 50th percentile of drivers [4]. The letter height and letter font were changed until the minimum required legibility distance was attained. Due to inherent limitations in the legibility performance database of Tarvip, we could only study a stroke width/height range of 0.05 to 0.15 while Series D font has 0.16 stroke width/height. Thus the maximum legibility distance should increase from what was obtained from Tarvip.

3.1 TARVIP ANALYSIS RESULTS

By comparing the MRLD with the computed legibility distance, it was possible to determine the required sign legend font, letter height, and overall sign size. The Tarvip results demonstrated that a traffic sign legend with Series D font has a longer legibility distance than a sign with a Series B font. However, using the larger Series D font is not always possible, due to sign size trade-offs. The Federal Highway Administration (FHWA) has six different fonts "A" (the narrowest), "B", "C", "D", "E(M)", and "F" (the widest). The Tarvip results also demonstrated that if a full cube corner sheeting material was used on the legend and background the maximum legibility distance was increased. Thus, Tarvip was helpful in evaluating the extent to which one may be able to overcome smaller fonts by using sheeting materials with higher retroreflectivity.

Table 1. Minimum Required Legibility Distance (MRLD) of Different Percentiles

Mile Marker (0.2 eff.) Green Background	**Minimum Required Legibility Distance (MRLD) Using ASTM Type III Sheeting Material**				
Speed[1]: 65 mph Age: 62 Low Beam Headlamps	**MRLD[2] (ft)**	**Letter Height**[E] rror! Bookmark not defined. **(in)**	**Width/Height**	**Stroke Width/Height**	**Spacing/Height**
To meet the 50th- percentile MRLD	288	8.7	Series D	0.15	Series D
To meet the 85th- percentile MRLD	396	11.8	Series D	0.15	Series D
To meet the Average MRLD	312	9.3	Series D	0.15	Series D

When the signs were designed to meet the 85th-percentile MRLD, the signs appeared to be too large to be practically considered for implementation due to cost of the signs. The increased cost per sign was not going to be that beneficial because the signs are going to be in chronological order and replicated every tenth, two tenths, or half a mile. Thus, based on a size and effect trade-off, the average MRLD was selected as the design legibility distance requirement. A standard MUTCD sign blank size for the mile markers was selected as the design target for sign size. This left font size (subject to word length limitation) and sign sheeting

[1] mph = 1.61 km/h
[2] 1 ft = 0.305 m
[3] 1 in = 2.54 cm

material as the two primary design variables that drive legibility distance. The standard blank sizes were obtained from the Manual on Uniform Traffic Control Devices (MUTCD) for the mile marker signs without tenths of a mile annunciation. The sign blank size was set at 18 in. x 48 in. (45.7 cm x 121.9 cm, Indiana mile marker). For the mile marker signs that had tenths of a mile, the sign blank size was set at 18 in. x 60 in. (45.7 cm x 152.4 cm, MUTCD's D10-5).

Using these design parameters, we generated new Tarvip scenarios and determined the required letter height for Series B and D fonts and for ASTM Type III and full cube corner sheeting materials. The resulting legibility distances are shown in Table 2 for green backgrounds and Table 3 for blue background.

Table 2. Tarvip Results for a Green Mile Marker Sign

Mile Marker (0.2 eff.) Green Background	**To meet Average MRLD must have legibility distance of 311.69 ft**			
Speed[1]: 65 mph Age: 62 Low Beam Headlamps	**Type III Material Series B**	**Full Cube Corner Series B**	**Type III Material Series D**	**Full Cube Corner Series D**
Letter Height[2] (in)	13.0	11.2	9.3	7.8
Width/Height	Series B	Series B	Series D	Series D
Stroke Width/Height	0.13	0.13	0.15	0.15
Spacing/Height	Series B	Series B	Series D	Series D
Select Legend Sheeting	3M HI-1998	3MDG3	3M HI-1998	3MDG3
Max Legibility Distance[3] (ft)	311	311	312	312

Table 3. Tarvip Results for a Blue Mile Marker Sign

Mile Marker (0.12 eff.) Blue Mile Background	**To meet Average MRLD must have legibility distance of 311.69 ft**			
Speed[1]: 65 mph Age: 62 Low Beam Headlamps	**Type III Material Series B**	**Full Cube Corner Series B**	**Type III Material Series D**	**Full Cube Corner Series D**
Letter Height[2] (in)	11.5	9.8	7.6	5.8
Width/Height	Series B	Series B	Series D	Series D
Stroke Width/Height	0.13	0.13	0.15	0.15
Spacing/Height	Series B	Series B	Series D	Series D
Select Legend Sheeting	3M HI-1998	3MDG3	3M HI-1998	3MDG3
Max Legibility Distance[3] (ft)	312	312	311	310

The above tables can be used by the traffic sign practitioner as a guideline to design mile marker signs that provide the average MRLD. For example, a 13 inch (33 cm) Series B letter height could be used with ASTM Type III white on green mile marker sign design. If the designer wanted to reduce the overall size of the sign, he/she could use full cube corner sheeting material and reduce the Series B letter height to 11.2 inches (28.4 cm). Each column in the above

[1] 1 mph = 1.61 km/h
[2] 1 in = 2.54 cm
[3] 1 ft = 3.05 m

tables represents a feasible set of design parameters that the sign designer may use to achieve the required MRLD.

4. Phase II--COMPREHENSION ANALYSIS

In the second phase, the comprehension analysis was designed to investigate mile marker and ramp sign design, layout, and content. A stimulus presentation program was designed and 40 participants (n = 40) took part in the study. There were 18 female and 22 male participants with an average age of 36 years. The computer program presented a simulated sign on a computer screen for a short pre-determined amount of time of three seconds. After viewing the sign, the participants were asked a series of questions that probed on sign comprehension. The experiment series and sequence of questions are shown in Figure 3.

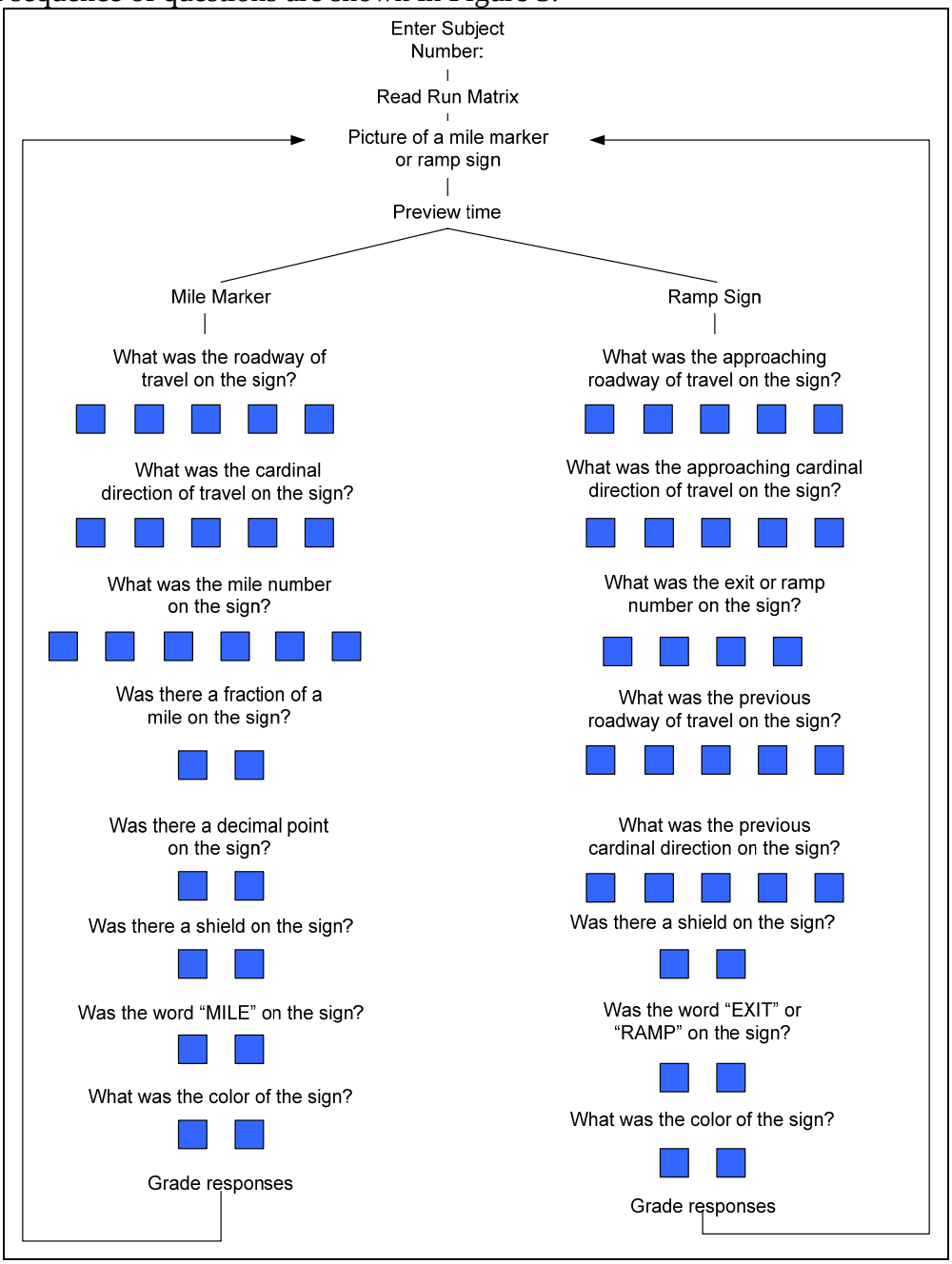


Figure 3. Diagram of Stimulus Program

4.1 EVALUATED SIGNS

The mile marker signs that were evaluated were taken from the MUTCD and some were taken from states including Indiana, New Hampshire, New Jersey, Pennsylvania, and West Virginia. The MUTCD has four different groups of mile marker signs: (1) the Reference Location Signs (RLS), which have only the word "MILE" and the mile number: (2) the Intermediate Reference Location Signs (IRLS), which have the word "MILE" and the mile number with a tenth of a mile: (3) the Enhanced Reference Location Signs (ERLS), which have the cardinal direction, roadway, the word "MILE" and the mile number: and (4) the Intermediate Enhanced Reference Location Signs (IERLS), which have the cardinal direction, roadway, the word "MILE" and the mile number with a tenth of a mile. The ramp signs that were evaluated were taken from Georgia, Kentucky, and New Jersey. Additionally, the investigators at the Operator Performance Laboratory designed a new ramp sign concept to test along side the Georgia, Kentucky, and New Jersey Signs.

Participants were encouraged not to guess at the answers to the questions because if an incorrect location was given to first responders, they would not arrive at the correct location. Answers that were left blank were scored as incorrect answers.

4.1.1 Mile Marker Probing Questions

Figure 4,illustrates the stimulus presentation program. After presentation of the sign stimulus, the following probing questions were shown:

1. What was the roadway of travel on the sign?
    - Interstate 94
    - US 94
    - Interstate 49
    - US 49
    - N/A
2. What was the cardinal direction of travel on the sign?
    - North
    - East
    - South
    - West
    - N/A
3. What was the mile number on the sign?
    - 682.1
    - 621.8
    - 618.2
    - 681.2
    - 612.8
    - 286.1
4. Was there a fraction of a mile on the sign?
    - Yes
    - No
5. Was there a decimal point on the sign?

- Yes
- No

6. Was there a shield on the sign?
   - Yes
   - No
7. Was the word “MILE” on the sign?
   - Yes
   - No
8. What was the color of the sign?
   - Blue
   - Green

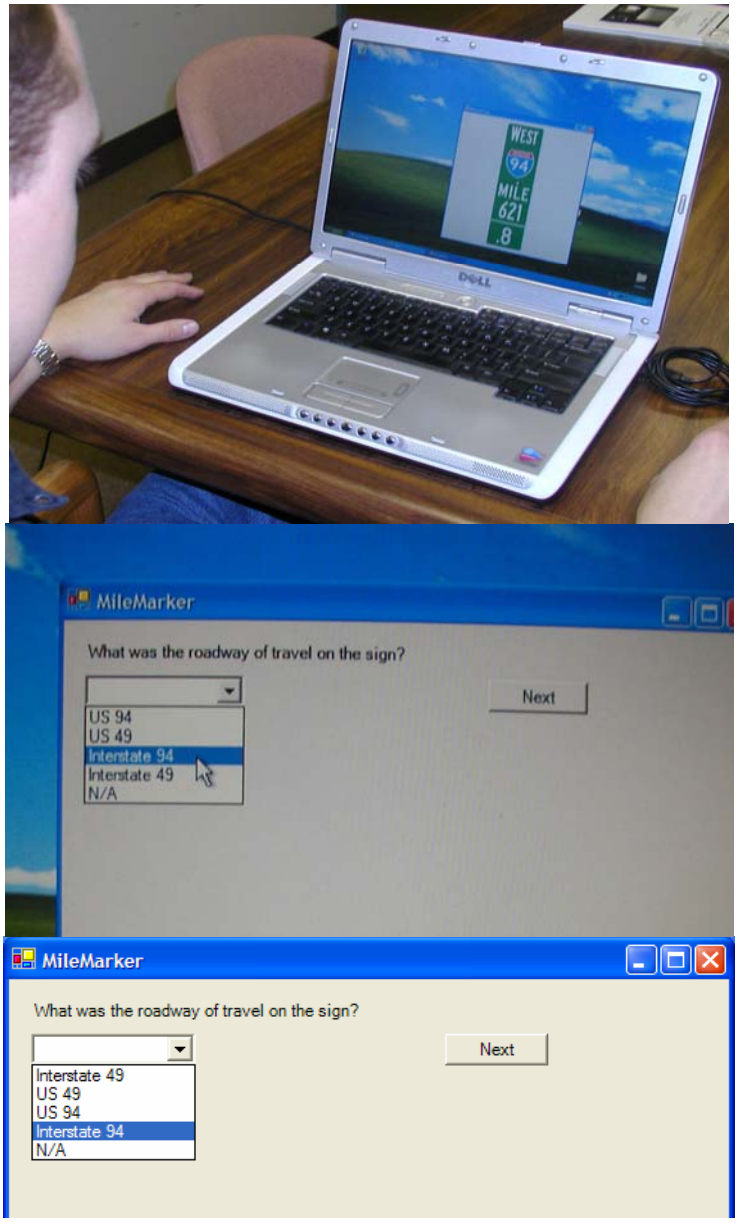


Figure 4. Stimulus Program Example of the MUTCD D10-5 Mile Marker

4.1.2 Ramp Designation Questions

Figure 5, shows an example of the stimulus presentation program for ramp designation sign questions.

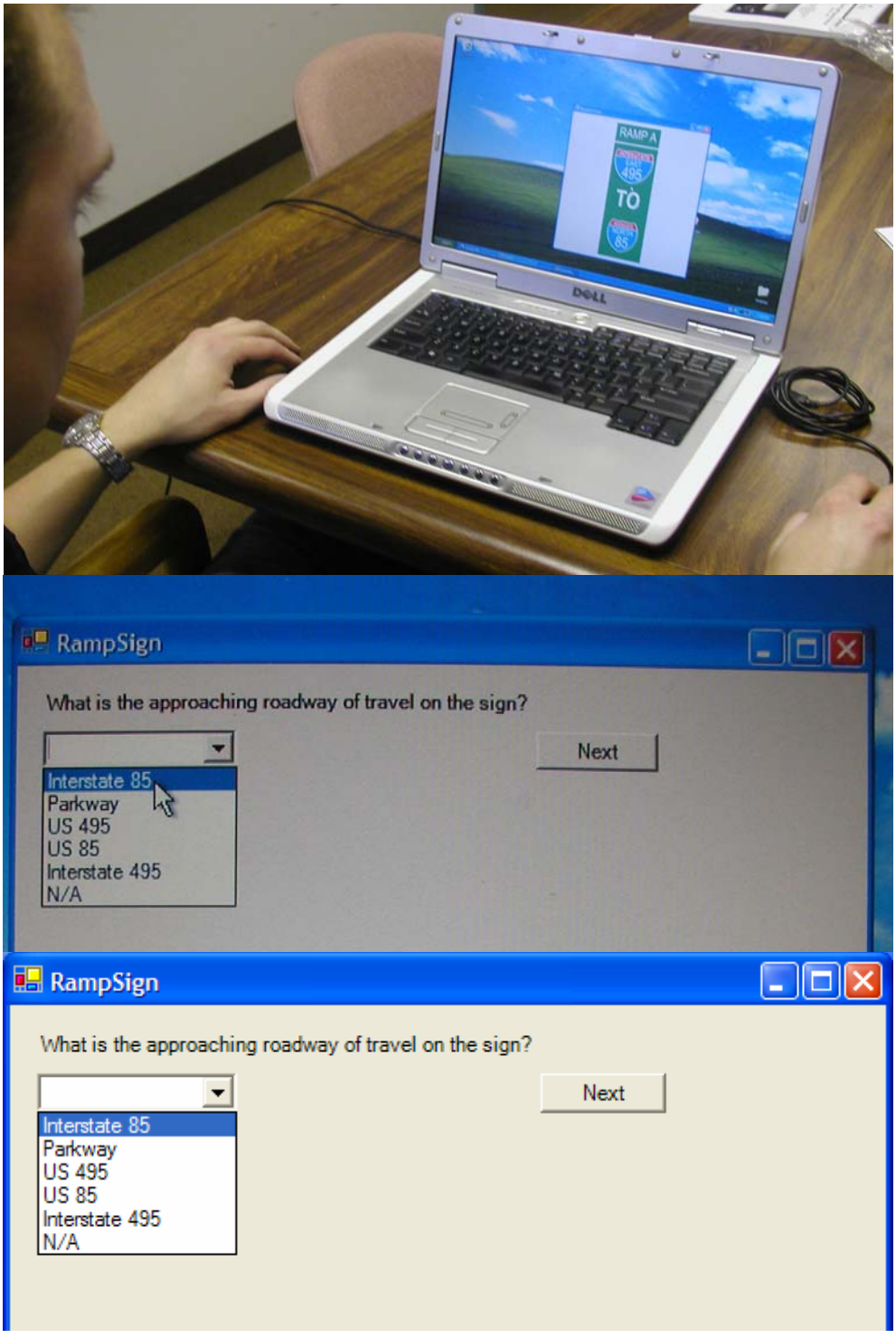


Figure 5. Stimulus Program Example of the Georgia.1 Ramp Sign

The following probing questions were shown to the participant:

1. What was the approaching roadway of travel on the sign?
    - Interstate 495
    - US 495
    - US 85
    - Interstate 85
    - N/A
2. What was the approaching cardinal direction of travel on the sign?
    - North
    - East
    - South
    - West
    - N/A
3. What was the exit or ramp number on the sign?
    - 85
    - A
    - 495
    - N/A
4. What was the previous roadway of travel on the sign?
    - Interstate 495
    - US 495
    - US 85
    - Interstate 85
    - N/A
5. What was the previous cardinal direction on the sign?
    - North
    - East
    - South
    - West
    - N/A
6. Was there a shield on the sign?
    - Yes
    - No
7. Was the word “EXIT” or “RAMP” on the sign?
    - Yes
    - No
8. What was the color of the sign?
    - Blue
    - Green

4.2 COMPREHENSION ANALYSIS RESULTS

The results from this phase of the study are broken up into two different groups:

(1) Type of sign: Mile Marker or Ramp Designation

(2) Content on the sign

4.2.1 Mile Marker Comprehension Results

Figure 6 shows the mile marker comprehension results from the first three questions asked during the stimulus program, which are questions that need to be conveyed to pinpoint a specific location. These questions were:

1. What was the roadway of travel on the sign?
2. What was the cardinal direction of travel on the sign?
3. What was the mile number on the sign?

In Figure 6, the sign that performed the best on average was the MUTCD D10-4. However, that particular sign does not have tenths of a mile. The sign that performed the best on average with the tenths of a mile shown was the Indiana mile marker sign.

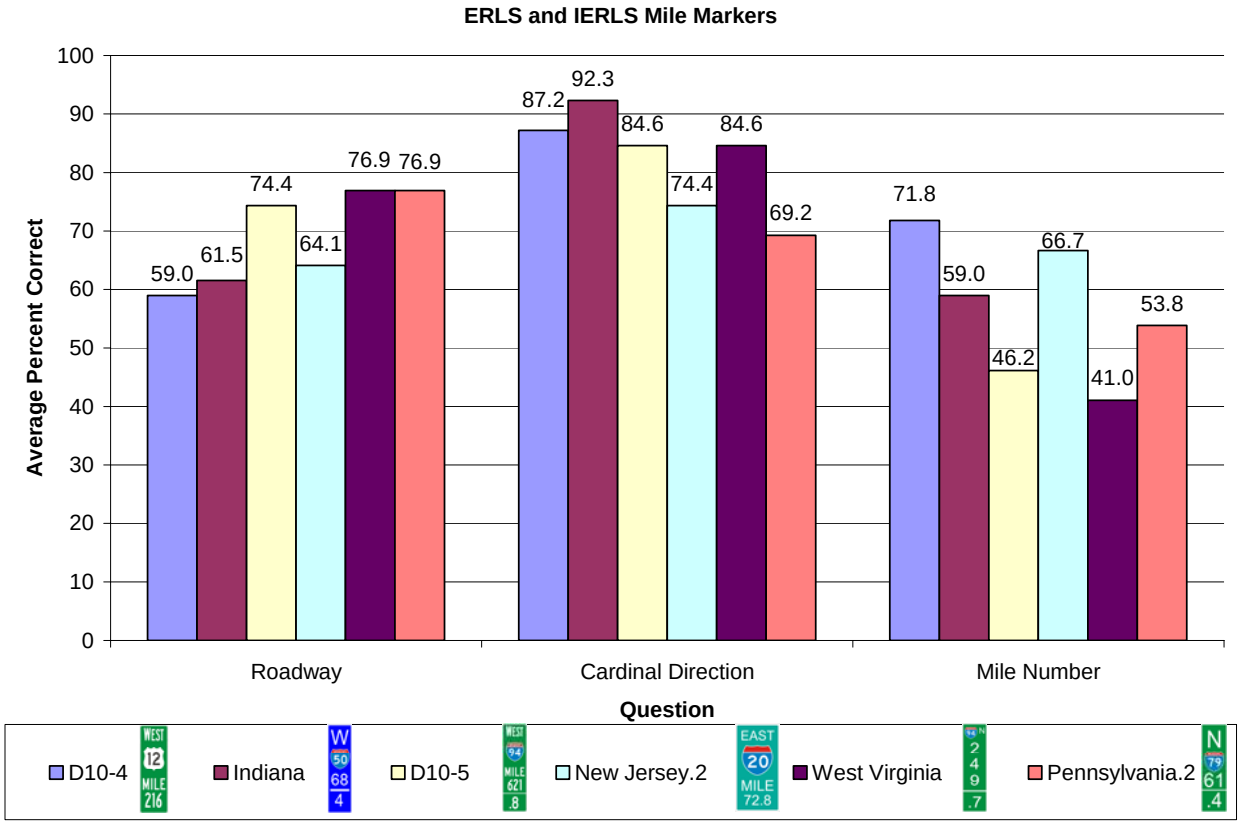


Figure 6. Results of the Enhanced and Intermediate Enhanced Reference Location Signs

The comprehension results for the Intermediate Reference and Reference Location Signs are shown in Figure 7. These mile marker signs assume the driver already knows the roadway and direction of travel. Figure 7 shows the average percent correct when the participants were asked what the mile number was on the sign. In Figure 7, the MUTCD D10-3 performed the best on average. However, this sign does not depict tenths of a mile. The mile marker sign that performed the best on average that depicts tenths of a mile was the New Hampshire mile marker

sign. The mile marker sign results to all of the questions asked during the comprehension study can be found in the APPENDIX.

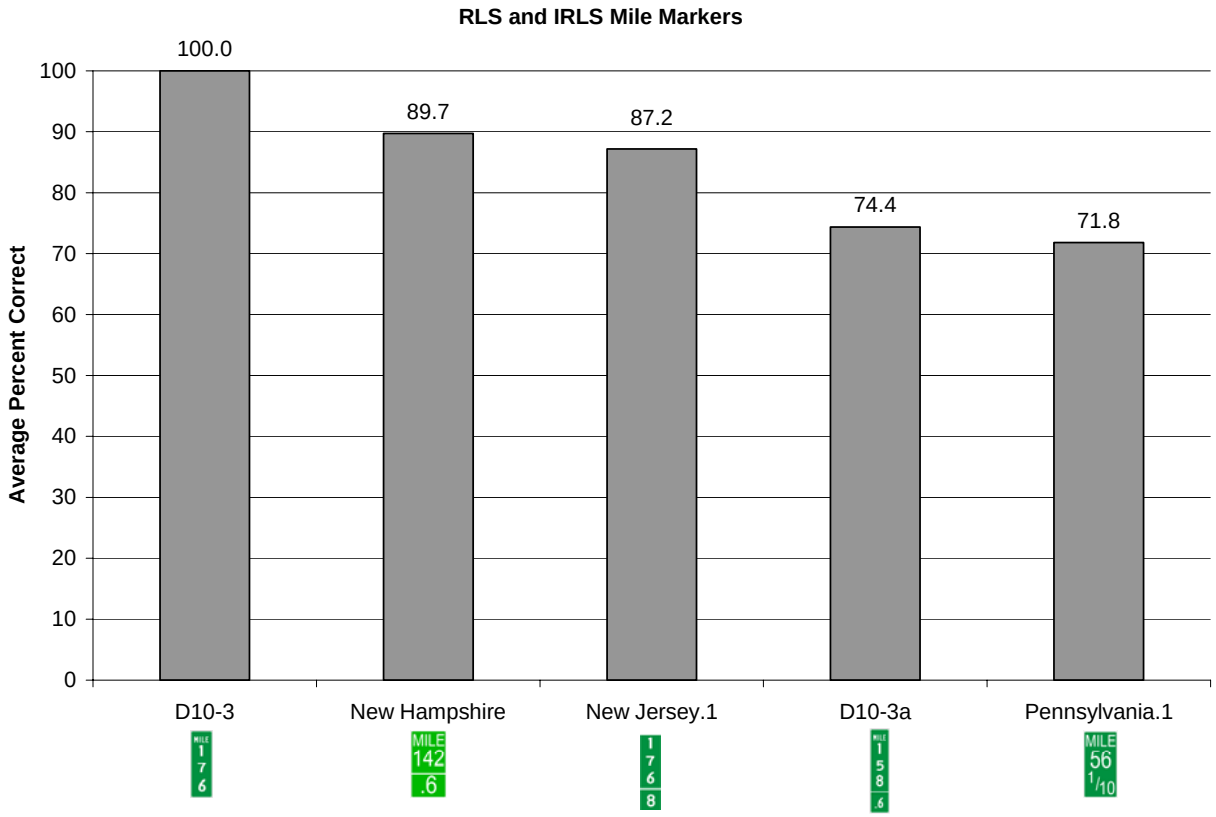


Figure 7. Results of the Reference and Intermediate Reference Location Signs

4.2.2 Ramp Designation Comprehension Results

Figure 8 shows the ramp sign results from the first five questions asked during the stimulus program, which are questions that need to be conveyed to pinpoint a specific location on a ramp. The first five probing questions were:

1. What was the approaching roadway of travel on the sign?
2. What was the approaching cardinal direction of travel on the sign?
3. What was the exit or ramp number on the sign?
4. What was the previous roadway on the sign?
5. What was the previous cardinal direction on the sign?

Note that the ramp signs are placed every tenth of a mile on the ramp. The approaching roadway and direction refer to the roadway and direction the driver is going to be driving on after the driver is off of the ramp. The previous roadway and direction refer to the roadway and direction the driver was previously driving on before exiting onto the ramp.

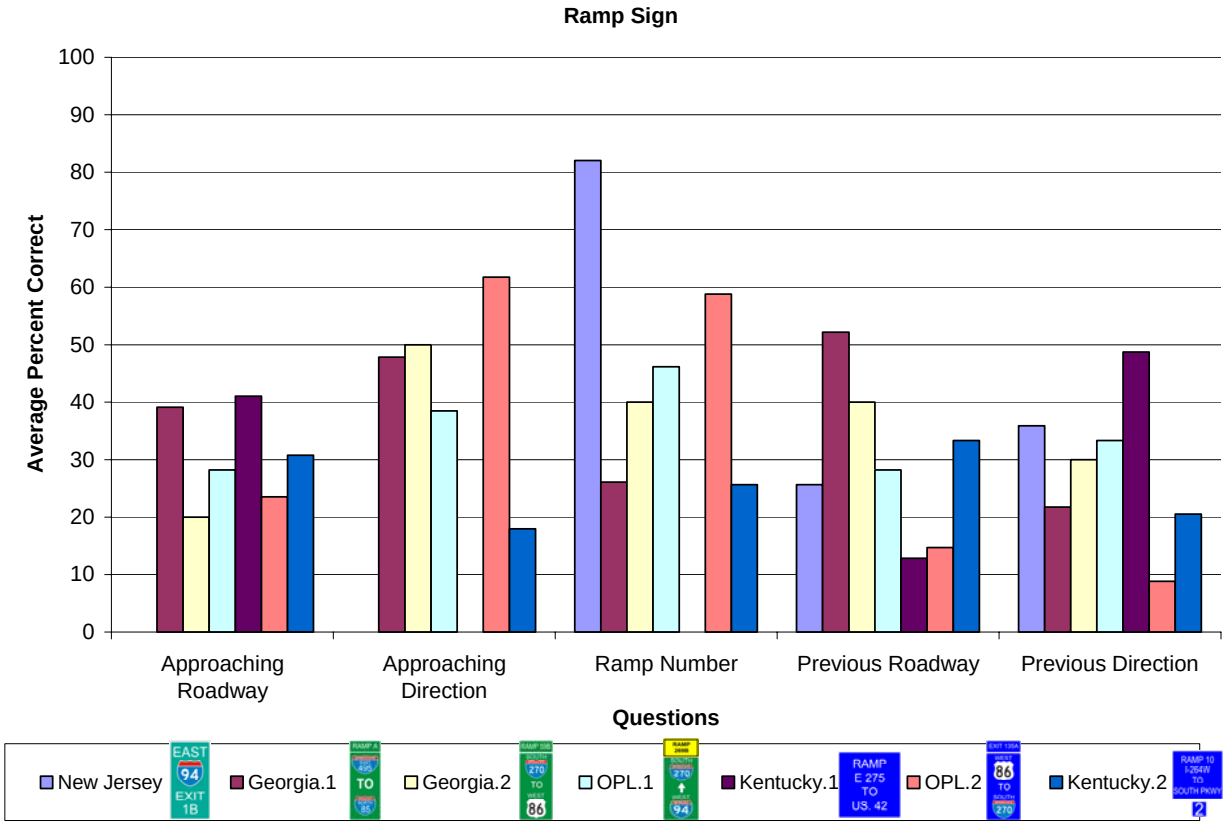


Figure 8. Results of the Ramp Sign Comprehension Survey

The reader should bear in mind that the New Jersey ramp sign conveys less information, as it does not contain a from-to mapping. Since there are fewer information elements, the legend was larger than in all other signs. Sign designers need to weigh the trade-off between content and legibility. For more complex interchanges such as the one shown in Figure 9, the New Jersey ramp sign might not be that effective. However, for less complex interchanges, such as the one shown in Figure 10, the New Jersey ramp sign might be ideal.

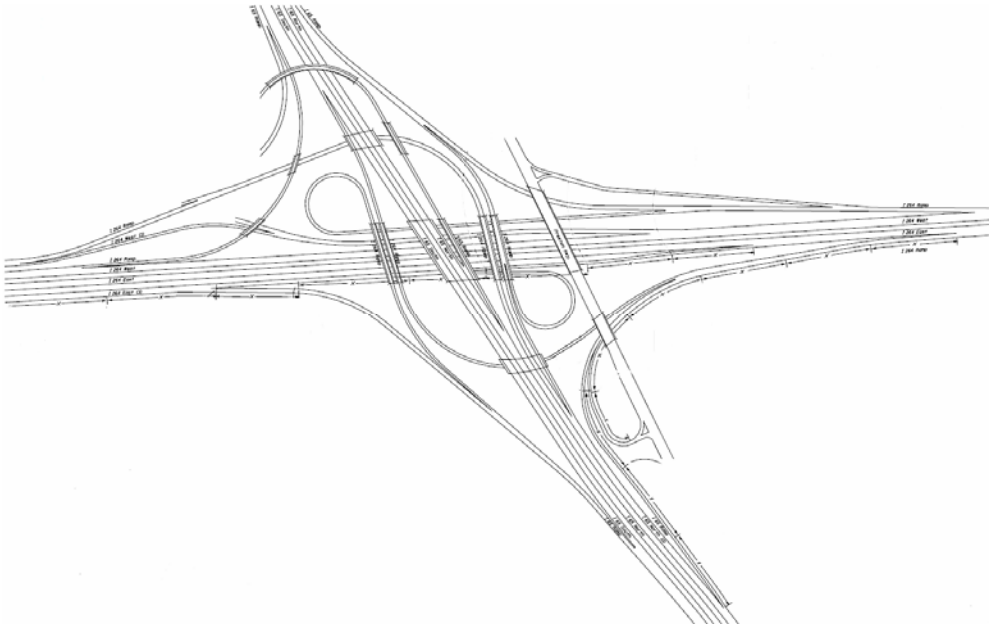


Figure 9. Complex Interchange

Figure 10. Less Complex Interchange

Figure 11 shows the average percentage of correct responses for the ramp signs. The average was computed from the five subgroup questions. The signs that performed the best and contained from-to mapping were the Georgia signs and the OPL.1 sign. The Kentucky signs fared the worst. What was quite surprising is the overall low percentage of correct responses, indicating the difficulty people have in keeping five elements of information in working memory. The ramp sign results to all of the questions asked during the comprehension study can be found in the APPENDIX.

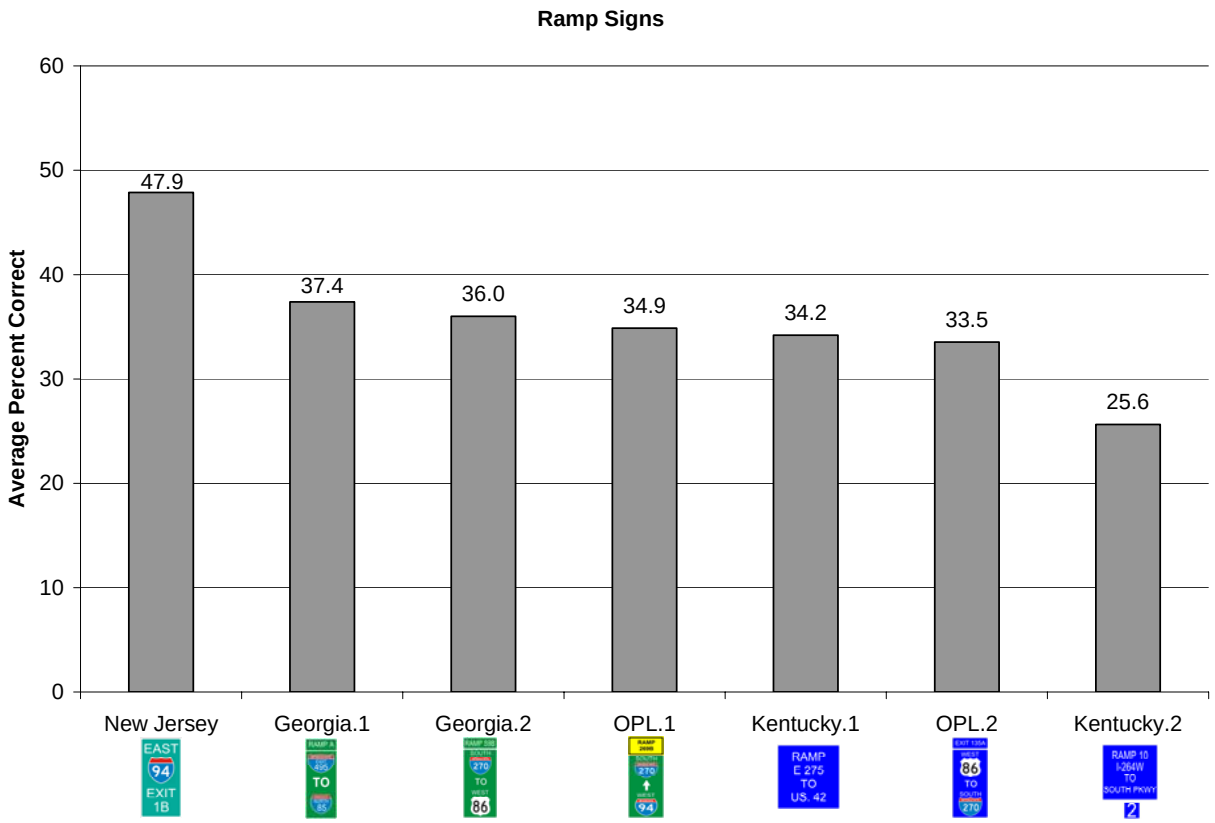


Figure 11. Average of Ramp Sign Comprehension Results

During the comprehension study, participants conveyed a dislike of the mileage fraction shown on the Pennsylvania.1 sign. Also, some participants commented that the ramp signs contained too much information. Another comment made was that the yellow background on the OPL.1 sign really stood out, but some participants did not like that they had to read the information from the bottom up. One way to remedy this problem would be to turn the arrow in the OPL.1 sign to point downwards. Some participants also commented that with the New Jersey Ramp sign they did not know if they were leaving Interstate 94 or approaching Interstate 94.

5. Phase III--ROAD TEST STUDY

The third phase was designed to validate both the Tarvip models and the comprehension of the mile marker and ramp signs via a road test deployment. Mile marker and ramp signs were fabricated to an optimum design based on Phase I and Phase II study results. The signs were mounted 13 feet from the edge of the pavement and the bottom of the sign was 4 feet above the top of the roadway to meet MUTCD standards of mounting mile marker and ramp signs. Seventeen signs were fabricated with ASTM Type III sheeting material and five signs with full cube corner sheeting material.

A Ford Taurus SE (2000) instrumented car was equipped with an audio and video recorder and a Distance Measurement Instrument (DMI) system to measure the legibility distance to the signs. The participant drove with one test engineer who monitored the DMI and video recorder.

Figure 12. Instrumented Vehicle

The road test study was performed over the course of two weeks with 12 participants (n = 12) driving by the fabricated signs. There were 4 female and 8 male participants with an average age of 40 years, with a minimum age of 24 and a maximum age of 65. The participants drove on a public county road by the different mile marker and ramp signs.

Figure 13 shows the schematic layout of the road test for evaluating legibility distance of the color and content. The roadway had minimal traffic, and participants were instructed to pull the vehicle over to the side of the road and stop when oncoming traffic was spotted to negate the effects of glare. Participants were also instructed to pull their car over to the side of the road when other vehicles approached from behind the experimental car.

To validate the Tarvip model runs from Phase I, each participant was required to provide a ranking of each test sign that was viewed in terms of visibility, legibility, and comprehension after driving past those signs. Visibility implies conspicuity and the sign's overall ability to stick out or be noticed. Legibility refers to how well the text on the sign can be read. Comprehension refers to how much sense the sign content made to the observer. The ranking scale was from zero to ten with zero corresponding to very poor performance, and ten implying excellent performance.

To validate the Phase II comprehension study, the participants were given a post run survey that probed on their comprehension of the signs immediately after they finished driving through the test area. The post run survey consisted of a simple question to determine whether the sign was read correctly.

- For the mile marker signs the question was: What was the mile number? The goal of this question was to determine whether the mile number was shown in a confusing way. Some of the mile marker signs represented tenths of a mile under the whole mile number with a decimal point, some used solid lines, but no decimal points, while another sign had the entire mile number written out on a single, horizontal line.
- For the ramp signs the question was: What was the previous roadway of travel on the sign? The goal was to determine whether the participants read the sign the way the ramp sign was supposed to be interpreted.

For both mile marker and ramp designation signs, the participants were also asked to rank the presentation of the information on a scale from zero to ten with zero corresponding to a poor representation, and ten implying an excellent representation.

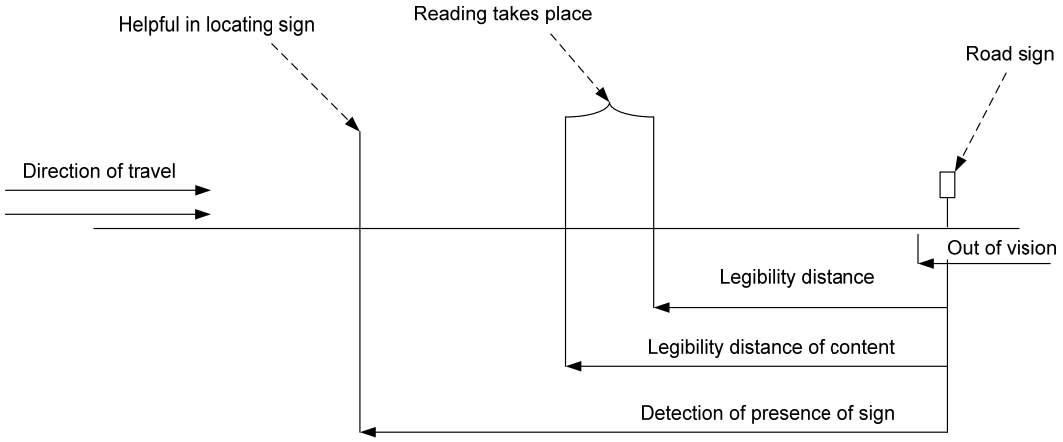


Figure 13. Schematic of Road Test Study

5.1 ROAD TEST RESULTS FOR REGULAR MILEMARKERS

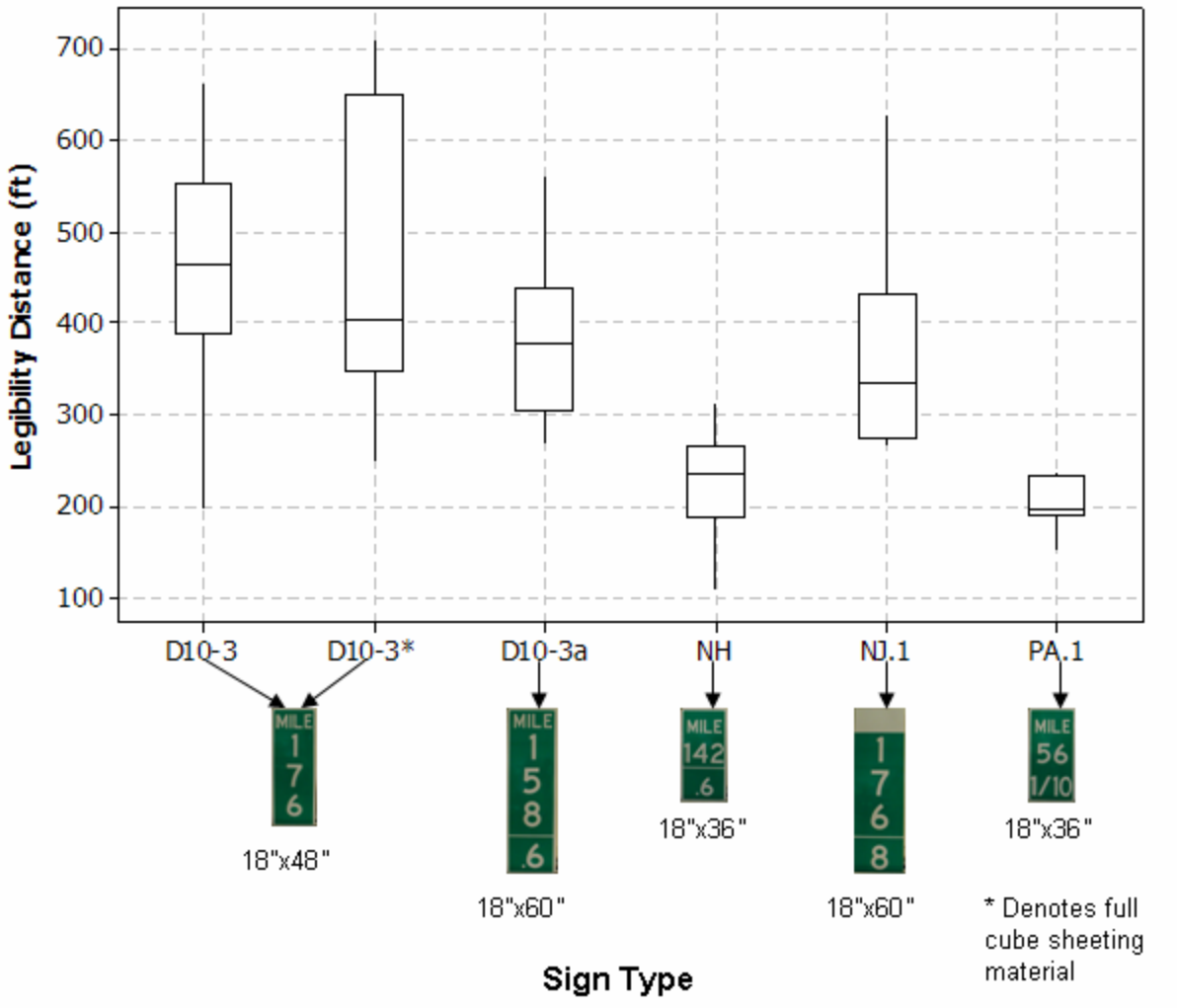
5.1.1 Road Test Tarvip Verification Results

The legibility distance results of the mile marker signs are broken down by subcategories for legibility of:

1. Mile number
2. Cardinal direction
3. The word “MILE”

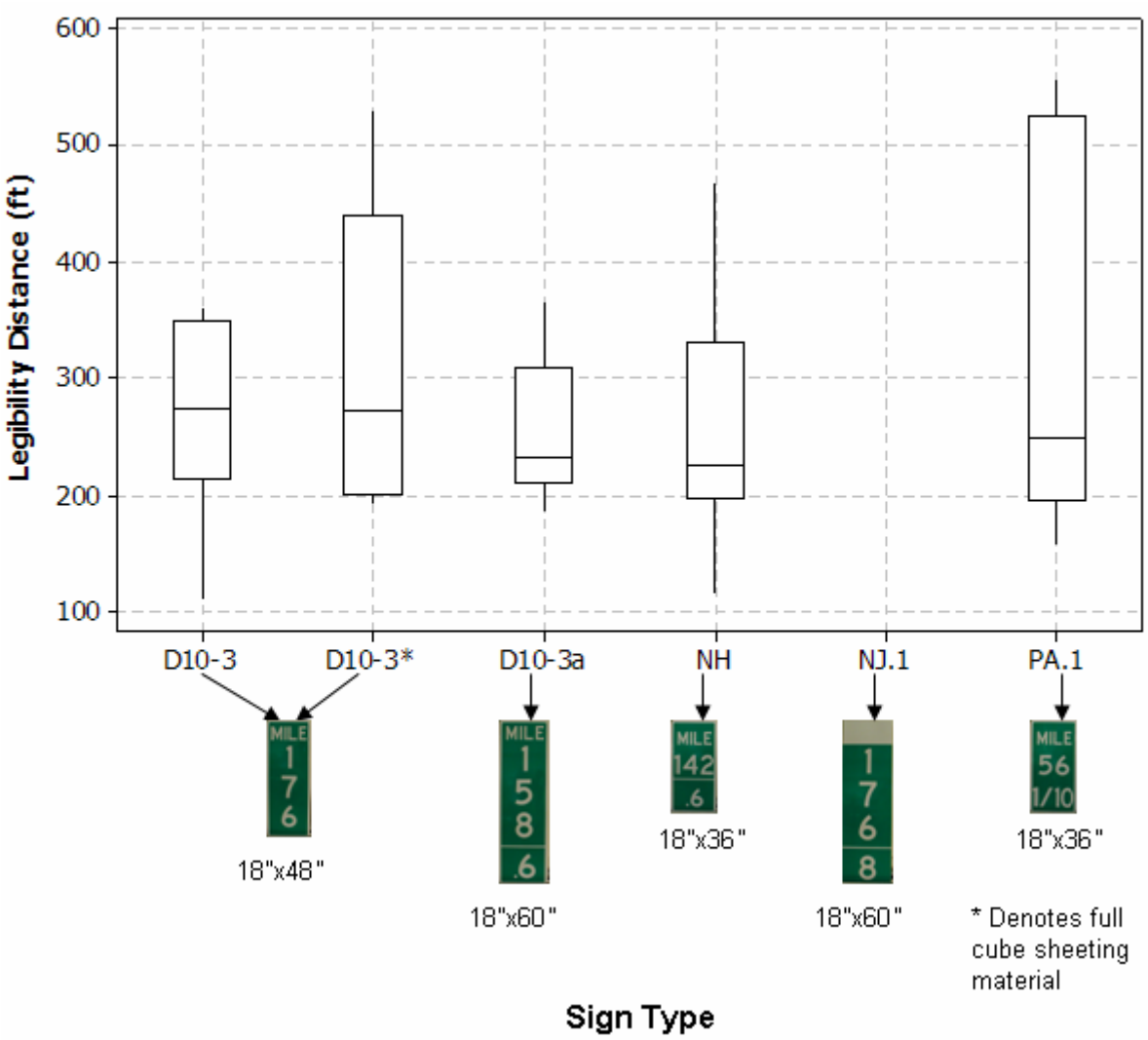
Box plots demonstrating the nighttime legibility distance of the mile number and the word “MILE” recorded for the Reference Location Signs and Intermediate Reference Location Signs are shown in Figure 14 and Figure 15, respectively. The bottom whisker represents the 10^{th} percentile, the bottom of the box represents the 25^{th} percentile, the line in the box is the 50^{th} percentile, the top of the box corresponds to the 75^{th} percentile, and the top whisker designates the 90^{th} percentile.

All test signs were optimized according to the design guidelines previously established in Table 2 and Table 3 of Phase I of the study**.** In order to obtain the same results in an actual field deployment, it is of utmost importance that the sign designer adjusts the MUTCD or other specifications of letter height according to our minimum guidelines in Table 2 and Table 3. The mile number letter height for the D10-3, D10-3a, and NJ.1 signs was 9.25 inches with Series D font. The NH and PA.1 signs could only have 7.25-inch-tall mile numbers with Series D font to stay within the sign blank size of the other mile marker signs. The word “MILE” was 5 inches tall with Series D font for the D10-3 and D10-3a. The NH and PA.1 signs were able to fit the word “MILE” with 5.5-inch-tall letters with Series D font.



N=12 participants in test vehicle on test road at night

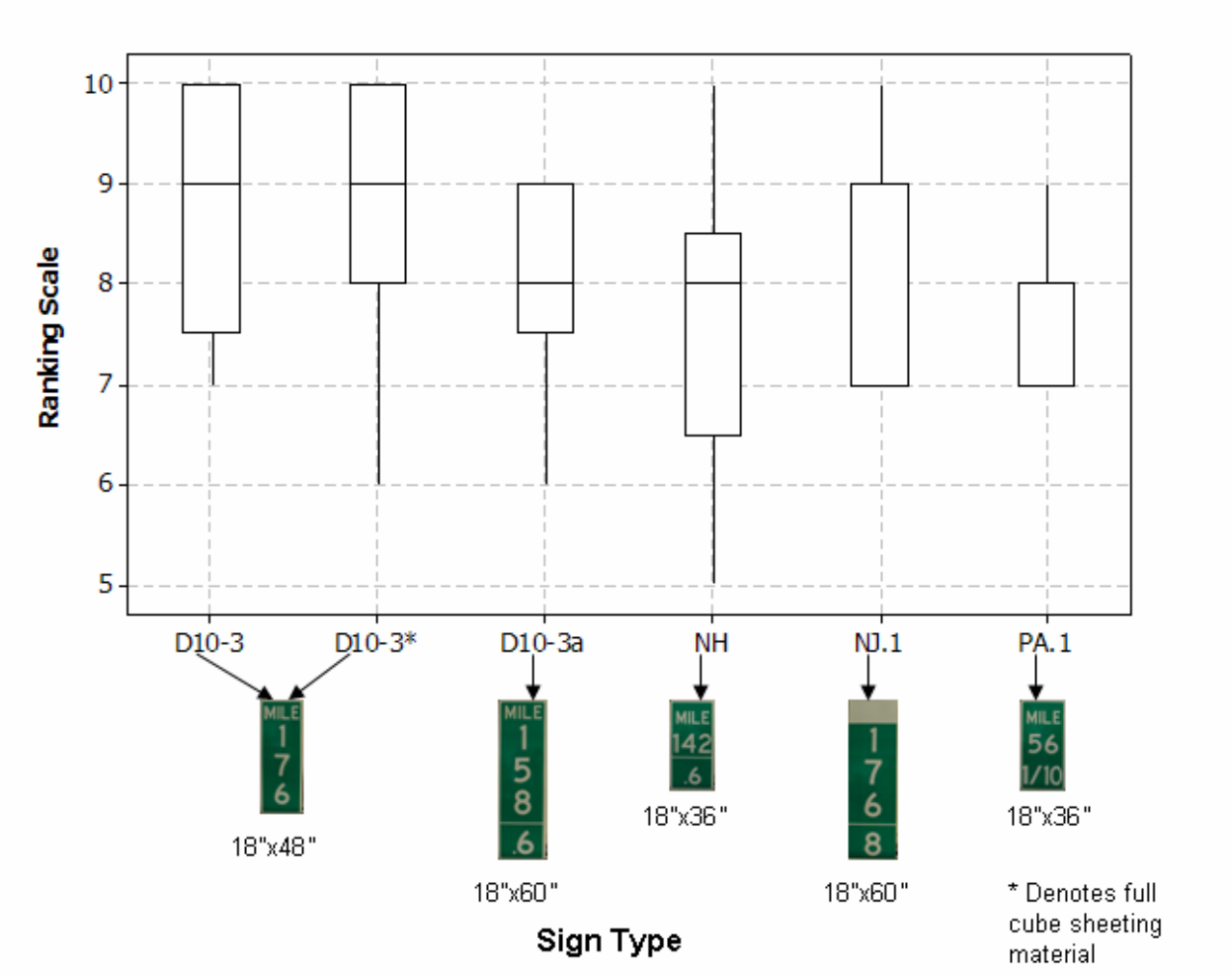
Figure 14. Box Plot of Legibility Distance of the Mile Number



N=12 participants in test vehicle on test road at night

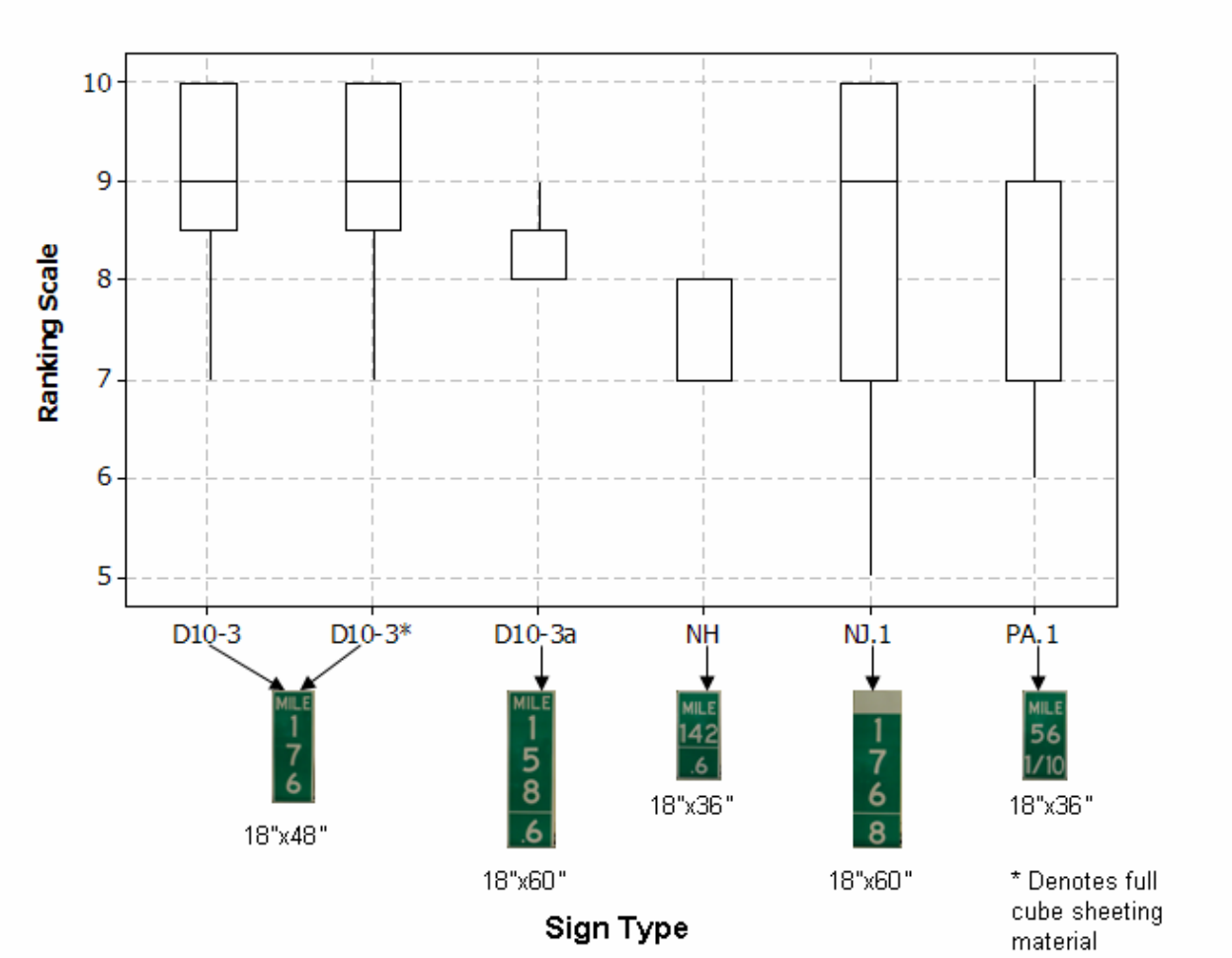
Figure 15. Box Plot of Legibility Distance of the Word "MILE"

When the participants were asked to rank each of the Reference and Intermediate Reference Location Signs with regard to visibility, legibility, and comprehension the results demonstrated the MUTCD D10-3 and the NJ.1 sign performed the best on average. The MUTCD D10-3 sign had an average ranking of 9 for its visibility and legibility. The MUTCD D10-3 sign had an average of 10, when the participants ranked the comprehension of the sign. The NJ.1 sign had an average of 9 for visibility, legibility, and comprehension. In Figure 17, and Figure 18 are the visibility, legibility, and comprehension results of the Reference and Intermediate Reference Location Signs.



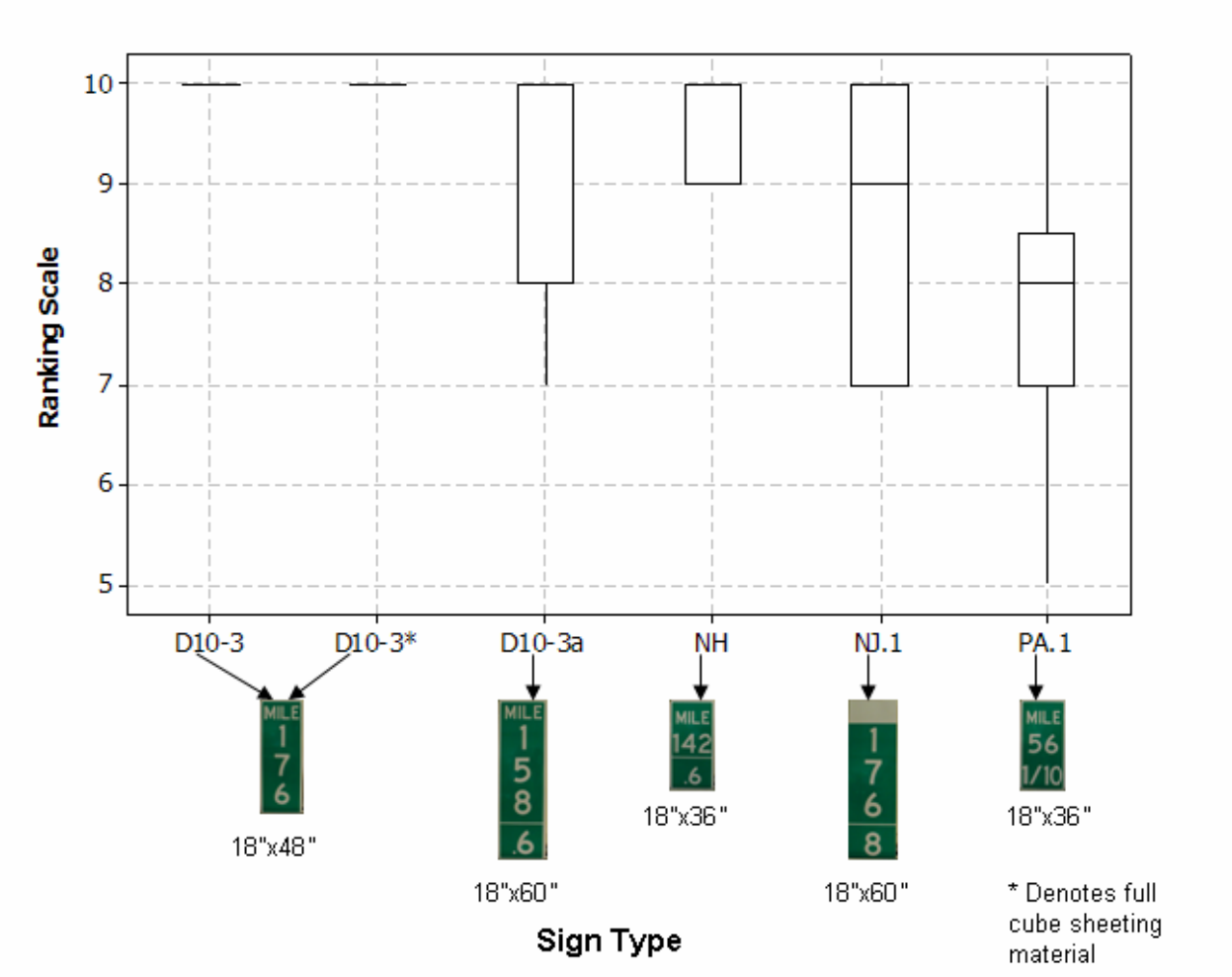
N=12 participants in test vehicle on test road at night

Figure 16. Box Plot of Ranking the Visibility for the Reference and Intermediate Reference Location Signs



N=12 participants in test vehicle on test road at night

Figure 17. Box Plot of Ranking the Legibility for the Reference and Intermediate Reference Location Signs

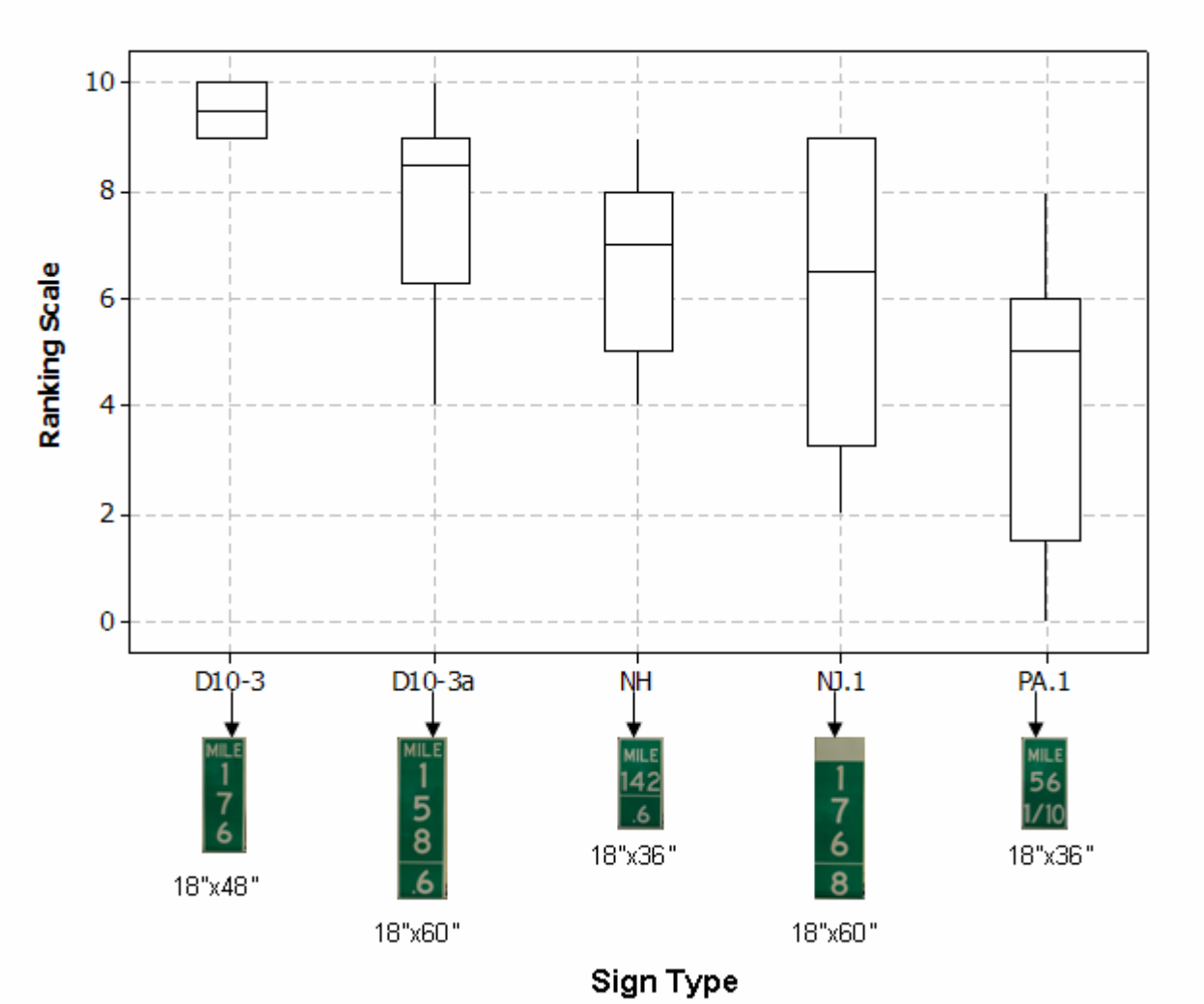


N=12 participants in test vehicle on test road at night

Figure 18. Box Plot of Ranking the Comprehension for the Intermediate Reference and Reference Location Signs

5.1.2 Road Test Comprehension Verification Results

The post-survey showed that all the mile numbers of the Reference and Intermediate Reference Location Signs were interpreted correctly. When the participants were asked to rank the presentation of the mile number on the Reference and Intermediate Reference Location Signs, the post-survey results demonstrated on average the preference for the MUTCD's D10-3 and D10-3a. The post-survey results are shown in Figure 19.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 19. Box Plot of Ranking the Presentation of the Mile Number

The data collected from the road test study demonstrated that signs that were fabricated with full cube corner sheeting material performed on average better than the signs with ASTM Type III sheeting material. The sign that performed the best on average among Reference Location Sign was the MUTCD D10-3. For the Intermediate Reference Location Signs, the sign that performed the best on average was the MUTCD D10-3a.

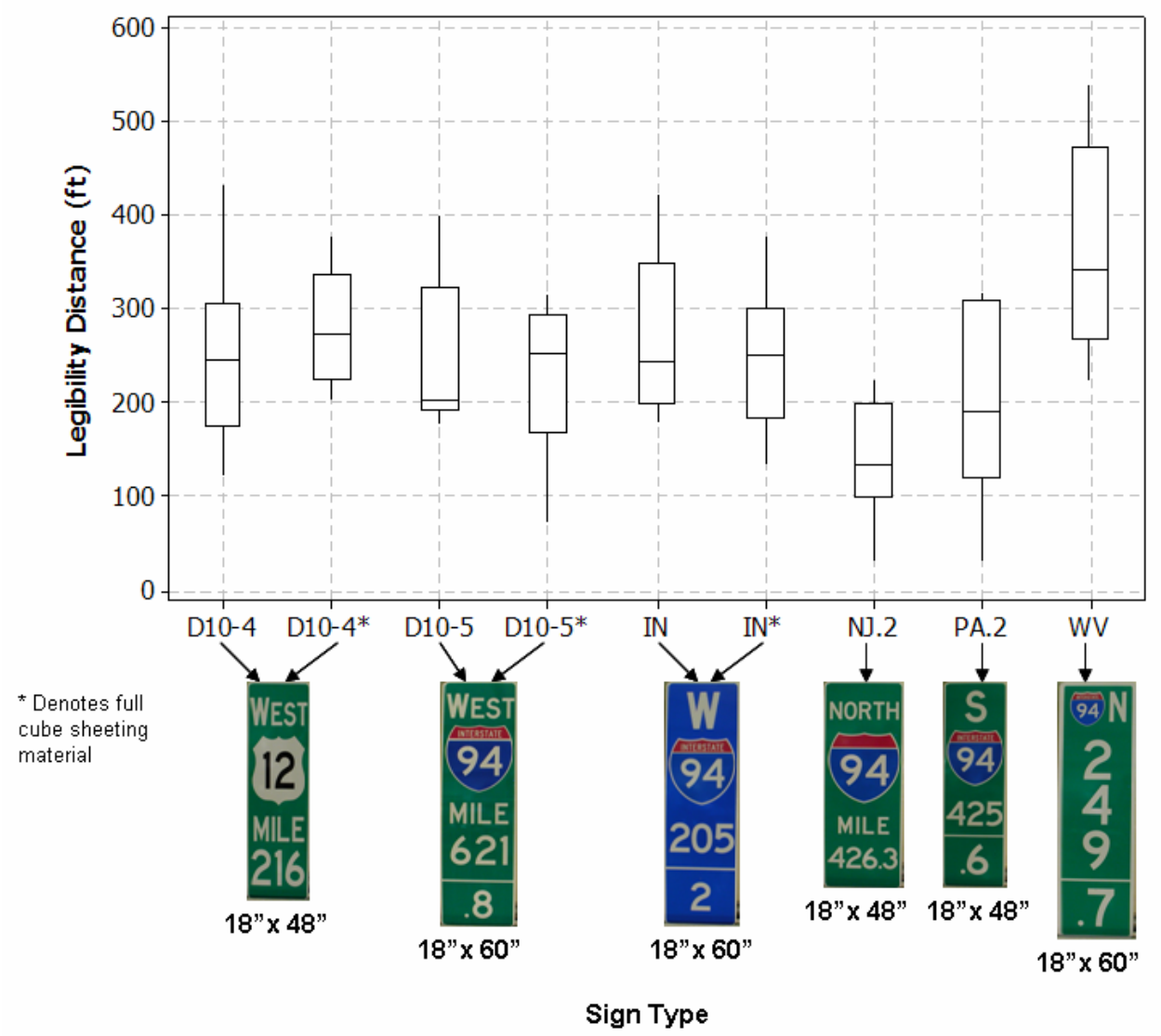
5.2 ENHANCED MILE MARKER ROAD TEST RESULTS

5.2.1 Tarvip Road Test Verification

The sign that performed the best on average among the Enhanced Reference Location Signs was the MUTCD D10-4 sign. The sign that performed the best on average among the Intermediate Enhanced Reference Location Signs was the Indiana sign. However, it was found that if the MUTCD's D10-5 mile marker sign had full cube corner sheeting material, the sign performed better on average than the Indiana sign with full cube corner or ASTM Type III sheeting

material. A box plot demonstrating the nighttime legibility distance of the mile number, cardinal direction, roadway, and the word "MILE" recorded for the Enhanced and Intermediate Enhanced Reference Location Signs are shown in Figure 20 through Figure 23.

Again, it is very important to note that we optimized all our test signs according to the design guidelines we have established in Table 2 and Table 3. The WV sign was able to have 9.25-inch-tall mile numbers with Series D font because the cardinal direction and roadway were shrunk to fit on the same line. The D10-4 sign had 9-inch-tall mile numbers with Series D font. The D10-5, IN, and PA.2 sign had 7-inch-tall mile numbers with Series D font. The NJ.2 sign had 5-inch-tall mile numbers with Series D font.

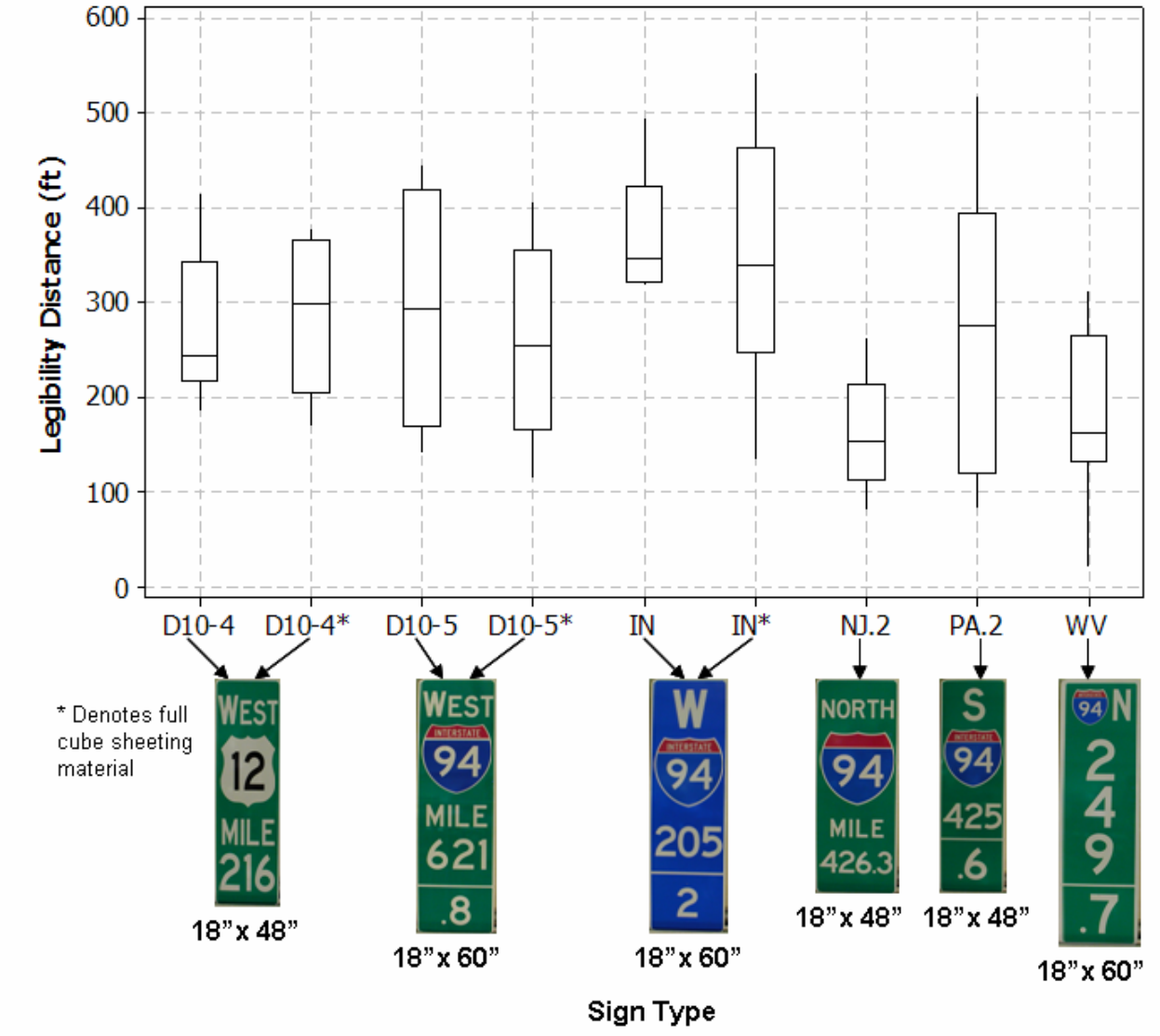


N=12 participants in test vehicle on test road at night

Figure 20. Box Plot of Legibility Distance of the Mile Number

In Figure 21, the IN sign was able to have a 9.25-inch-tall cardinal direction because it was abbreviated and the word "MILE" was not included on the sign. The D10-4 and D10-5 both had a 6-inch-tall "W" with Series D font while the "EST" was 5 inches tall with Series D font,

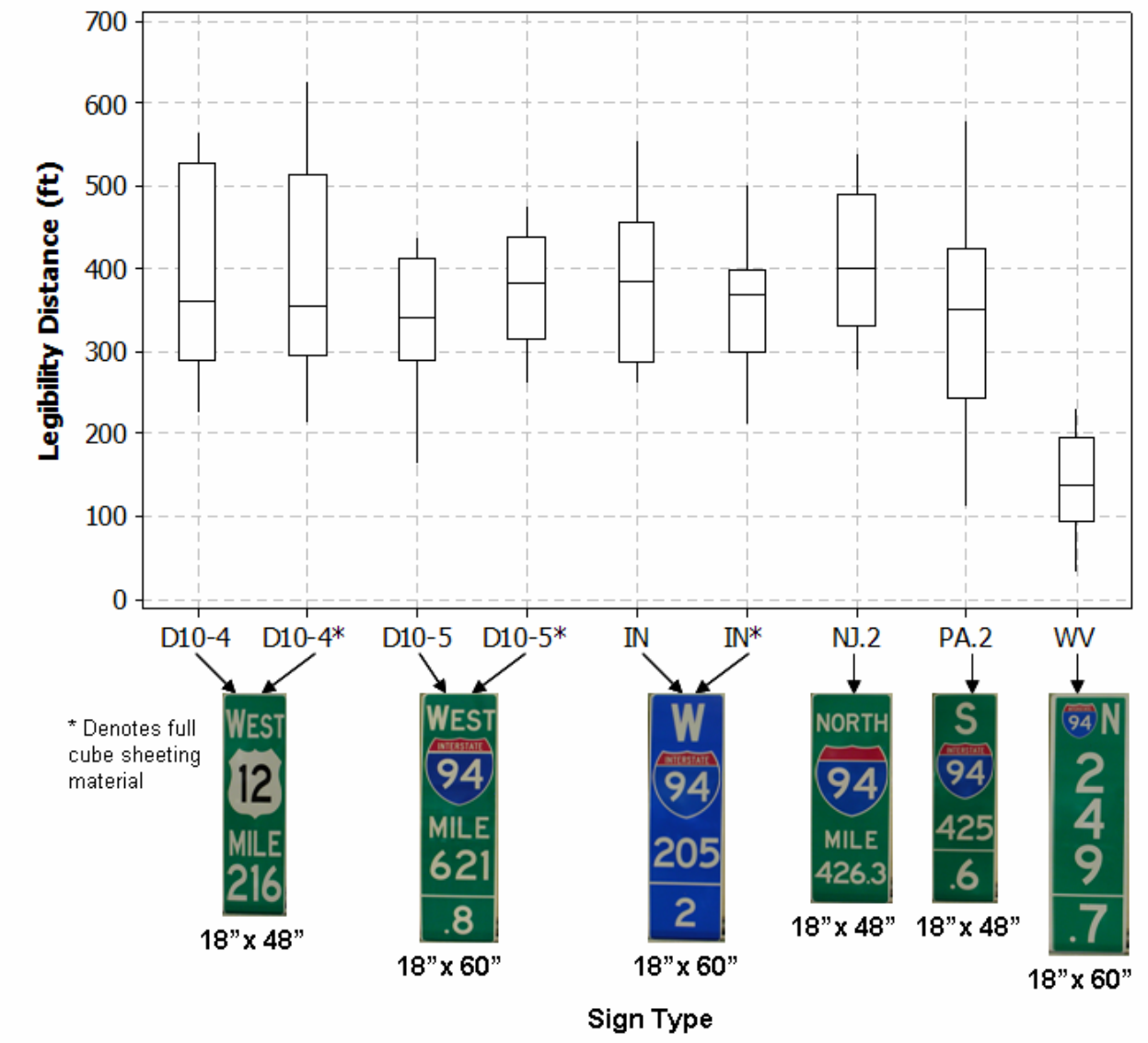
which follows MUTCD standards. The PA.2 had a 7-inch-tall "S" with Series D. The NJ.2 cardinal direction is only 4 inches tall with Series D font.



N=12 participants in test vehicle on test road at night

Figure 21. Box Plot of Legibility Distance of the Cardinal Direction

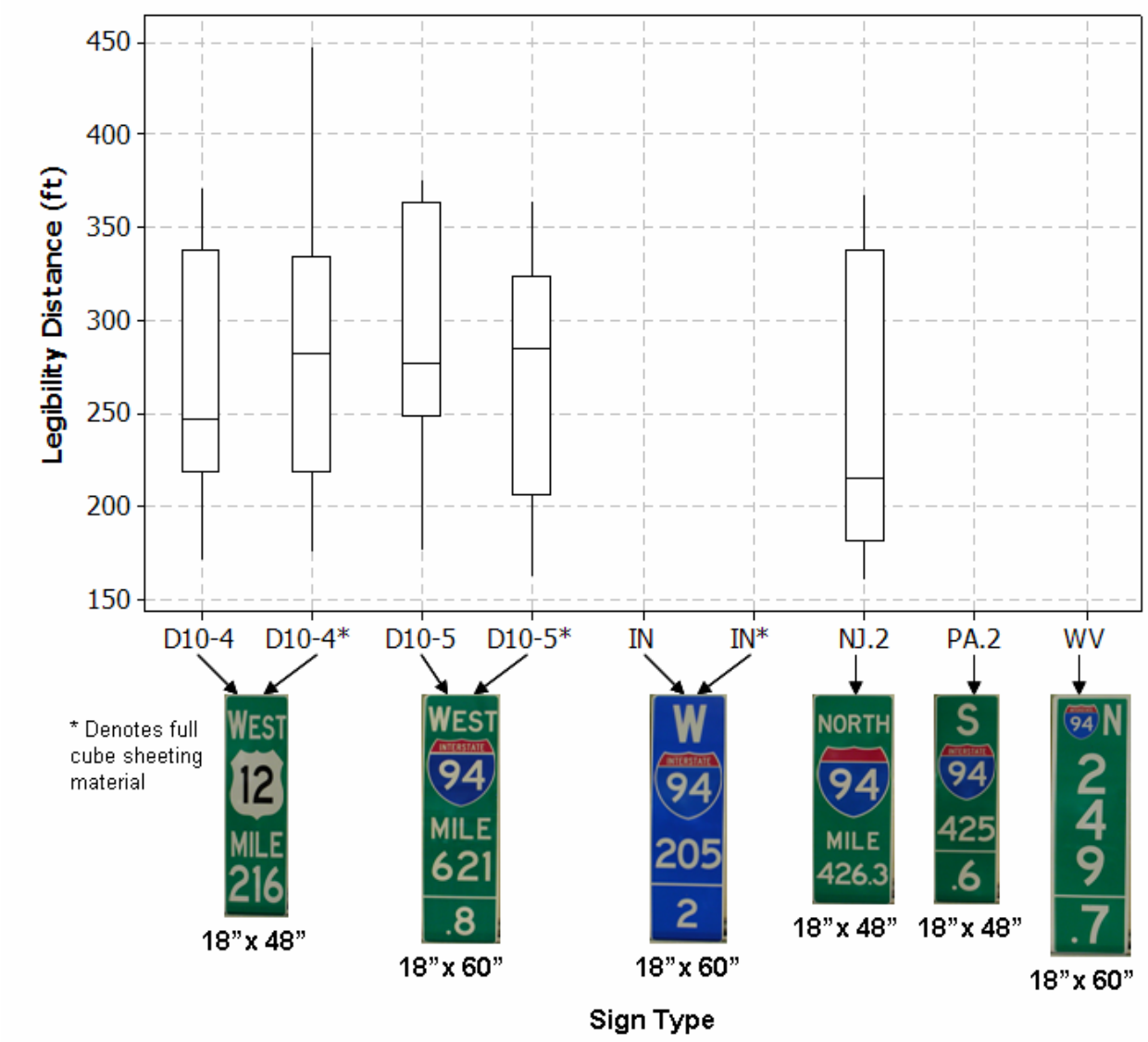
In Figure 22, the D10-4 sign had a 9-inch-tall "12" with Series D font. The WV sign had a 7-inch-tall shield. The D10-5, IN, NJ.2, and PA.2 had a 7-inch-tall "94" with Series D font.



N=12 participants in test vehicle on test road at night

Figure 22. Box Plot of Legibility Distance of the Roadway Number

In Figure 23, the D10-4 and D10-5 both had the word "MILE" with 5-inch-tall letters with Series D font, while the NJ.2 had the word "MILE" with 4-inch-tall letters with Series D font.

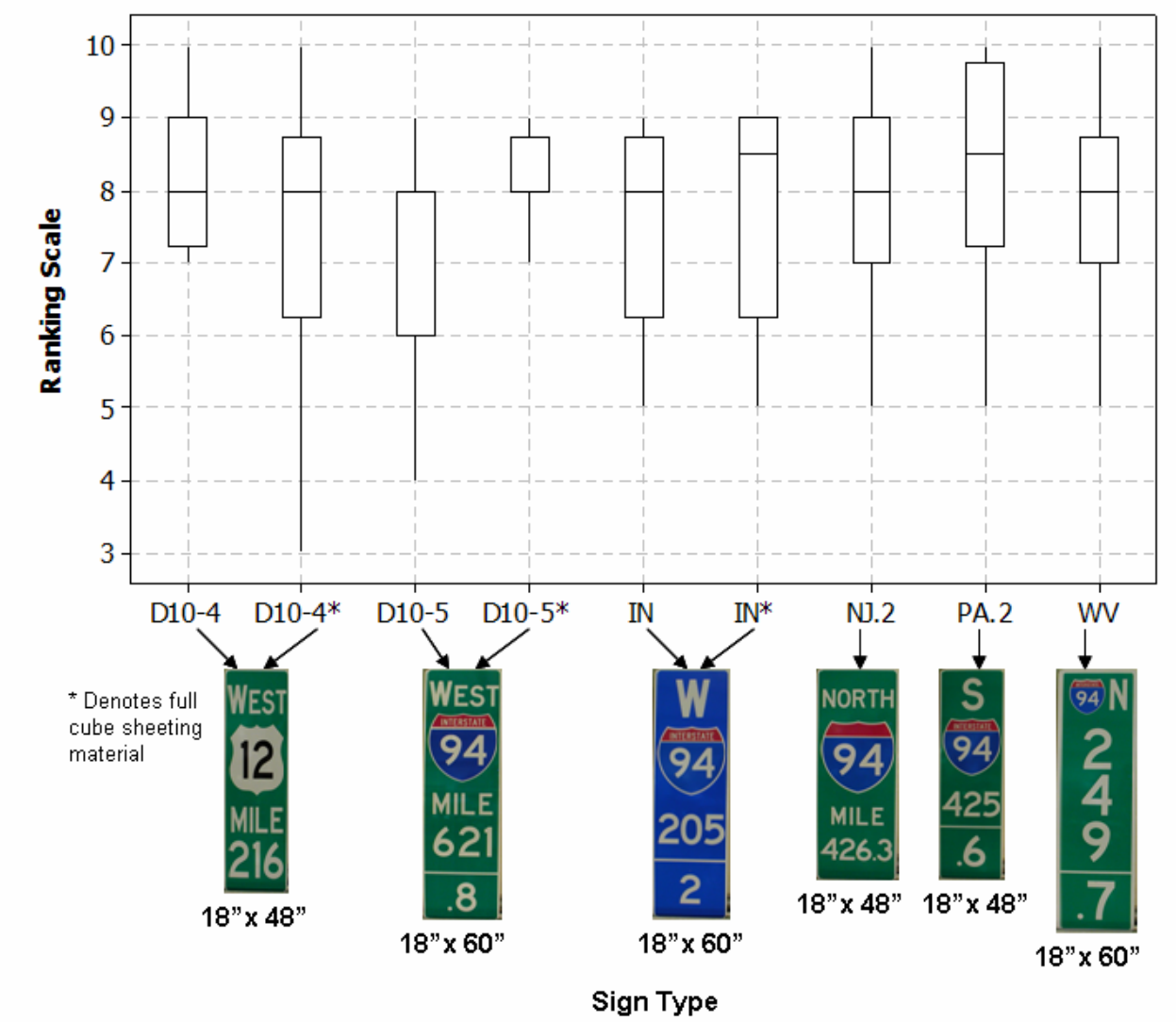


N=12 participants in test vehicle on test road at night

Figure 23. Box Plot of Legibility Distance of the Word "MILE"

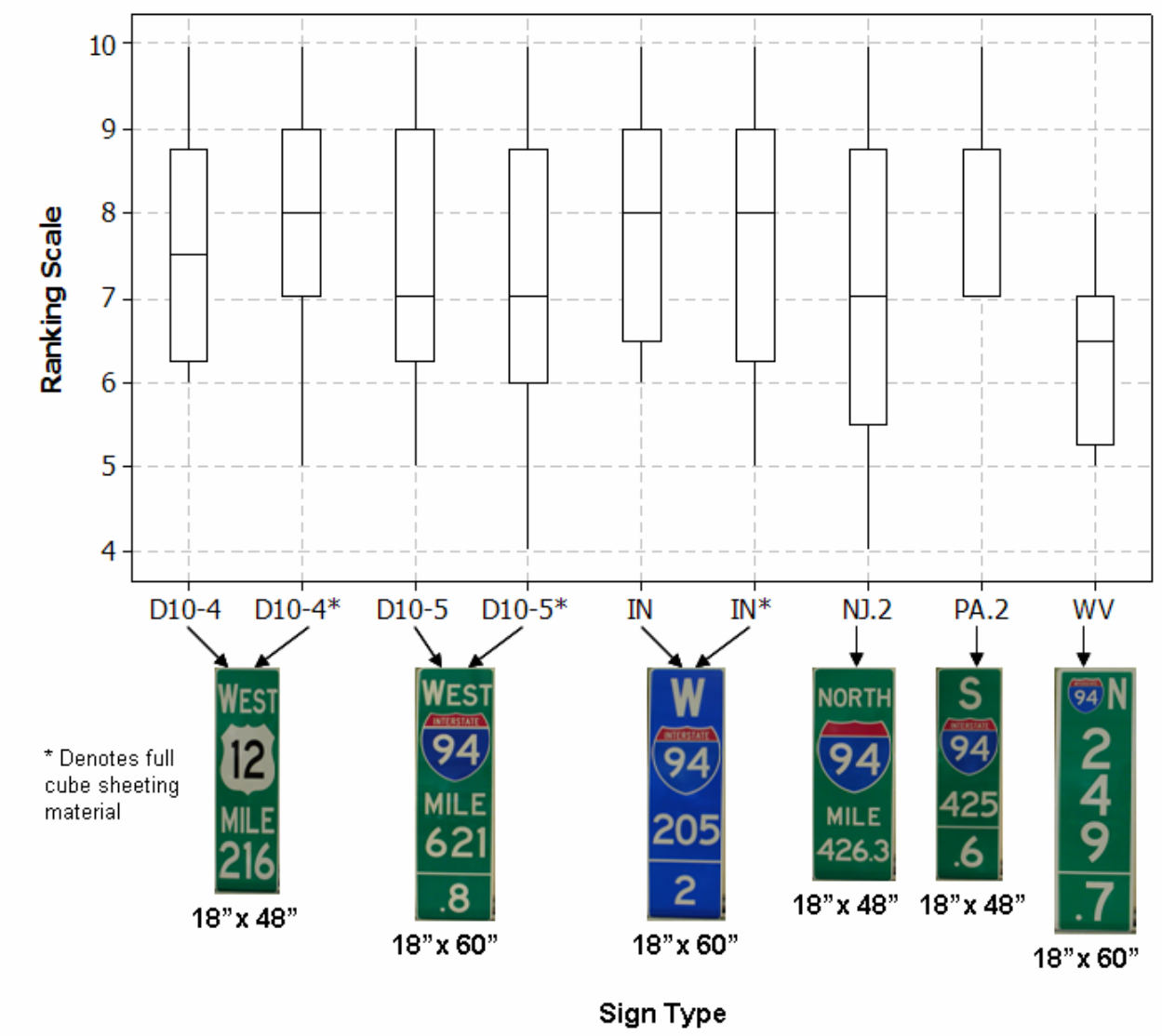
When the participants were asked to rank each of the signs with regards to visibility, legibility, and comprehension the results demonstrated on average the MUTCD D10-4 sign with full cube corner sheeting material performed better than the ASTM Type III sheeting material MUTCD D10-4 sign. On average the IN* sign performed the best among the other Intermediate Enhanced Reference Location Signs when the participants ranked the visibility, legibility, and comprehension of the signs. The MUTCD D10-4* sign had an average of 8, when the participants ranked the visibility and legibility of the sign. The MUTCD D10-4 sign had an average of 9, when the participants ranked the comprehension of the sign. The IN* sign had an average of 8.5, when the participants ranked the visibility of the sign. The IN* sign had an average of 8, when the participants ranked the legibility of the sign. The IN* sign had an average of 9, when the participants ranked the comprehension of the sign. In Figure 24, Figure 25, and,

Figure 26, are the visibility, legibility, and comprehension results of the Enhanced and Intermediate Enhanced Reference Location Signs.



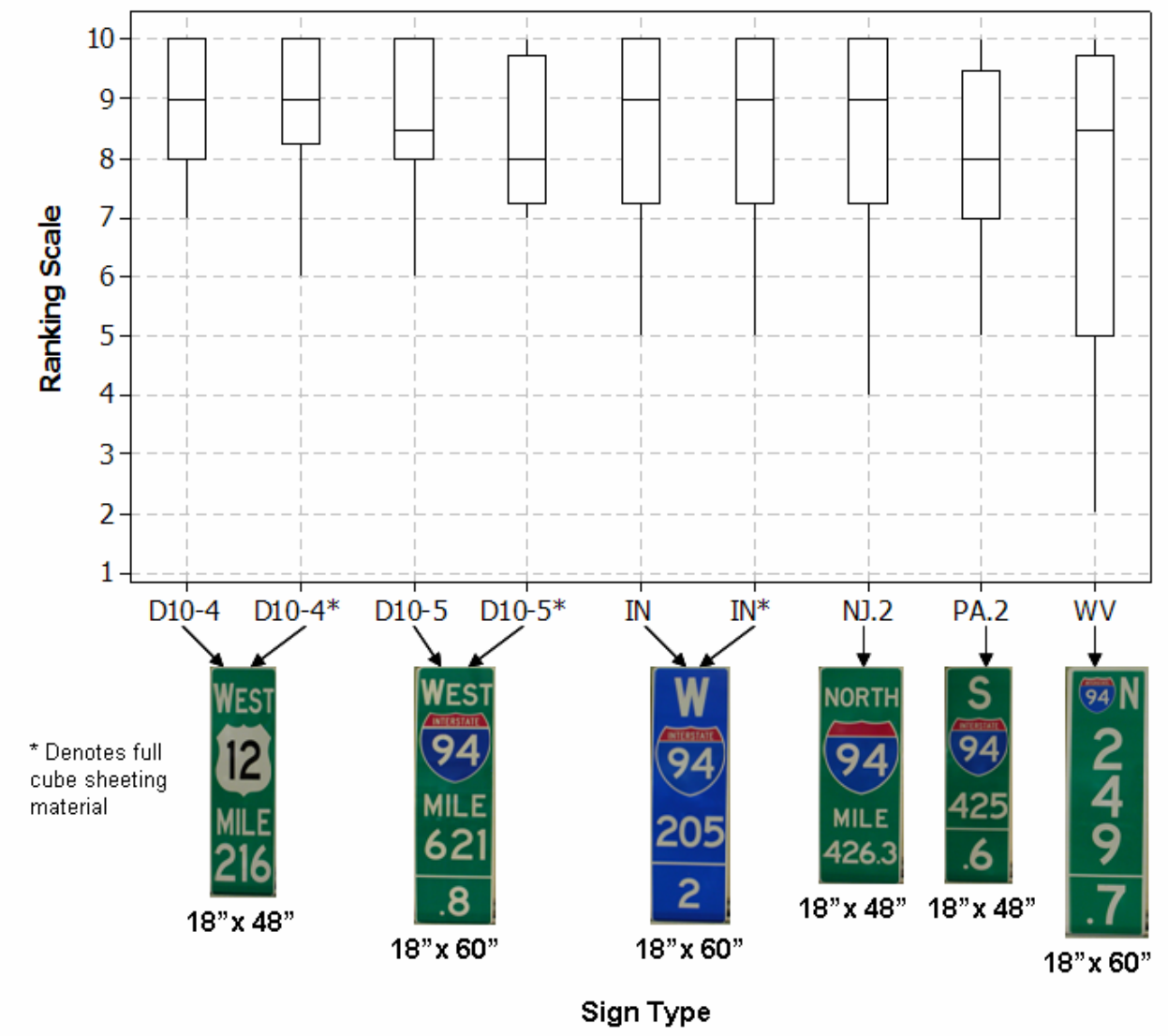
N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 24. Box Plot of Ranking the Visibility for the Enhanced and Intermediate Enhanced Reference Location Signs



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 25. Box Plot of Ranking the Legibility for the Enhanced and Intermediate Enhanced Reference Location Signs

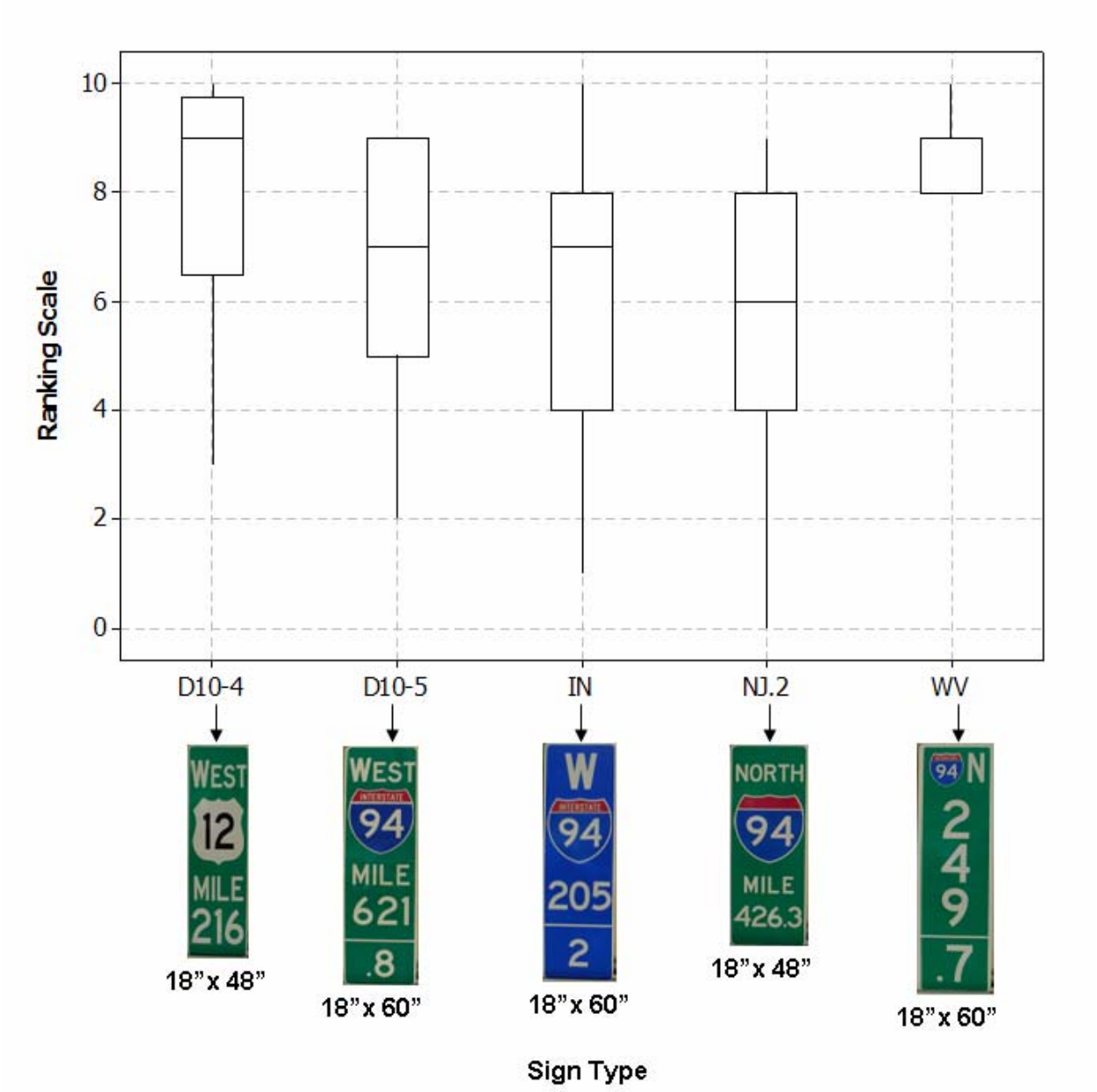


N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 26. Box Plot of Ranking the Comprehension for the Enhanced and Intermediate Enhanced Reference Location Signs

5.2.2 Comprehension Road Test Verification

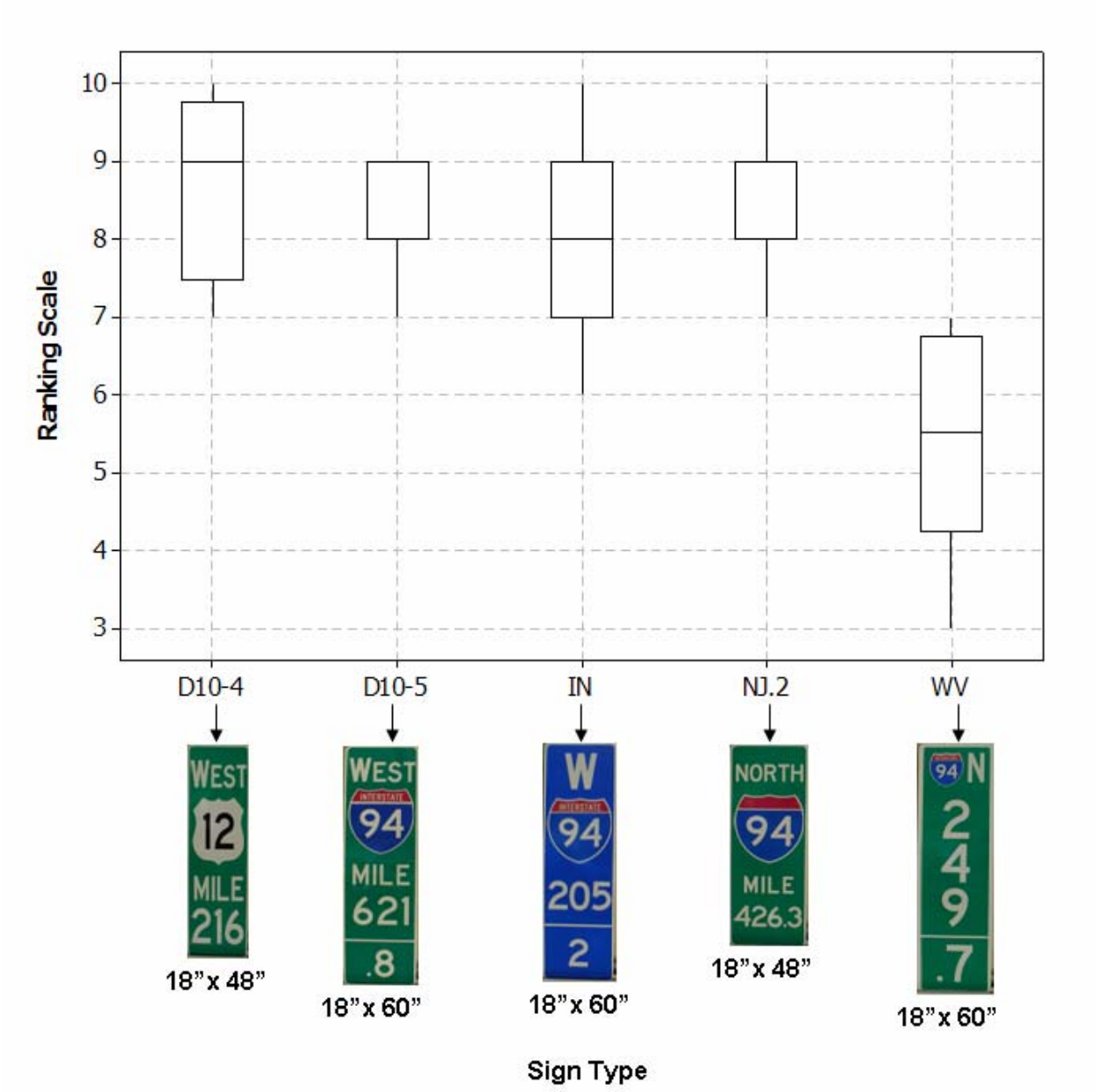
The post run survey results showed that all the mile numbers of the Enhanced and Intermediate Enhanced Reference Location Signs were interpreted correctly. The post-survey also demonstrated of the Enhanced and Intermediate Enhanced Reference Location Signs on average there was a preference for the MUTCD's D10-4 and D10-5, as shown in Figure 27. Figure 27 through Figure 29 show the results from the post-survey of the Enhanced and Intermediate Enhanced Reference Location Signs when the participants were asked to rank the presentation of the mile number, cardinal direction, and roadway. Because the post-survey questions pertained to the legend layout only, the PA.2 sign was taken out because it and the Indiana sign both had the same content layout.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 27. Box Plot of Ranking the Presentation of the Mile Number

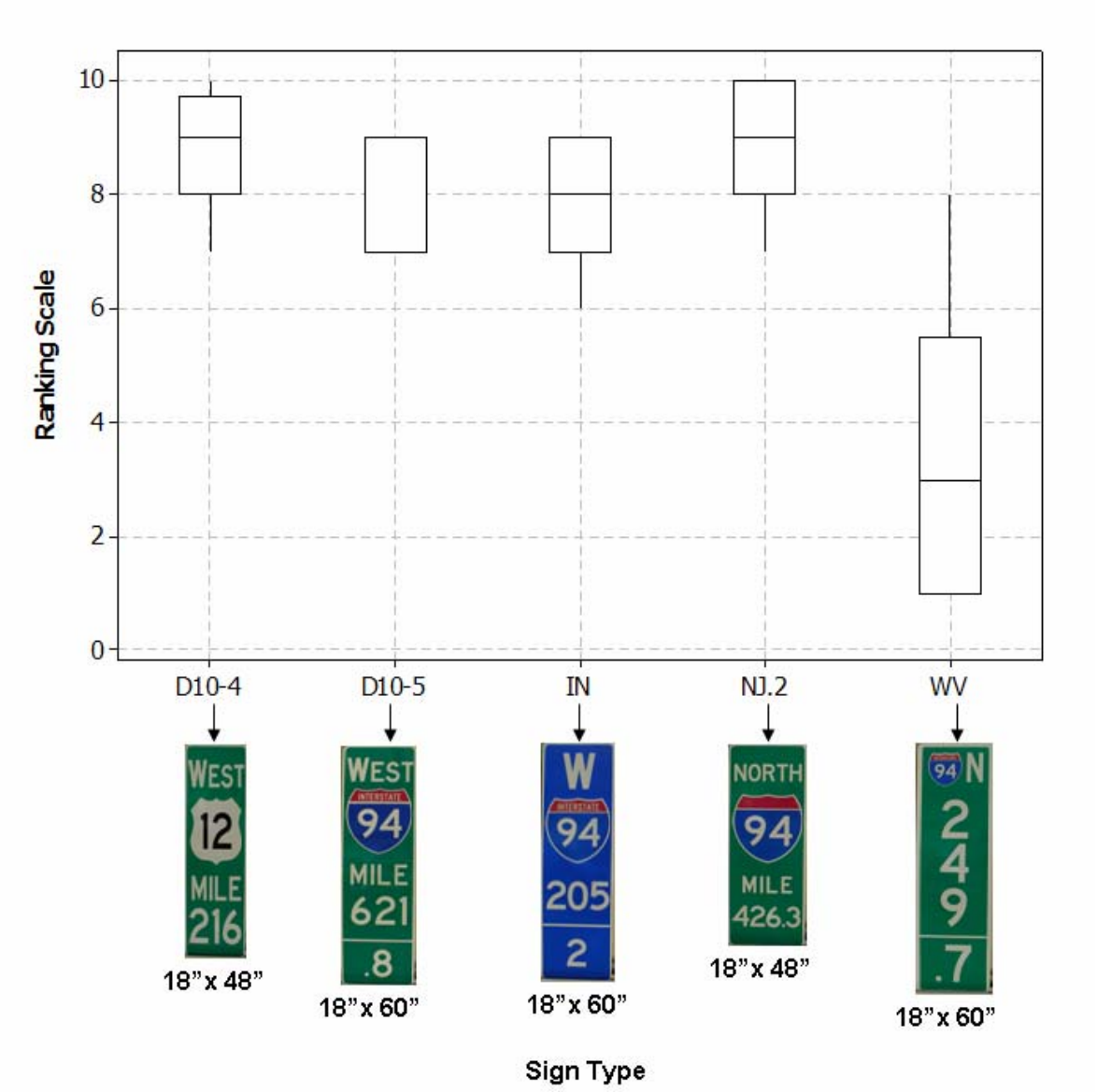
The post-survey results showed that the participants ranked the D10-4 as the best way on average to represent the cardinal direction, as shown in Figure 28.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 28. Box Plot of Ranking the Presentation of the Cardinal Direction

The post-survey results demonstrated the participants ranked the D10-4 and NJ.2 as the best way to represent the roadway. The post-survey results are shown in Figure 29.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

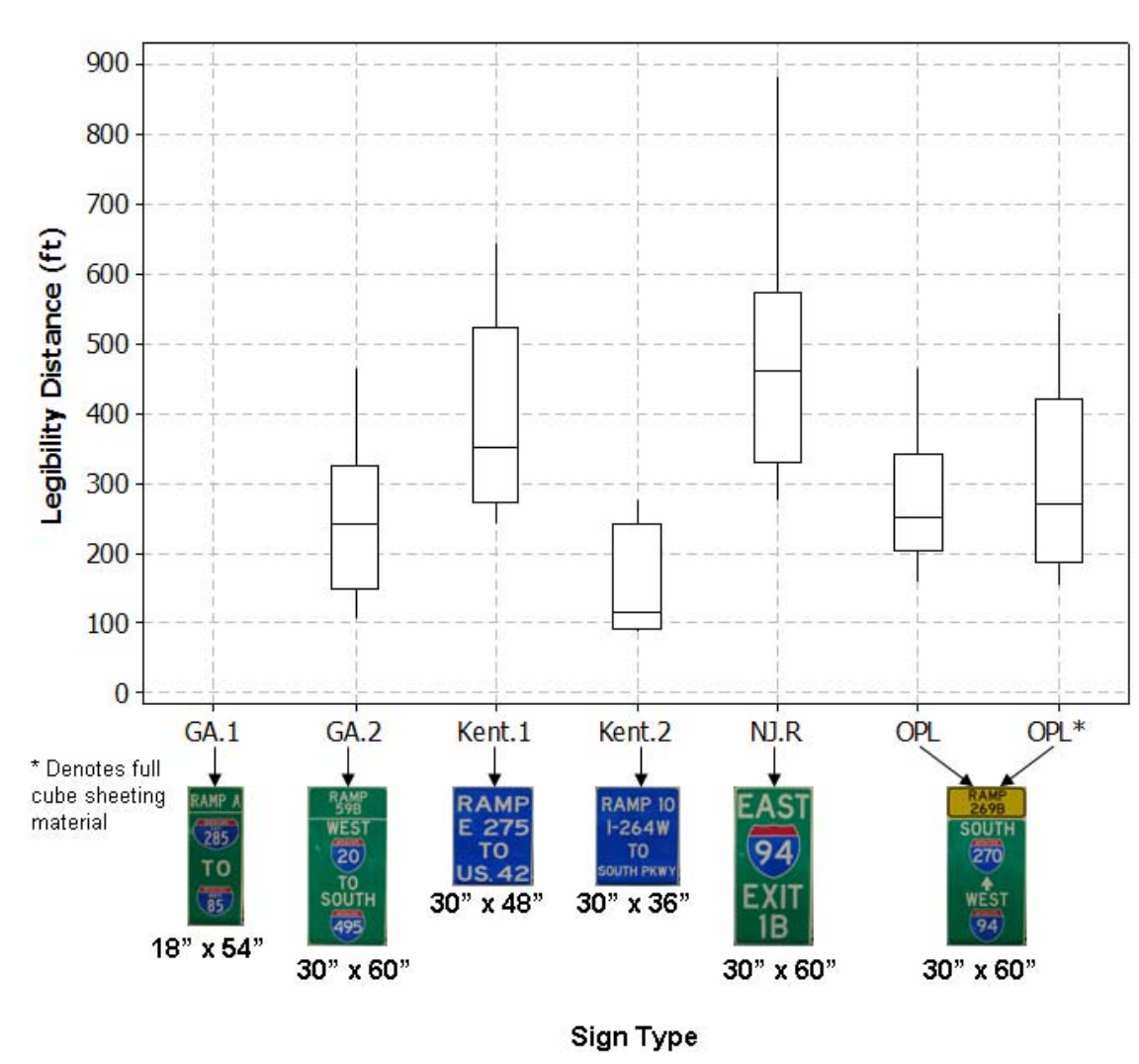
Figure 29. Box Plot of Ranking the Presentation of the Roadway Number

5.3 ROAD TEST TARVIP VALIDATION RESULTS FOR RAMP SIGNS

The results of the ramp signs were subdivided into subcategories such as previous cardinal direction, approaching cardinal direction, previous roadway, approaching roadway, ramp number, the word "RAMP," and the word "TO" or an arrow legibility distance. Only two of the six different ramp sign content layouts were interpreted correctly. The GA.2 and Kent.2 were the two ramp signs that were interpreted correctly by the twelve subjects. Of the twelve participants five misinterpreted the Kent.1 ramp sign. The OPL and GA.1 signs were misinterpreted by two of the twelve participants. The NJ.R ramp sign was misinterpreted by one of the twelve participants.

5.3.1 Tarvip Road Test Verification

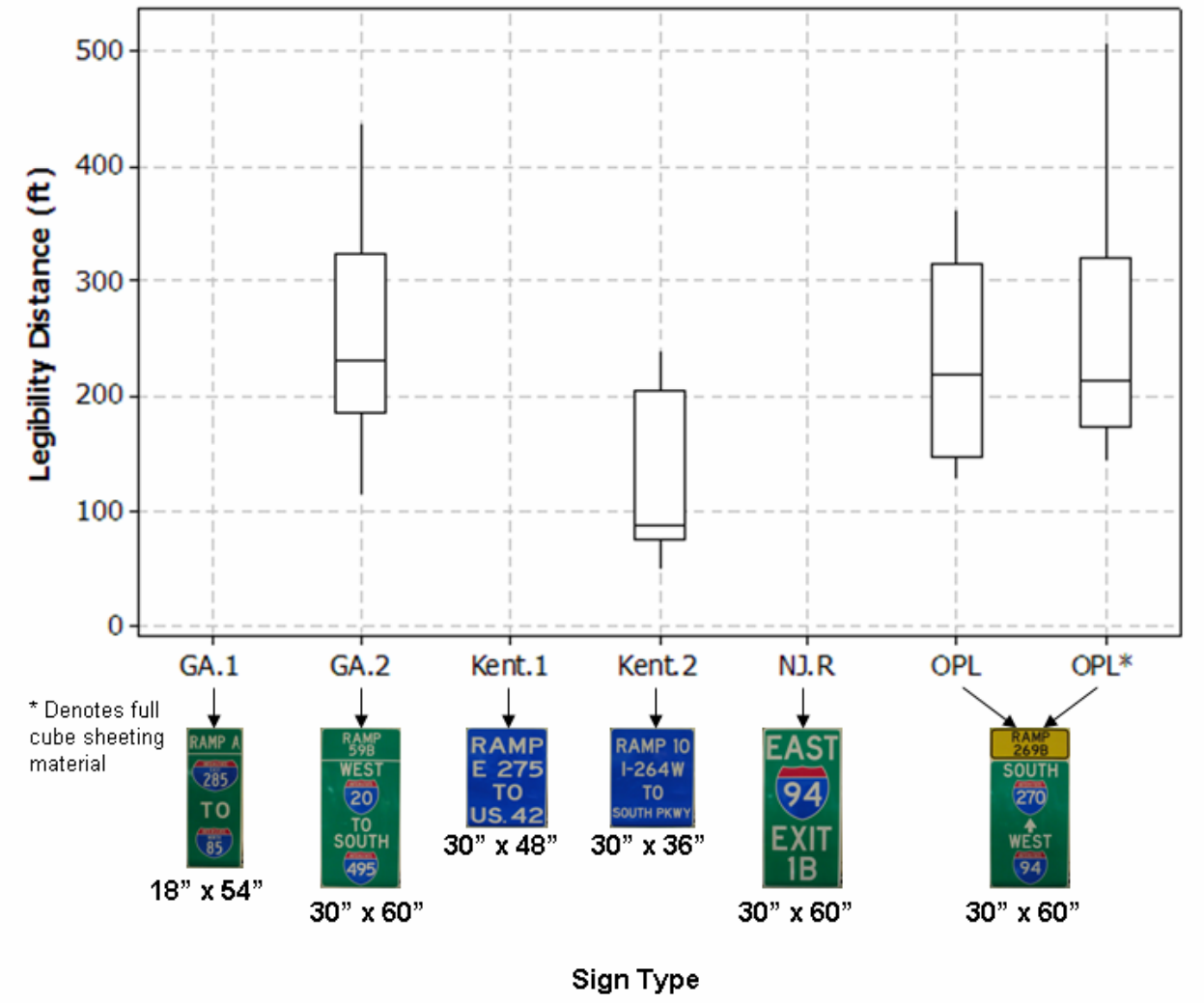
The legibility distance results of the previous and approaching cardinal direction box plots can be seen in Figure 30 and Figure 31, respectively. **Again, it is very important to note that we optimized all our test signs according to the design guidelines we have established in Table 2 and Table 3.** The Kent.1 and NJ.R ramp sign's previous cardinal direction had 9.25-inch letters with Series D font. The GA.2, Kent.2, OPL, and OPL* signs had the previous direction indicated with 5-inch letters and Series D font. The GA.1 sign had the previous cardinal direction indicated with 1.5-inch letters using Series B font. In looking at the legibility distance results that follow, the reader should bear in mind that the New Jersey ramp sign conveys less information, as it does not contain a from-to mapping. Since there are fewer information elements, the legend was larger than in all other signs. Sign designers need to weigh the trade-off between content, size, and legibility.



N=12 participants in test vehicle on test road at night

Figure 30. Box Plot of Legibility Distance of the Previous Cardinal Direction

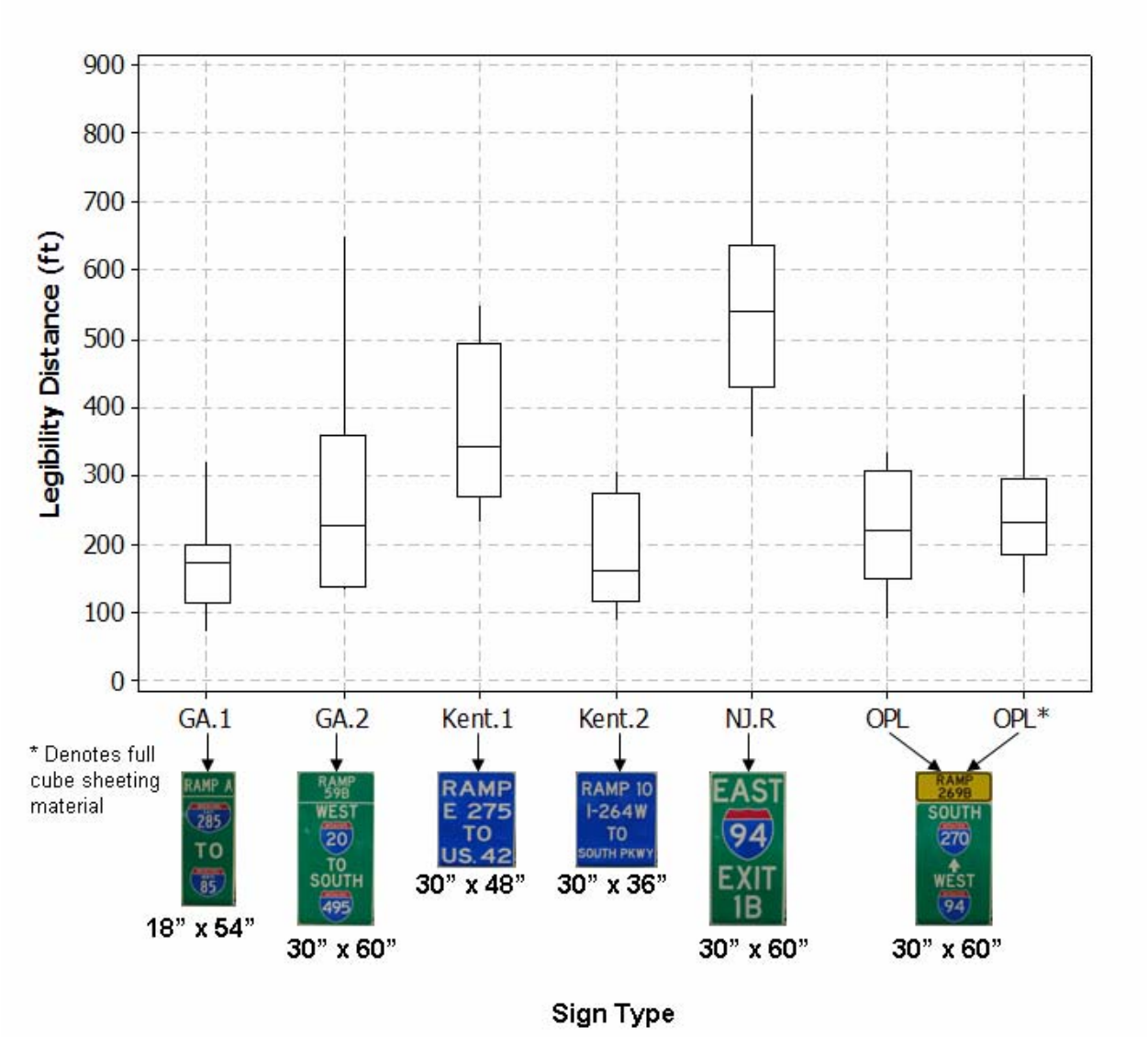
The Kent.1 (Kentucky) ramp sign's approaching cardinal direction had 9.25-inch letters with Series D font. The GA.2, OPL, and OPL* ramp signs had the approaching direction with 5-inch letters and Series D font. The GA.1 ramp sign had the approaching cardinal directions with 1.5-inch letters with Series B font. The Kent.2 ramp sign had 3.5-inch letter height with Series D font for the approaching cardinal direction.



N=12 participants in test vehicle on test road at night

Figure 31. Box Plot of Legibility Distance of the Approaching Cardinal Direction

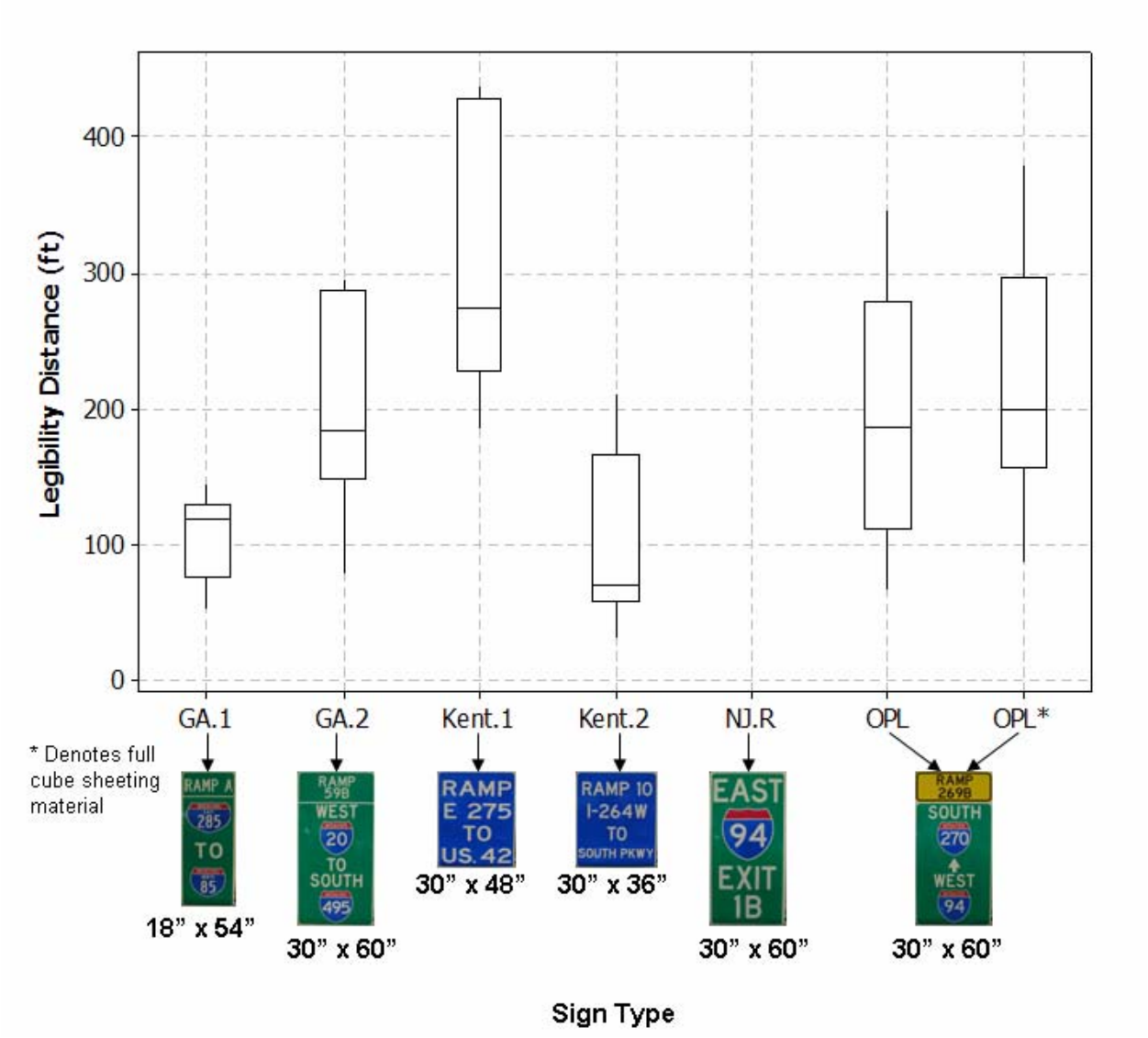
Figure 32 shows the legibility distance results of the previous roadway. The Kent.1 and NJ.R ramp signs had 9.25-inch route numbers with Series D font. The GA.2, Kent.2, OPL, and OPL* ramp signs had the previous roadway with 5-inch-tall route numbers with Series D font. The GA.1 ramp sign had 5-inch-tall route numbers with Series B font.



N=12 participants in test vehicle on test road at night

Figure 32. Box Plot of Legibility Distance of the Previous Roadway

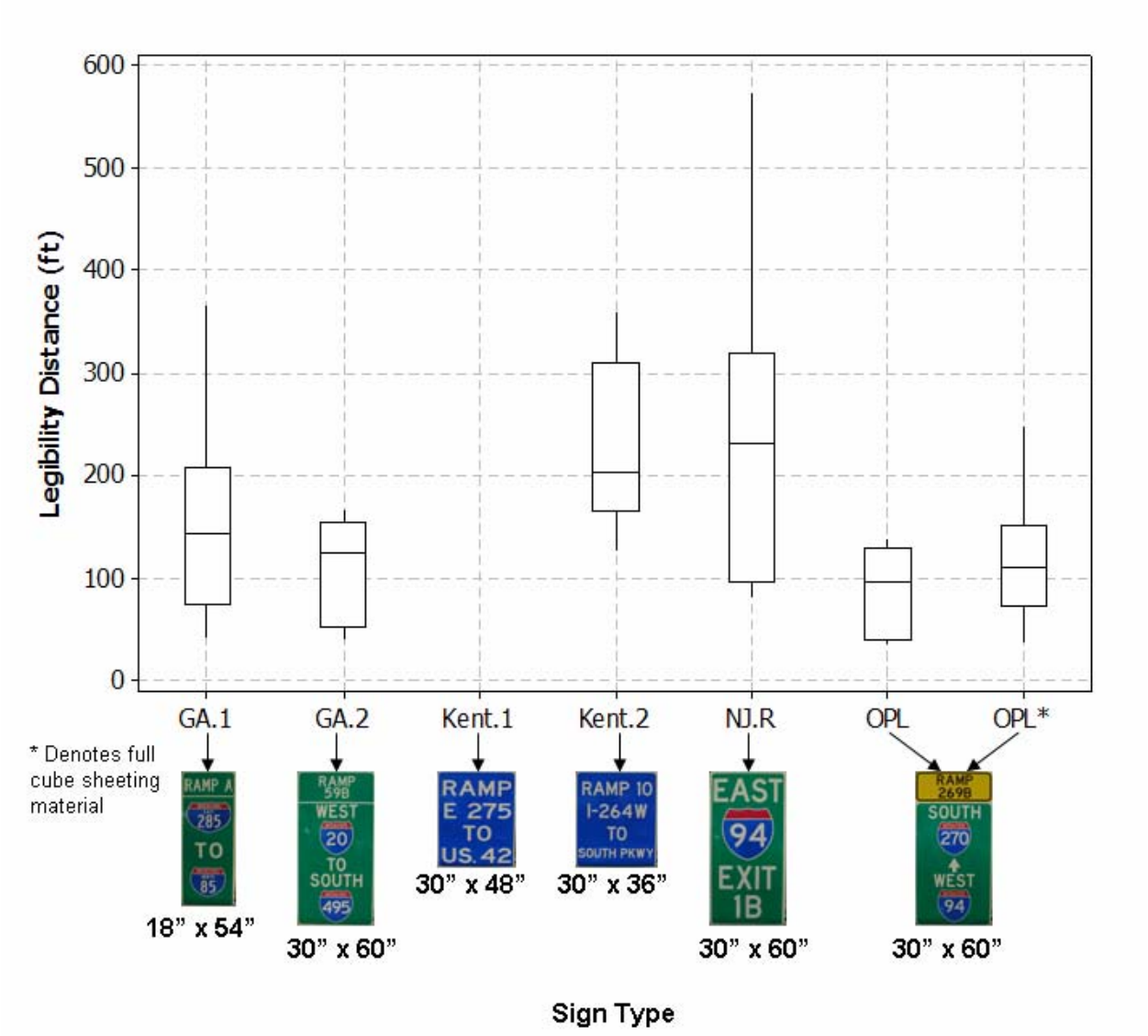
Figure 33 shows the legibility distance results of the approaching roadway. The Kent.1 ramp signs had 9.25-inch route numbers with Series D font. The GA.2, OPL, and OPL* ramp signs had the approaching roadway with 5-inch-tall route numbers with Series D font. The Kent.2 ramp sign had the approaching roadway with 3.5-inch-tall route numbers with Series D font. The GA.1 ramp sign had 5-inch-tall route numbers with Series B font.



N=12 participants in test vehicle on test road at night

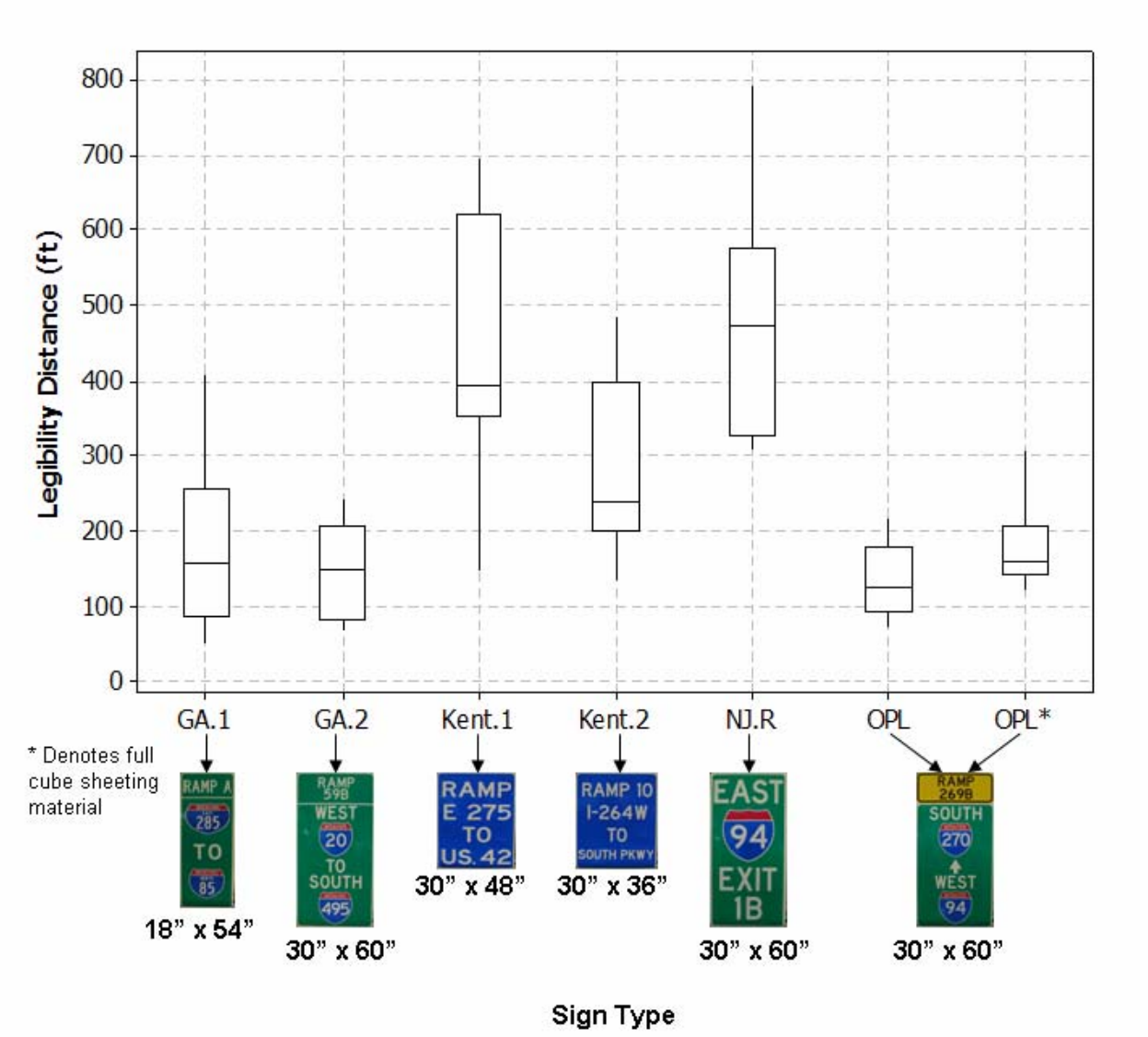
Figure 33. Box Plot of Legibility Distance of the Approaching Roadway

Figure 34 and Figure 35 show the ramp number and the word "RAMP" or "EXIT" legibility distance results. The NJ.R ramp sign's ramp number and the word "EXIT" were 9.25 inches tall with Series D font. The GA.1 ramp sign's ramp number and the word "RAMP" were 5 inches tall with Series B font. The GA.2 ramp sign's ramp number and the word "RAMP" were 5 inches tall with Series D font. The Kent.2 ramp sign's ramp number and the word "RAMP" were 5 inches tall with Series D font. The ramp number and the word "RAMP" for the OPL and OPL* ramp signs were 3.5 inches with Series D font.



N=12 participants in test vehicle on test road at night

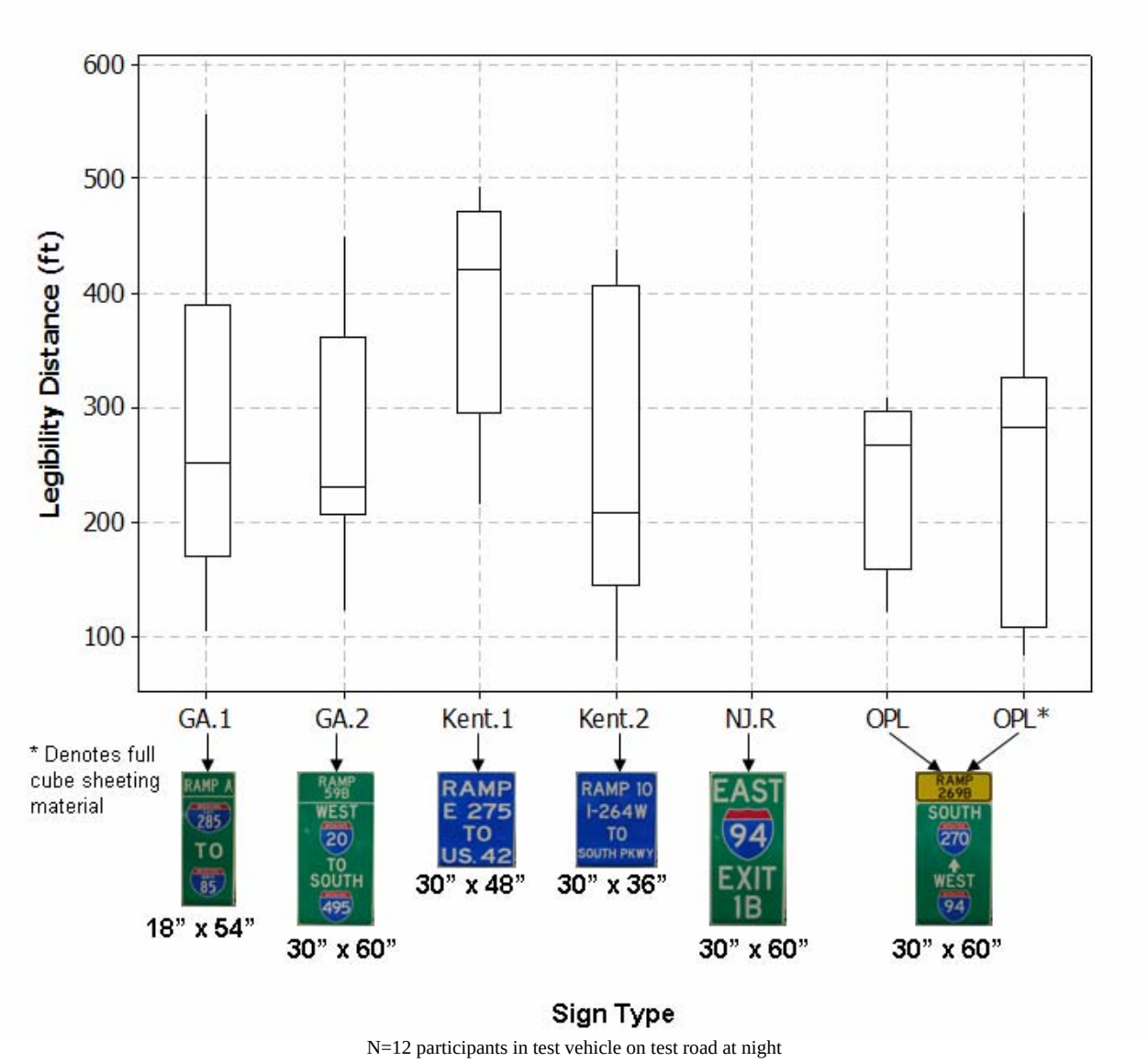
Figure 34. Box Plot of Legibility Distance of the Ramp Number



N=12 participants in test vehicle on test road at night

Figure 35. Box Plot of Legibility Distance of the Word "RAMP" or "EXIT"

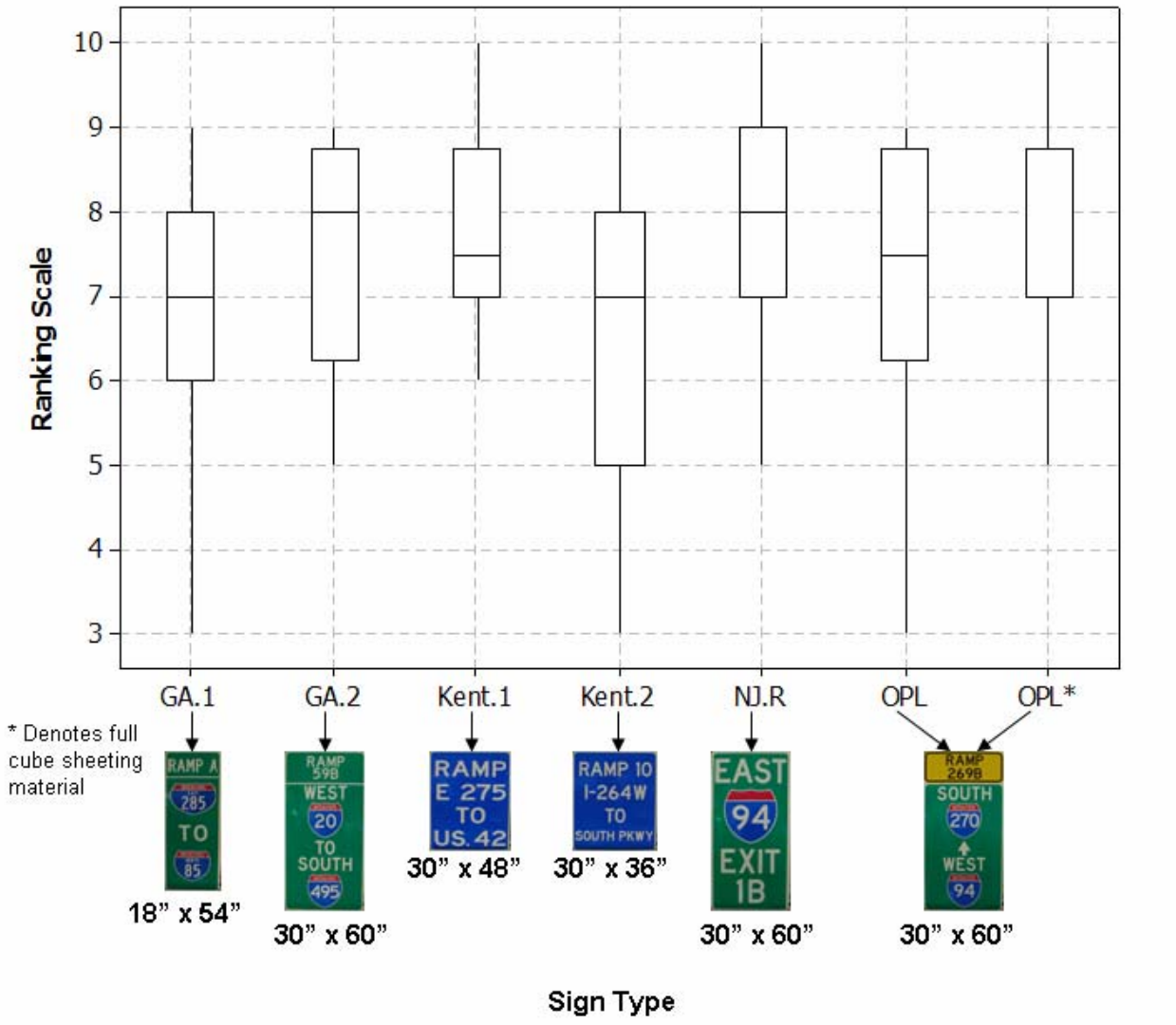
Figure 36 shows the legibility distance results of the word "TO" or the arrow. The Kent.1 ramp sign had the word "TO" with 9.25-inch-tall letters with Series D font, while the rest of the ramp signs had the word "TO" in 5-inch-tall letters with Series D font.



N=12 participants in test vehicle on test road at night

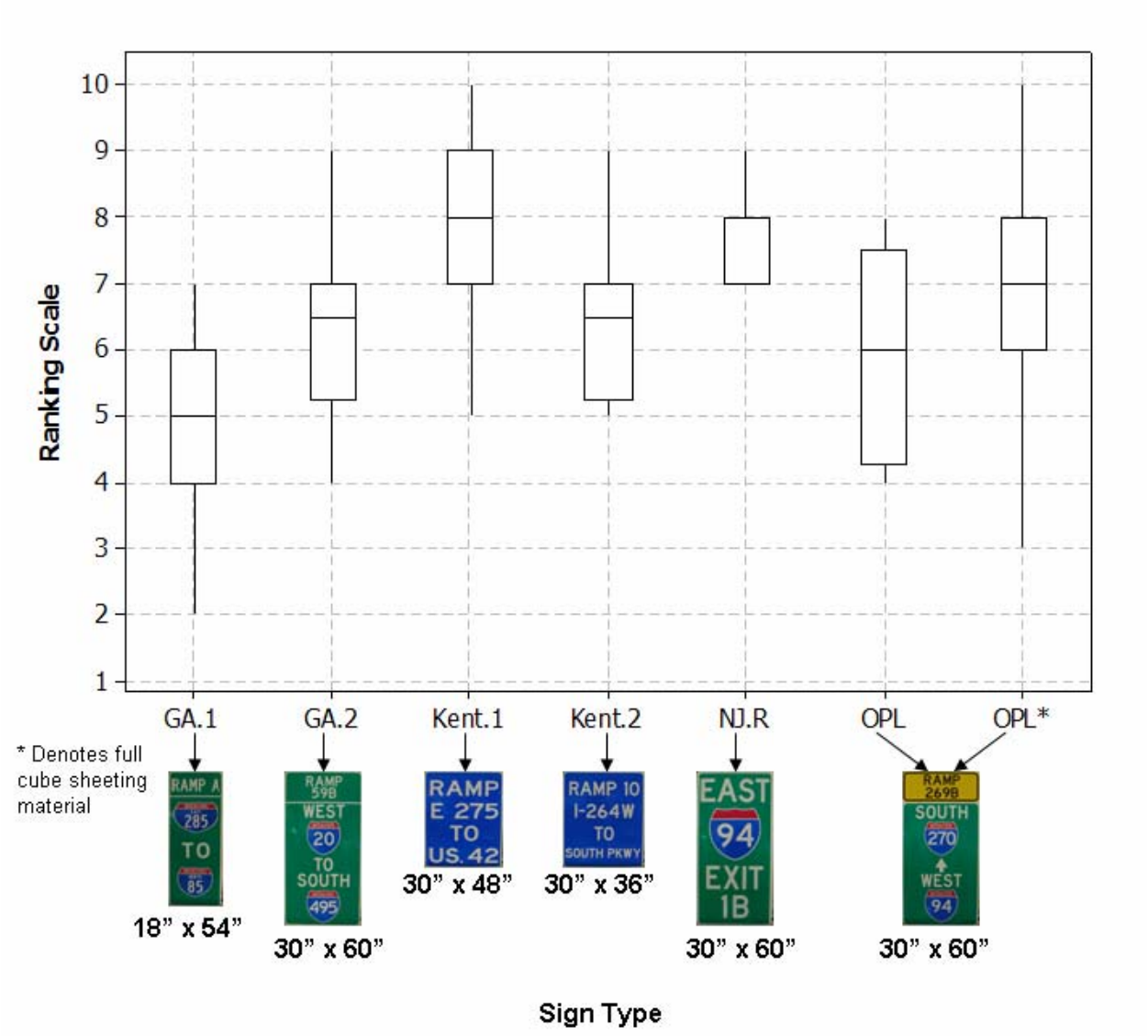
Figure 36. Box Plot of Legibility Distance of the Word "TO" or the Arrow

When the participants were asked to rank each of the ramp signs with regards to visibility, legibility, and comprehension the results demonstrated on average the NJ.R ramp sign performed the best. The NJ.R ramp sign had an average 8, when the participants ranked the visibility and legibility of the sign. The NJ.R ramp sign had an average of 9, when the participants ranked the comprehension of the sign. In Figure 37, Figure 38, and Figure 39 are the visibility, legibility, and comprehension results of the ramp signs.



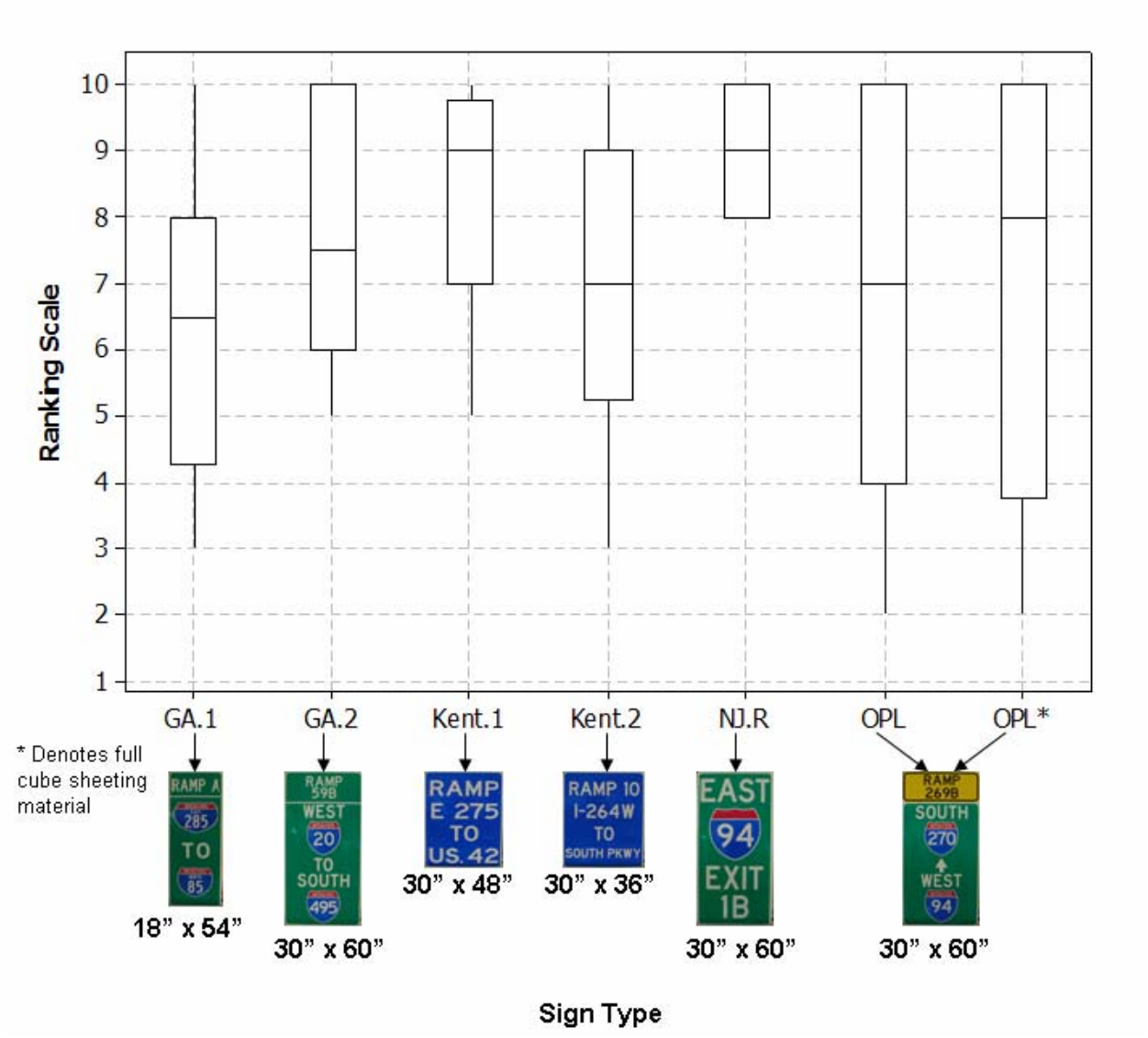
N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 37. Box Plot of Ranking the Visibility for the Ramp Signs



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 38. Box Plot of Ranking the Legibility for the Ramp Signs

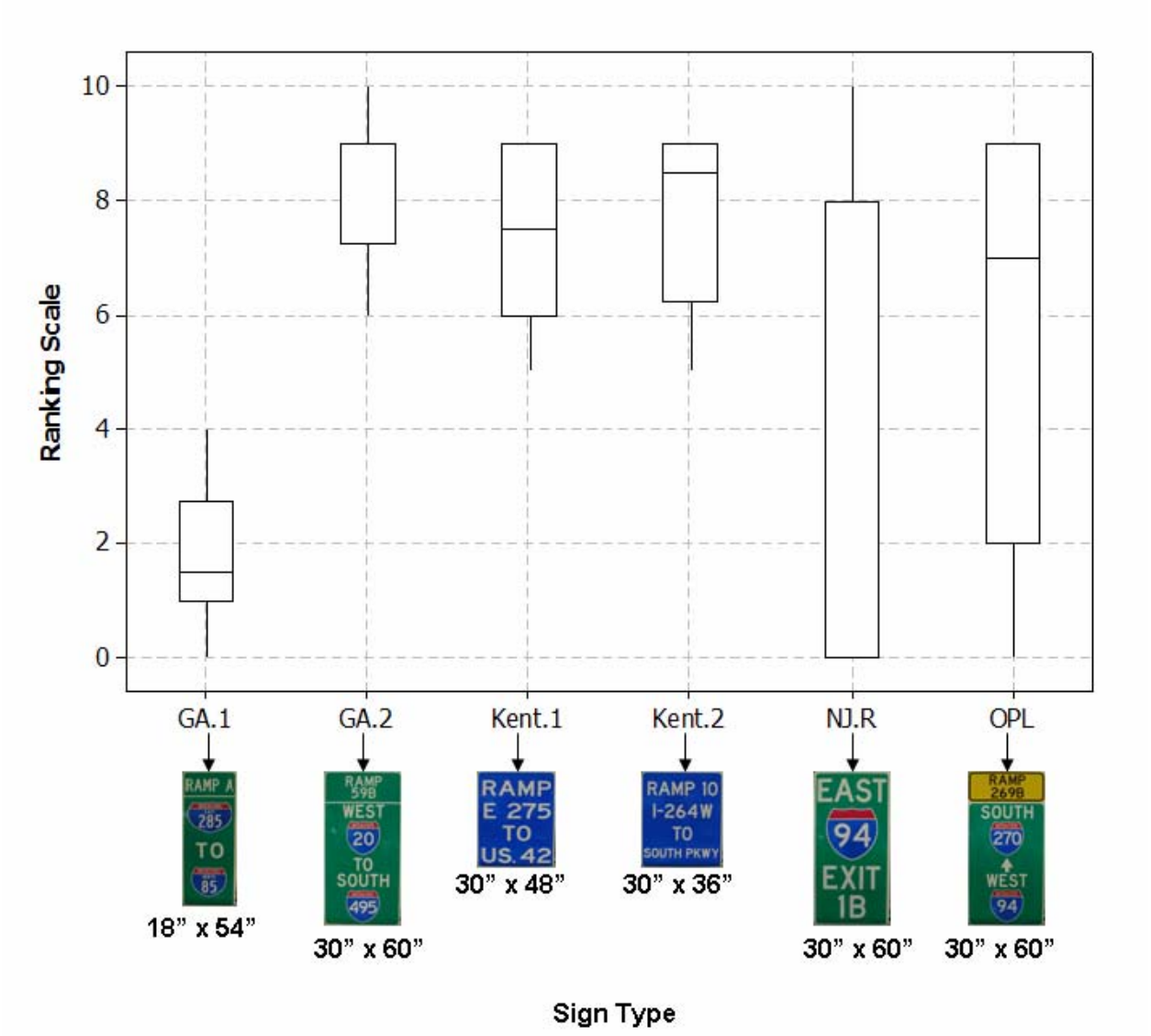


N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 39. Box Plot of Ranking the Comprehension for the Ramp Signs

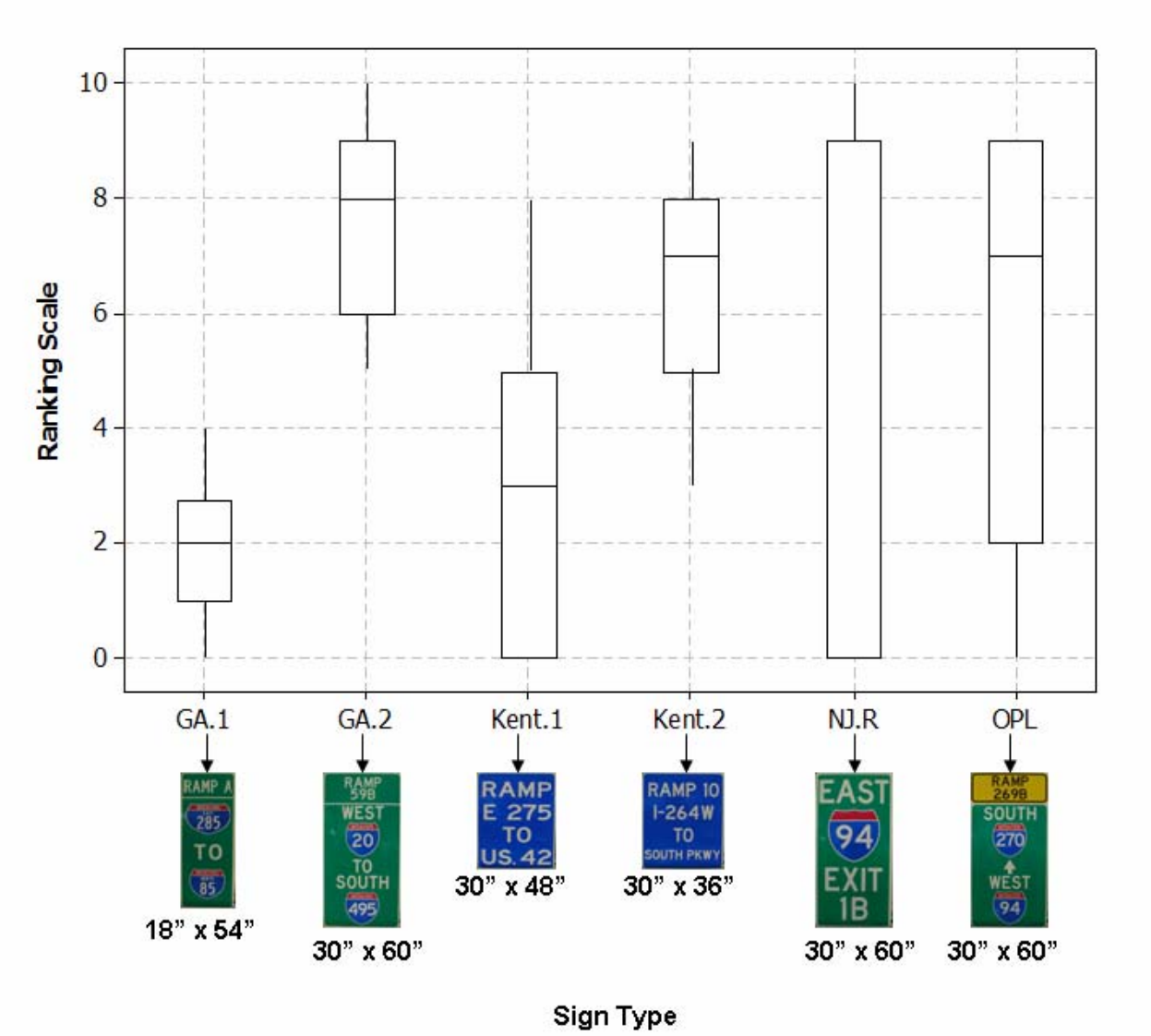
5.3.2 Comprehension Road Test Verification

The post-survey results showed that the participants ranked the GA.2 ramp sign as the best way on average to represent the previous and approaching cardinal directions, as shown in Figure 40 and Figure 41.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

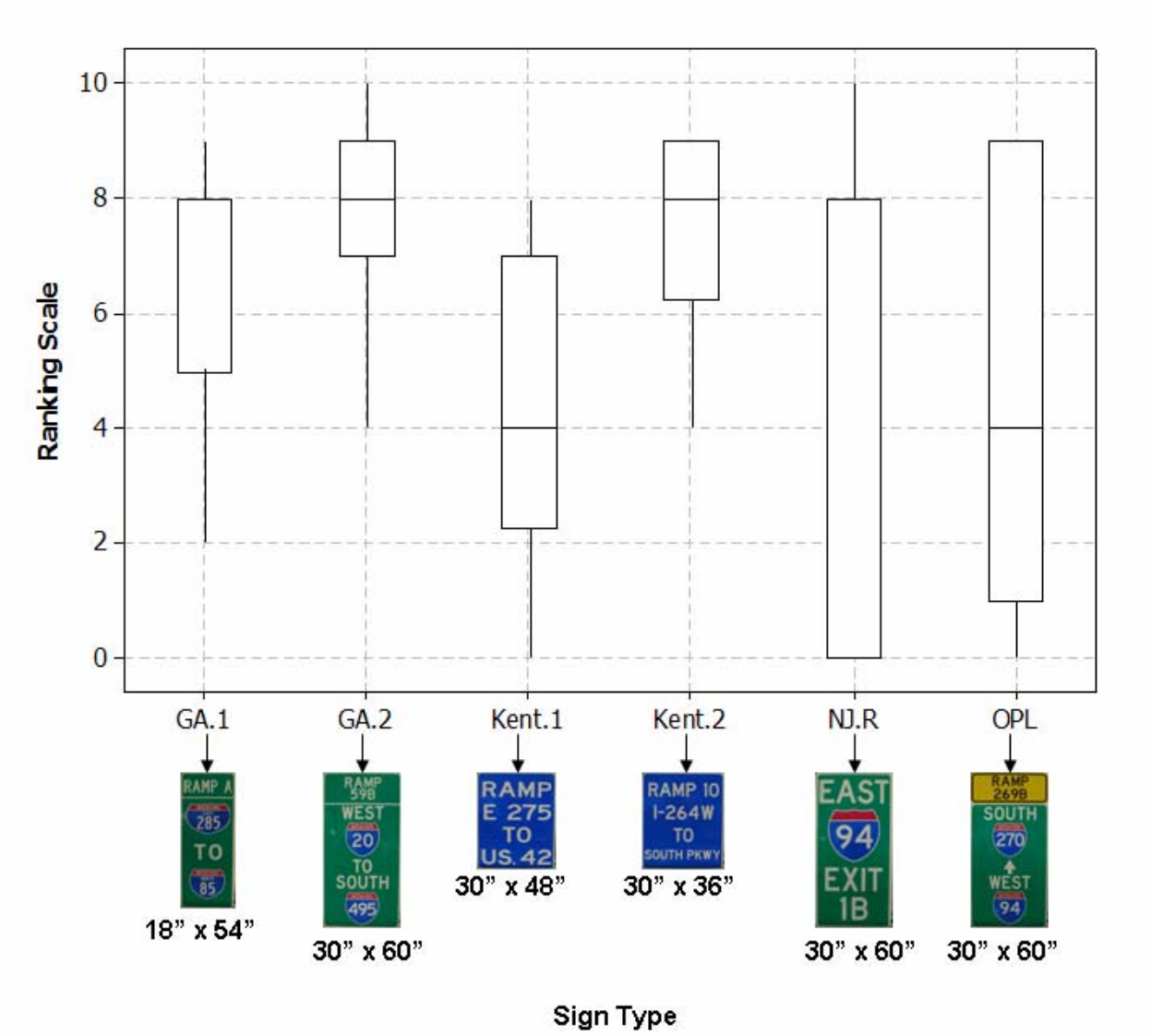
Figure 40. Box Plot of Ranking the Presentation of the Previous Cardinal Direction



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 41. Box Plot of Ranking the Presentation of the Approaching Cardinal Direction

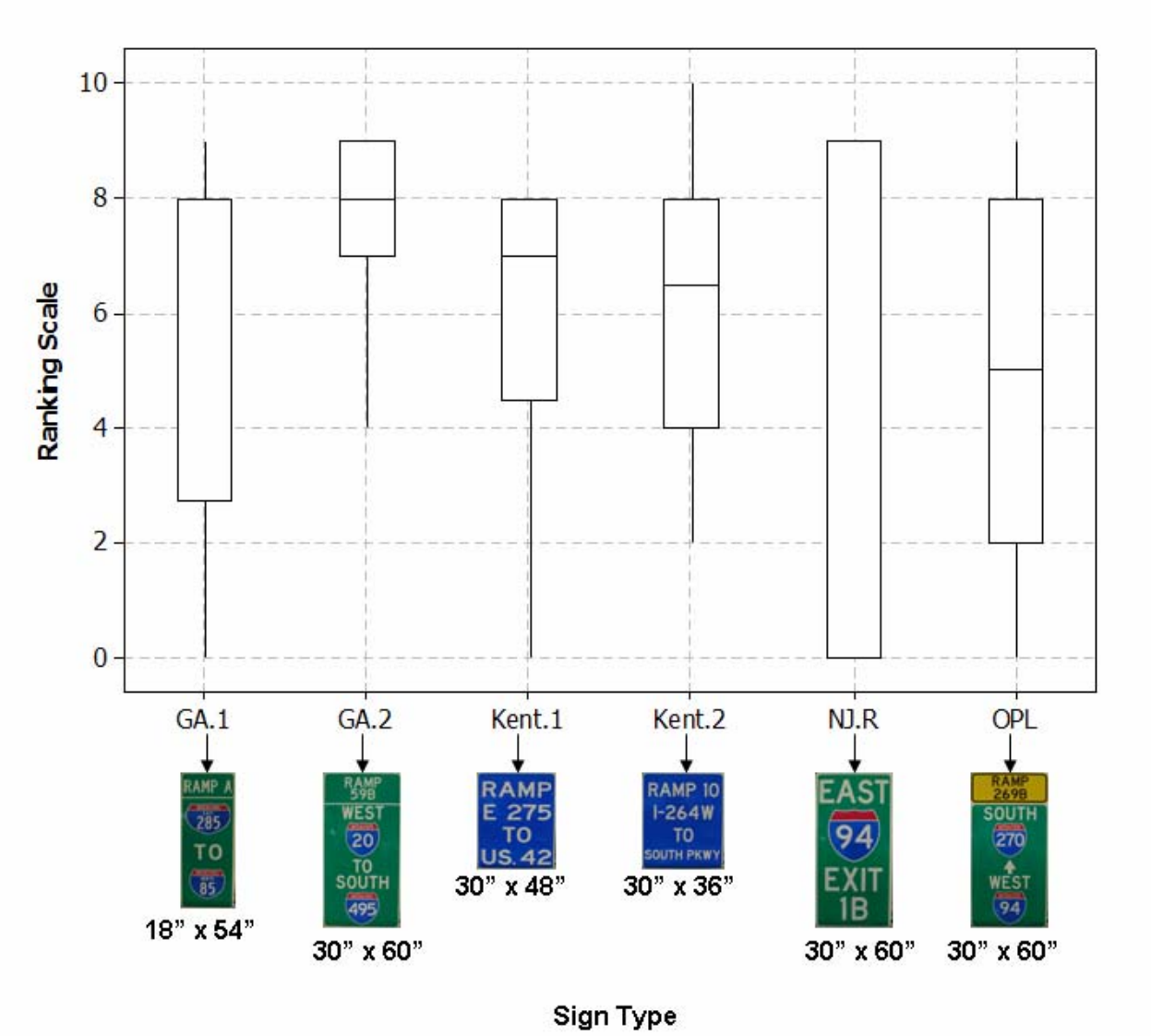
The post-survey results showed that the participants ranked the GA.2 and Kent.2 ramp signs as the best way on average to represent the previous roadway, as shown in Figure 42.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 42. Box Plot of Ranking the Presentation of the Previous Roadway

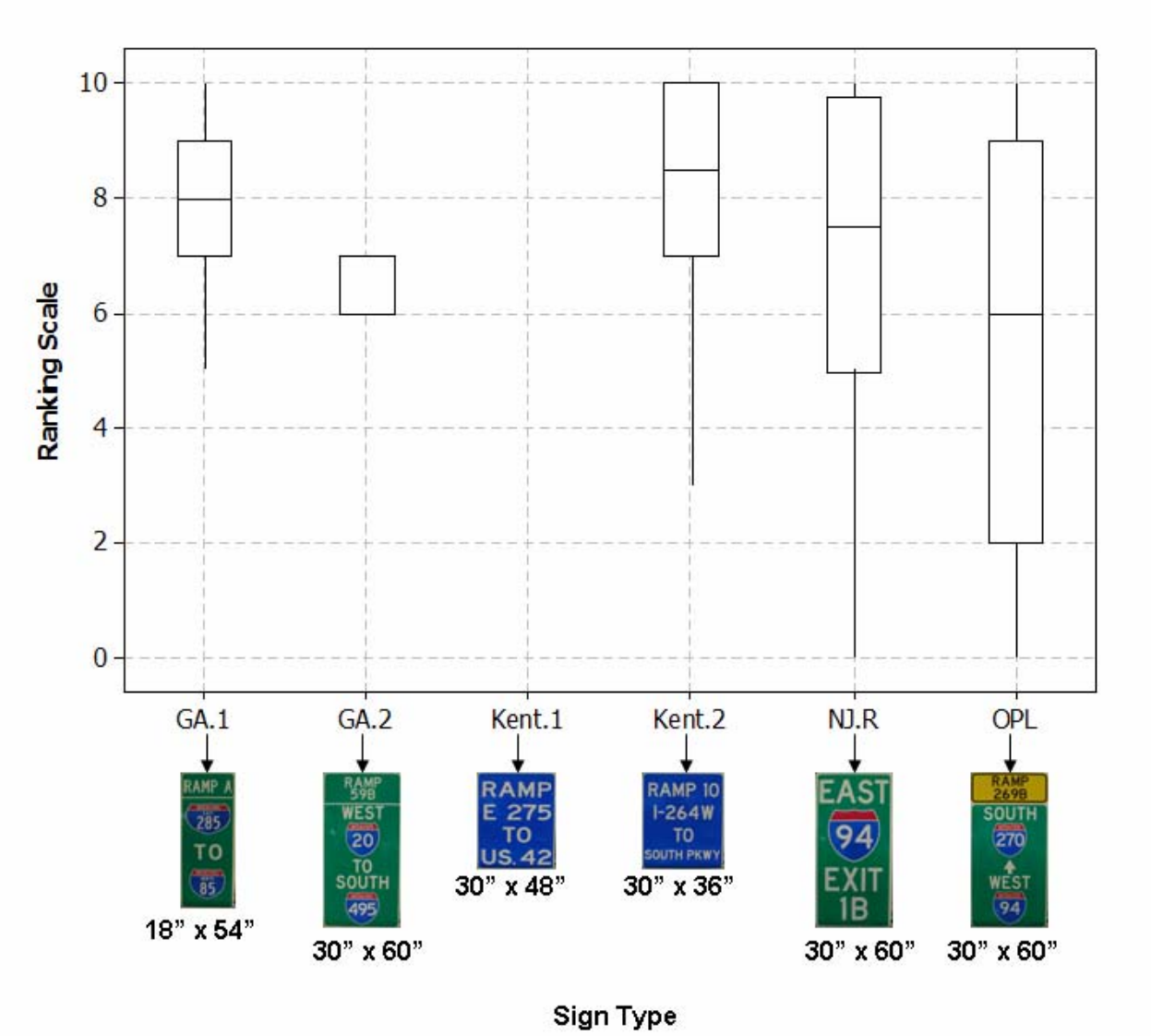
The post-survey results showed that the participants ranked the GA.2 ramp sign as the best way on average to represent the approaching roadway, as shown in Figure 43.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 43. Box Plot of Ranking the Presentation of the Approaching Roadway

The post-survey results showed that the participants ranked the Kent.2 ramp sign as the best way on average to represent the ramp number, as shown in Figure 44.



N=12 participants in test vehicle on test road at night, evaluation of sign was done parked on shoulder after passing sign

Figure 44. Box Plot of Ranking the Presentation of the Ramp Number

5.4 OTHER TEST SUBJECT COMMENTS

During the road test study, five of the twelve participants commented that they did not like the fraction form of the Pennsylvania.1 sign, which had the one-tenth fraction. Three of the twelve participants commented on not being able to see the decimal point on the New Jersey.2 sign until they were really close to the sign. There were also conflicting comments on the use of the line and a decimal point to separate the tenths of mile; some participants were okay with the design, while others did not like the decimal point because they thought the line was enough to distinguish it to be a tenth of a mile. Some participants preferred to have the mile number vertically represented, while others preferred to have the mile number represented horizontally. Some preferred the cardinal direction to be spelled out, while others preferred the cardinal direction to be abbreviated. The majority of our subjects commented that the ramp signs contained a lot of information and that they would not have been able to read all the information

if driving by the signs at any reasonable speed. However, this may not be an issue if a motorist is stranded on the ramp and calls for help on his or her own.

6. WEIGHING AND RANKING

To properly rank the mile marker and ramp signs, weights were assigned to the various legibility distance and comprehension parameters. For the mile marker signs the different parameters included legibility distance and comprehension of the mile number, cardinal direction, and roadway. The weights were determined by examining each parameter and comparing it to another parameter for a particular sign type. Greater weight was given to parameters deemed more critical than others. Ten points were assigned to each set of parameters. For example, if comparing the legibility distance of the mile number and the legibility of the cardinal direction, three points were assigned to the legibility distance of the cardinal direction. The remaining seven points were then assigned to the legibility distance of the mile number. After comparing each parameter among the others, a total score was calculated for each parameter. In order to calculate a weight for each parameter, an overall score was obtained by summing all of the individual parameters totals. Finally, the weight for each parameter was calculated by taking the individual total scores divided by the overall score. Figures A.5-A.6 in the appendix show the detailed spreadsheets used for calculating the overall score for each set of signs.

For the Reference Location Signs and Intermediate Reference Location Signs the mile number is the only element that is needed to be read and understood. Comprehension was weighted higher and thus given greater priority than legibility distance because it is necessary for the motorist to truly understand what the sign is conveying when he or she calls in their location in able to properly notify emergency responders of their exact location. If a motorist can read the sign but does not understand how to convey the information to someone else, being able to see the sign is irrelevant.

Table 4. Weights and Priority for Reference and Intermediate Reference Location Signs

RLS and IRLS		
Requirement	**Weight**	**Priority**
Comprehension (Mile Number)	0.600	1
Legibility Distance (Mile Number)	0.400	2
Total Weight =	**1.000**	

When it came to scoring the legibility distance of the mile number, cardinal direction, and roadway, the mile number was scored the highest because that is what pin points the motorists location on the roadway. The cardinal direction and roadway simply tell which road the motorist was driving. The roadway was scored higher than cardinal direction because the cardinal direction only tells the emergency responder what side of the road the motorist is on. Knowing which side of the road the motorist is traveling on is important, but if the emergency responders do not know which roadway the motorist is on in the first place, then the direction of travel is irrelevant.

Table 5. Weights and Priority for Enhanced and Intermediate Enhanced Reference Location Signs

ERLS and IERLS

Requirement	Weight	Priority
Comprehension (Mile Number)	0.213	1
Comprehension (Roadway)	0.193	2
Legibility Distance (Mile Number)	0.187	3
Legibility Distance (Roadway)	0.167	4
Comprehension (Cardianl Directrion)	0.127	5
Legibility Distance (Cardinal Direction)	0.113	6
Total Weight =	**1.000**	

For the ramp signs the different parameters were the legibility distance and comprehension of the ramp number, previous cardinal direction, approaching cardinal direction, previous roadway, and approaching roadway. Comprehension was given higher priority than legibility distance for the same reason as stated above. When it came to scoring the ramp number, previous cardinal direction, approaching cardinal direction, previous roadway, and approaching roadway, the ramp number was scored the highest because it tells the most about the motorist's location. The previous roadway was considered the next most important information because it tells the roadway the motorist was driving on before the exit ramp was taken. The approaching roadway was the next most important because it conveys where the motorists will be traveling on next. The cardinal direction was considered the lowest because if the two roadways and the ramp number are known, cardinal direction is less important. The previous cardinal direction was more important than the approaching cardinal direction because it is the direction the motorist was traveling and they haven't reached the next cardinal direction yet.

Table 6. Weights and Priority for Ramp Signs

Ramp Signs

Requirement	Weight	Priority
Comprehension (Ramp Number)	0.137	1
Legibility Distance (Ramp Number)	0.133	2
Comprehension (Prev. Roadway)	0.122	3
Legibility Distance (Prev. Roadway)	0.109	4
Comprehension (Approaching Roadway)	0.100	5
Legibility Distance (approaching Roadway)	0.096	6
Comprehension (Prev. Cardinal Dir.)	0.087	7
Legibility Distance (Prev. Cardinal Dir.)	0.080	8
Comprehension (Approaching Cardinal Dir.)	0.069	9
Legibility Distance (Approaching Cardinal Dir.)	0.067	10
Total Weight =	**1.000**	

7. SUMMARY AND RECOMMENDATIONS

Based on the scores received during testing and the weightings listed in the previous section of this report the MUTCD D10-3 sign was found on average to have the best design, layout, and content for a Reference Location Sign (Table 7). The MUTCD D10-3a sign had the best design, layout, and content for an Intermediate Reference Location Sign on average. The MUTCD D10-4 sign had the best design, layout, and content for an Enhanced Reference Location Sign on average (Table 8). The sign that had the best design, layout, and content for an Intermediate Enhanced Reference Location Sign was the Indiana mile marker on average. It is important to note that all our signs have been optimized for legibility according to Table 2 and Table 3.

Table 7: RLS & IRLS Rankings

		Comprehension	Legibility		
	Sign Name	Score	Score	Total Score	Ranking
RLS & IRLS	D10-3a	2.65	2.91	5.56	2
	D10-3	3.60	3.58	7.18	1
	New Jersey.1	3.14	2.35	5.49	3
	Pennsylvania.1	2.58	1.51	4.10	5
	New Hampshire	3.23	1.80	5.03	4

Table 8: ERLS & IERLS Rankings

		Comprehension	Legibility		
	Sign Name	Score	Score	Total Score	Ranking
ERLS & IERLS	D10-4	2.27	2.56	4.83	2
	Indiana	2.13	2.86	4.99	1
	D10-5	2.13	2.46	4.59	3
	New Jersey.2	2.16	2.12	4.28	5
	West Virginia	2.10	2.01	4.12	6
	Pennsylvania.2	2.14	2.40	4.54	4

Figure 45. MUTCD D10-3

Figure 46. MUTCD D10-3a

Figure 47. MUTCD D10-4

Figure 48. Indiana's Mile Marker

With regard to ramp signs (Table 9), the New Jersey ramp sign was found on average to have the best design, layout, and content when it came to ramp signs. However, the reader should bear in mind that the New Jersey ramp sign conveys less information, as it does not contain a from-to mapping. Since there are fewer information elements, the legend was larger than in all other signs. Sign designers need to weigh the trade-off between content and legibility. For more complex interchanges such as the one shown in Figure 9, the New Jersey ramp sign might not be that effective. However, for less complex interchanges, such as the one shown in Figure 10, the New Jersey ramp sign might be ideal. Sign designer will need to decide who do they want to accommodate, emergency personnel or motorist. Emergency personnel only need signs like the New Jersey sign since it tells them exactly where the motorist is. However, when a motorist is new to the area and is lost the from-to mapping is a very nice sign, since the sign tells them what road they were traveling on and the road they are approaching. So when they tell somebody their location it will be an exact location and easily found on a map compared to the cardinal direction, roadway, and exit number they were just on. The ramp sign that performed the best on average with from-to mapping was the Geogia.2 ramp sign.

Table 9: Ramp Signs Rankings

	Sign Name	Comprehension Score	Legibility Score	Total Score	Ranking
Ramp Signs	New Jersey	1.05	2.43	3.48	1
	OPL.2	1.04	0.00	1.04	7
	Kentucky.1	0.59	1.76	2.35	4
	Kentucky.2	0.82	1.28	2.10	5
	OPL.1	1.14	1.72	2.87	3
	Georgia.1	1.14	0.95	2.10	5
	Georgia.2	1.11	1.81	2.92	2

Figure 49. New Jersey Ramp Sign

Figure 50. Georgia.2 Ramp Sign

This study demonstrated that the best design of mile marker signs is to have the mile number written vertically such as MUTCD's D10-1, D10-2, D10-3, D10-1a, D10-2a, and D10-3a with Series D font. When the mile number is vertically represented rather than horizontally represented the numbers can be enlarged and have Series D font, which increases legibility distance. However, if the Intermediate Enhanced Reference Location Sign's mile number is represented vertically, like the West Virginia sign, it is not recommended to shrink the cardinal direction and roadway to fit on the same line. The West Virginia mile marker sign did not perform well with regard to detection distance of the cardinal direction and roadway. Performance and preference of the mile markers with the cardinal direction and roadway had the mile number being represented horizontally with the tenths of a mile underneath the whole mile. The mile number should have a line separating the tenths of a mile and a decimal point in front of the tenth of a mile. The Indiana sign was able to have a cardinal direction that was 3.25 inches taller, while having the same sign blank size because the mile marker sign did not contain the word "MILE" on the sign. The Indiana's cardinal direction being 3.25 inches taller and with a blue background compared to MUTCD's D10-4 and D10-5, participants were able to see the cardinal direction on average 77 feet before the participants could see the cardinal direction on the MUTCD's D10-4 and D10-5 signs. The Indiana sign also performed better than the MUTCD's D10-5 when it came to legibility distance of the mile number by an average of 41 feet. The Indiana sign's roadway was recognized 45 feet farther back on average than the MUTCD's D10-5 sign. This study has found the existing MUTCD mile marker standards are pretty much okay as they exist today. However, the ramp signs are those which still need work as discussed below.

This study demonstrated that for a ramp sign to be effective it should be direct and simple. The ramp sign should be understood with minimal guesswork. This study also demonstrated that the cardinal direction should be spelled out for the previous and approaching roadways. The previous and approaching roadways should be distinguished by a shield and use the word "TO" to separate the two roadways; this provides clear direction to the driver about which way to read the sign.

8. REFERENCES

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[4] Zwahlen, H. T. Traffic Sign Reading Distances and Sign Reading Times When Driving At Night. In *Transportation Research Record*: *Journal of the Transportation Research Board*, No. *1495*, TRB, National Research Council, Washington, D.C., 1995, pp.140-146.

APPENDIX

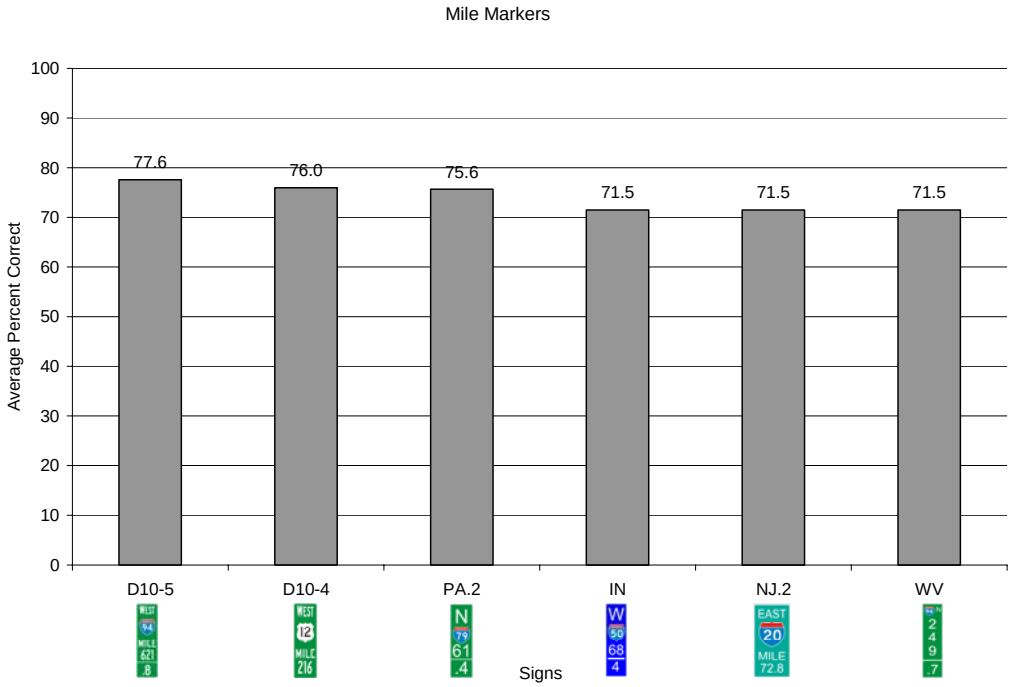

Figure A. 1 Results of Intermediate Enhanced and Enhanced Reference Location Signs to All of the Questions Asked During the Comprehension Study

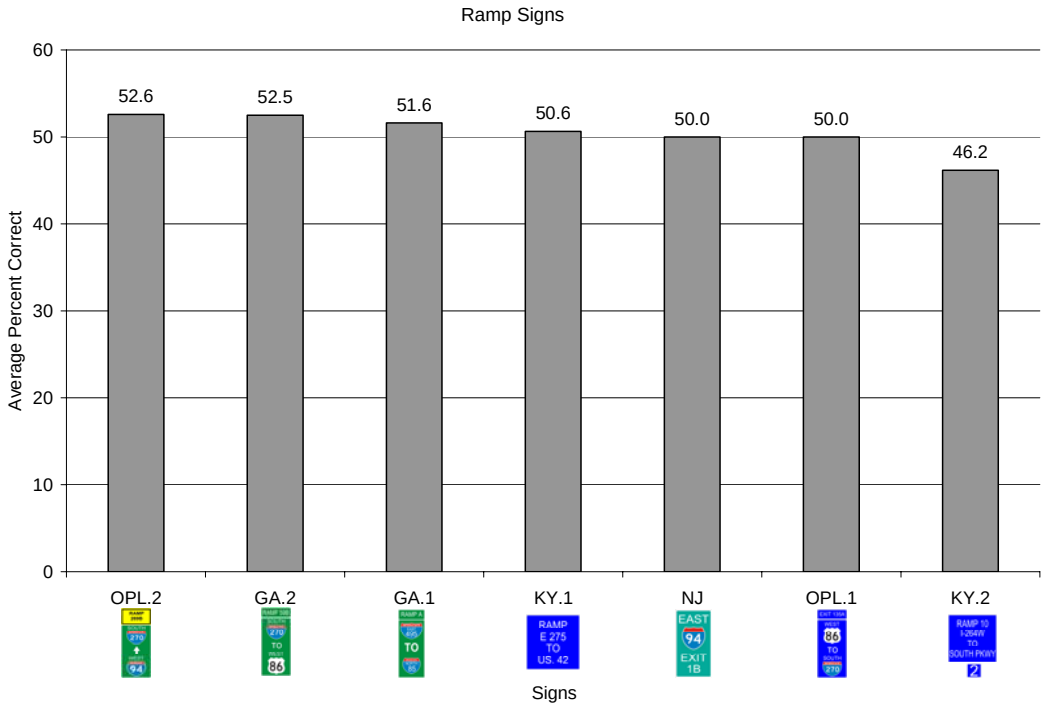

Figure A. 2 Results of the Ramp Signs to All of the Questions from the Comprehension Study

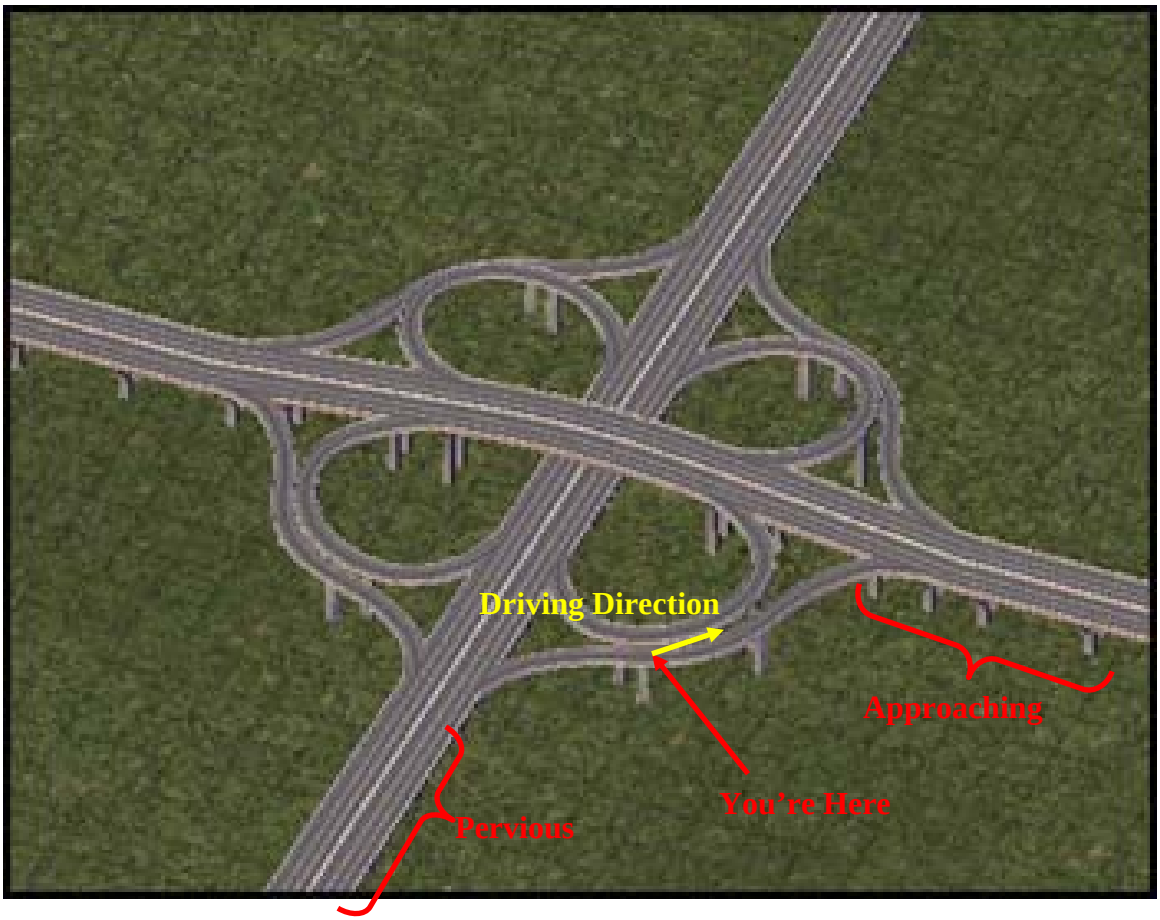

Figure A. 3 Definitions of Previous and Approaching Roadways and Cardinal Directions

RLS and IRLS

Requirement	Legibility Distance Mile Number	Comprehension Mile Number	Total Scores	Weight
Legibility Distance Mile Number		4.0	4.0	0.400
Comprehension Mile Number	6.0		6.0	0.600
	Overall Scores =		10	
			Total Weight =	1

ERLS and IERLS

Requirement	Legibility Distance Mile Number	Legibility Distance Cardinal Dir.	Legibility Distance Roadway	Comprehension Mile Number	Comprehension Cardinal Dir.	Comprehension Roadway	Total Scores	Weight
Legibility Distance Mile Number		7.0	6.0	4.0	6.0	5.0	28	0.187
Legibility Distance Cardinal Dir.	3.0		3.0	3.0	5.0	3.0	17	0.113
Legibility Distance Roadway	4.0	7.0		4.0	6.0	4.0	25	0.167
Comprehension Mile Number	6.0	7.0	6.0		7.0	6.0	32	0.213
Comprehension Cardinal Dir.	4.0	5.0	4.0	3.0		3.0	19	0.127
Comprehension Roadway	5.0	7.0	6.0	4.0	7.0		29	0.193
					Overall Scores =		150	
							Total Weight =	1.000

Ramp Signs

Requirement	Legibility Distance Ramp Number	Legibility Distance Prev. Cardinal Dir.	Legibility Distance Approaching Cardinal Dir.	Legibility Distance Prev. Roadway	Legibility Distance Approaching Roadway	Comprehension Ramp Number	Comprehension Prev. Cardinal Dir.	Comprehension Approaching Cardinal Dir.	Comprehension Prev. Roadway	Comprehension Approaching Roadway	Total Scores	Weight
Legibility Distance Ramp Number		7.0	8.0	6.0	7.0	4.0	7.0	8.0	6.0	7.0	60	0.133
Legibility Distance Prev. Cardinal Dir.	3.0		6.0	3.0	4.0	3.0	4.0	6.0	3.0	4.0	36	0.080
Legibility Distance Approaching Cardinal Dir.	2.0	4.0		3.0	3.0	3.0	4.0	4.0	3.0	4.0	30	0.067
Legibility Distance Prev. Roadway	4.0	7.0	7.0		6.0	3.0	7.0	7.0	4.0	4.0	49	0.109
Legibility Distance Approaching Roadway	3.0	6.0	7.0	4.0		3.0	6.0	7.0	3.0	4.0	43	0.096
Comprehension Ramp Number	6.0	7.0	7.0	7.0	7.0		7.0	8.0	6.0	7.0	62	0.138
Comprehension Prev. Cardinal Dir.	3.0	6.0	6.0	3.0	4.0	3.0		6.0	4.0	4.0	39	0.087
Comprehension Approaching Cardinal Dir.	2.0	4.0	6.0	3.0	3.0	2.0	4.0		3.0	4.0	31	0.069
Comprehension Prev. Roadway	4.0	7.0	7.0	6.0	7.0	4.0	6.0	7.0		7.0	55	0.122
Comprehension Approaching Roadway	3.0	6.0	6.0	6.0	6.0	3.0	6.0	6.0	3.0		45	0.100
									Overall Scores =		450	
											Total Weight =	1.000

Figure A. 4 Weight of Different Parameters for Mile Markers and Ramp Signs

Comprehension

	Sign Name	Mile #	Weight	Total Score
RLS & IRLS	D10-3a	4.421	0.600	2.653
	D10-3	6.000	0.600	3.600
	NJ.1	5.231	0.600	3.138
	PA.1	4.308	0.600	2.585
	NH	5.385	0.600	3.231

	Sign Name	Mile #	Weight	Current Direction	Weight	Current Roadway	Weight	Total score
ERLS & IERLS	D10-4	3.783	0.213	5.348	0.127	4.043	0.193	2.266
	Indiana	3.467	0.213	5.467	0.127	3.600	0.193	2.128
	D10-5	4.462	0.213	5.077	0.127	2.769	0.193	2.130
	New Jersey.2	3.846	0.213	4.462	0.127	4.000	0.193	2.159
	West Virginia	4.615	0.213	5.077	0.127	2.462	0.193	2.104
	Pennsylvania.2	4.615	0.213	4.154	0.127	3.231	0.193	2.135

	Sign Name	Ramp #	Weight	Prev. Direction	Weight	Approaching Direction	Weight	Prev. Roadway	Weight	Approaching Roadway	Weight	Total score
Ramp Signs	NJ	4.923	0.138	2.154	0.087	0.000	0.069	1.538	0.122	0.000	0.100	1.053
	OPL.2	3.529	0.138	0.529	0.087	3.706	0.069	0.882	0.122	1.412	0.100	1.036
	KY.1	0.000	0.138	2.923	0.087	0.000	0.069	0.769	0.122	2.462	0.100	0.594
	KY.2	1.538	0.138	1.231	0.087	1.077	0.069	2.000	0.122	1.846	0.100	0.822
	OPL.1	3.000	0.138	2.000	0.087	2.143	0.069	1.714	0.122	2.000	0.100	1.144
	GA.1	1.565	0.138	1.304	0.087	2.870	0.069	3.130	0.122	2.348	0.100	1.144
	GA.2	2.400	0.138	1.800	0.087	3.000	0.069	2.400	0.122	1.200	0.100	1.107

Figure A.5: Comprehension Weight Matrix Score Sheet

Legibility

RLS & IRLS

Sign Name	Mile #	Weight	Total score
D10-3a	7.26923	0.4	2.907692308
D10-3	8.94231	0.4	3.576923077
NJ.1	5.88462	0.4	2.353846154
PA.1	3.77885	0.4	1.511538462
NH	4.49038	0.4	1.796153846

ERLS & IERLS

Sign Name	Mile #	Weight	Current Direction	Weight	Current Roadway	Weight	Total score
D10-4	4.74038	0.1867	4.663461538	0.11333333	6.903846154	0.1667	2.564038462
IN	4.67308	0.1867	6.634615385	0.11333333	7.423076923	0.1667	2.861410256
D10-5	3.89423	0.1867	5.634615385	0.11333333	6.548076923	0.1667	2.456858974
NJ.2	2.67308	0.1867	2.951923077	0.11333333	7.721153846	0.1667	2.120384615
WV	6.54808	0.1867	3.125	0.11333333	2.625	0.1667	2.013974359
PA.2	3.64423	0.1867	5.317307692	0.11333333	6.711538462	0.1667	2.401474359

Ramp Signs

Sign Name	Ramp #	Weight	Prev. Direction	Weight	Approaching Direction	Weight	Prev. Roadway	Weight	Approaching Roadway	Weight	Total score
NJ	4.46154	0.1333	8.846153846	0.08	0	0.0667	10.36538462	0.108889	0	0.095556	2.431239
OPL.2	0	0.1333	0	0.08	0	0.0667	0	0.108889	0	0.095556	0
KY.1	0	0.1333	6.75	0.08	0	0.0667	6.557692308	0.108889	5.288461538	0.095556	1.759402
KY.2	3.91346	0.1333	2.230769231	0.08	1.682692308	0.0667	3.105769231	0.108889	1.365384615	0.095556	1.28109
OPL.1	1.86538	0.1333	4.865384615	0.08	4.221153846	0.0667	4.211538462	0.108889	3.605769231	0.095556	1.7225
GA.1	2.77885	0.1333	0	0.08	0	0.0667	3.326923077	0.108889	2.298076923	0.095556	0.952372
GA.2	2.41346	0.1333	4.682692308	0.08	4.423076923	0.0667	4.403846154	0.108889	3.538461538	0.095556	1.808932

Figure A.6: Legibility Weight Matrix Score Sheet