Elder Roadway User Program
Test Sections and Effectiveness Study

Final Report

Task 4

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Disclaimer

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Approximate Conversions to SI Units

Symbol	When You Know	Multiply By	To Find	Symbol
		Length		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		Area		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		Volume		
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		Mass		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lbs)	0.907	megagrams	Mg
		Temperature (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
		Illumination		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and **Pressure** or **Stress**		
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

Executive Summary
This report presents the results of a study whose goal was the evaluation of various traffic control devices to determine their effectiveness for older drivers. The objectives of this study were threefold. They are as follows: in Task 1: to field test existing improvements or currently being implemented throughout the state. These included overhead and advance street name signs with 6", 8", 10, and 12" letter sizes, pavement markers (stripes) of 4" and 6" in width, raised pavement markers (RPM) and offset left turn lanes. In Task 2: to evaluate the effectiveness of two types of enhanced traffic control devices: a) a new font and, b) new pavement marking materials. Both of these products are developed by 3M. The new font in question is called Clearview and purports to improve the visibility of signage which tend to be blurred as a result of halation. Clearview was compared to Highway series C, D, and E(M) on ground mounted and advance street name signs. The pavement marking materials evaluated were retroreflective tape stripes from 3M (i.e., 380I and 820) whose visibility was compared to that of thermoplastic materials under night driving conditions. Finally, Task 3 consisting in assessing the feasibility of evaluating traffic control devices using simulation.

The results of this study showed very definite advantages in the use of larger lettering on signage, as well as the use of wider pavement markers (stripes) and raised pavement markers. Offset left turn lanes did not show any definite advantage over conventional left turn lanes under the conditions tested. Clearview font was found to yield significantly greater legibility distances than the other fonts for advance street name signs but not for ground-mounted street name signs. As for the new lane markers evaluated, no significant differences were found in their absolute or comparative visibility. This was likely attributable to the newness of materials whose luminance contrast exceeds by far the minimum requirements for reflectivity of these materials. A more stringent evaluation would require testing these stripes at regular interval to determine if and when older drivers distinguish a difference among them before the end of their service life. These results clearly support the aim of the Elder Roadway Improvement Program in its approach to implement and evaluate traffic control devices that are geared toward enhancing a safe environment for the older driver.

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Problem Statement

The safety of older drivers is a national priority. Older persons 65+ make up 13% of the U.S. population. They are also the fastest growing segment of the population, especially those 85 and older (U.S. Bureau of the Census, 1996). Consequently, these demographics will also be reflected in the driving population. Florida has one of the fastest growing populations of older persons in the nation. By the year 2020 people 65 and older will represent almost 17% of the population (ibid) and over 25% of Florida resident drivers. Given the weather in Florida this number may increase seasonally. The car is the primary method of transportation for older persons (Rosenbloom, 1988). It permits them to attend to their daily activities (e.g., shopping, health-related trips, banking) and promotes greater socialization. As a group, older drivers have few collisions compared to their younger counterparts. However, when controlling for miles driven, drivers 75 and older are involved in twice as many collisions per mile than drivers 18 to 24 years old (Retchin, Cox, Fox, and Irwin, 1988). Furthermore, they are more likely than younger drivers to be injured or to die in a collision (Massie, Campbell, and Williams, 1995). Crashes in which older drivers are at fault are usually multi-causal. Among the most common attributions are the following: failure to yield the right of way, failure to obey traffic signs and signals, improperly negotiating intersections, careless or inaccurate lane changes, careless backing, and driving the wrong way on one-way streets (McKnight, 1988; Yaksich, 1985; U.S. DOT, 1997).

The increased difficulties of older drivers are in large part related to the cognitive, psychomotor, and sensory decrements that occur with aging (Owsley, Sloane, Ball, Roenker, and Bruni, 1991; Guerrier, Manivannan, Pacheco, and Wilkie, 1995; Cox, Broshek, Kiernan, Kovatchev, Guerrier, Giuliano, & George, 2002). Nevertheless there are also highway design elements that are particularly problematic for older drivers. These may include among other things, "intersection configuration… placement of signs relative to decision points, and the size of letters on signs" (US DOT, 1997, p.7). Consequently, engineers, scientists, and policy makers are working together to identify and implement interventions that will enhance the safe mobility of older drivers.

Florida Elder Roadway User Program

Research conducted on issues related to older drivers' involvement in crashes as well as promising interventions has resulted in the development of the Older Driver Highway Design Handbook (1997). This handbook makes various recommendations about highway design elements that can facilitate the performance of older drivers. The Florida Department of Transportation through its Florida Elder Roadway User Program has endeavored to implement improvements to traffic control devices and geometrics whose purpose is to facilitate driving for older persons. Some examples of these are larger letter size on overhead and advance street name signs, wider lane markings, and offset left turn lanes. This contract entitled "Florida Elder Roadway User Program: Test Sections and Effectiveness Study" was to accomplish the following:

Task 1: Field test improvements that are currently being implemented throughout the state. Specifically, this task called for the effectiveness evaluation of existing traffic control devices for older drivers

Task 2(A): Evaluate the effectiveness of enhanced traffic control devices. As such, the Florida Department of Transportation requested the evaluation of two types of enhancements. These are: the evaluation of Clearview font compared to Highway series C, D, and E(M) on ground-mounted street name signs and advance street name signs.

Task 2(B): Evaluate three pavement marking materials. Two of these are 3M retroreflective tapes (i.e., 380I and 820), and the third is thermoplastic which is the most widely used on our roads.

Task 3: Provide an assessment of what types of improvements can be successfully modeled with driving simulators under laboratory conditions.

Organization of this Report

This Final report is organized in three sections. The first entitled Task 1 presents the full report of activities conducted under that task. The second section presents the full report on the evaluation of Clearview font and of three types of lane markings, two of which are new products from 3M. The third section will document the results of a survey on simulation as it regards the capabilities of that technology for use in engineering assessments.

Task 1: Evaluation of Existing Traffic Control Devices

Five traffic control devices (TCDs) were to be studied in the first phase of the project. They were:

- Large overhead street name signs at intersections
- Advance street name signs before intersections
- Six inch lane markings
- Forty foot spacing on RPM
- Offset left-turn lanes

The first two were to be the most important components of this evaluation.

In order to conduct the study appropriately, letters were sent to FDOT Districts 4 (Traffic Operations), the Broward County Public Works Department: Traffic Engineering Division, to District 6, Traffic Engineering Division and to the Metro-Dade Public Works Department. Based on the information obtained we were able to assess six inch lane markings compared to four inch lane markings. Streets with 40ft RPM spacing compared to streets without RPMs (streets with 80ft spacing were not available within the area of interest).

Traffic Control Devices Studied

Prior to selecting the sites to be studied, the researchers sent requests to the Department of Public Works in Dade County and Broward County, as well as to Florida Department of Transportation's District IV (Broward) and VI (Dade) offices. Dade and Broward Counties provided a list of candidate sites. Based on these, we selected streets with the following features:

- Overhead street name signs of different letter sizes and/or series (see Appendix A-1)
- Advance street name signs
- Lane markings of 4" and 6" width
- Offset left turn lanes (full offset)
- 40ft RPM vs. no RPM

Description of streets used

The road course used in the daytime was about 15 miles long and ran through Dade and Broward counties. The course used at night was restricted to Miami-Dade county and was approximately 6 miles long (see Maps in Appendix A-2).

METHODOLOGY

Protocol

Licensed drivers of at least 55 years of age were recruited using advertisement through local newspapers (e.g., Miami Herald, New Times). They were met at the North Miami Beach Public Library. There, they signed a consent form and completed a driving questionnaire (see Appendix A-3). In addition, they were tested for static visual acuity and various cognitive and psychomotor tasks (see Appendix A-4). Following these evaluations, the participants drove on a fixed route, which contained the types of traffic control devices to be evaluated. While on route, they were asked to verbalize their perceptions of the traffic control devices and also to read overhead and advance street name signs only when these were legible to them. A graduate research assistant was charged with recording these data.

The participants drove a vehicle equipped with two forward-looking cameras:
The first camera was placed inside the vehicle behind the driver's seat, approximately at eye height and looking through the windshield at the forward scene in front of the driver. The second camera (i.e., a pinhole camera) was placed on top of the vehicle above the windshield. The camera was positioned to look forward, and also downward, providing the capability not only for seeing the environment in front of the vehicle but also for locating the position of the vehicle's front wheels in the lane.   The latter was determined by placing hood markers on the vehicle**.** These were adjusted to line up with the front wheels when the latter were directly upon the lane marker (see Appendix A-5: Car-setup).

In order to ensure the driver's safety, the vehicle used for this study was equipped with an auxiliary braking mechanism. In addition, a driving instructor was retained. His primary role was to ensure the safety of drivers and passengers by taking over the control of the car if necessary. A research assistant, sitting in the rear passengers' seat behind the driver, using a script (Appendix A-6), directed the driver as to the route to follow and what traffic control devices to comment about. Moreover, the research assistant solicited the driver's perception about various traffic control devices and collected data on these perceptions. The research assistant was also expected to do the following: 1) ensure that the cameras were aimed and functioning properly, and, 2) document the legibility distance of overhead and advance street name signs by recording the distance displayed by the Numetrics distance measuring instrument (DMI) as soon as the driver read these signs. All the participants drove the test route between the hours of 11:00 in the morning to 3:00 in the afternoon in order to avoid rush hour traffic.

The evaluation of the existing traffic control devices was carried out in two phases: one in the daytime and one at night.   The daytime phase involved evaluation of: 1) overhead and advance street name signs, 2) 4" and 6" lane markings, and 3) offset left turn lanes. The night phase consisted of the evaluation of 4" and 6" lane markings with or without RPMs. As mentioned earlier, these were 40FT RPMs, 80FT RPMs were not available. In addition, in order to understand better the older participants' perception of the offset left turn lanes as well as lane markings, a focus group was conducted.

Sample

The sample consisted of 51 drivers between the ages of 42 and 90. Twenty-six were male and twenty-five were female. They were divided into two age categories: the young 42 to 57 years old and the old 65 to 90years old with twenty-five and twenty-six persons in each group respectively. These drivers participated in all aspects of the daytime phase. Twelve of the older drivers participated in the night phase of the study. They were equally divided between males and females and ranged in age from 65 to 90 years old.

RESULTS

Demographics of Drivers

A questionnaire consisting of thirty-four questions was completed by each of the participants. It solicited a range of demographic information on the drivers. These included the driver's age, sex, driving experience, and automobile use. In addition, questions were asked on the drivers' difficulties with specific driving tasks, and health problems.

Age distribution – As mentioned earlier, fifty-one persons age 42 to 90 participated in this study. They were divided into two nearly equal age groups: 25 young (42-57) and 26 old (66-90). The mean (M) age of the sample was 61.99 years old with a standard deviation (SD) of 13.87 years. The distribution of males and females in each of the age groups was as follows: thirteen young males, twelve young females, thirteen old males and thirteen old females.

Driving experience – The participants' driving experience, based on the number of years they had held a license, ranged from 18 to 70 years. The average number of years participants had a
driving license was thirty years (SD= 13.96 years). There was no significant difference between male and female drivers in the number of years they held a drivers' license. Older drivers had had a license significantly longer than their younger counterparts in this sample (53years (SD=5.50) and 31years (SD=10.74) respectively).

Visual Acuity - The drivers' static visual acuity was also measured using the Snellen chart. Overall most drivers had a visual acuity in the better eye (right eye in this sample) of 20/20 with a mean of 20/34 (SD=18.84 (applies to denominator)). There was a significant age difference in visual acuity for the right eye. As expected, older drivers had worst acuity than younger drivers ($\underline{t}(1,46)=-3.58$, $\underline{p}=.001$). The mean visual acuity for younger and older drivers was respectively: 20/25 (SD=9.15) and 20/43 (SD=21.98).

Health characteristics – Participants were asked to report on various health conditions and to state whether these (if they existed) interfered with their driving. Of all the conditions listed, arthritis was the most frequently reported. Twenty-eight percent of all older drivers stated suffering from it. The older participants were in significantly greater proportion than the young (X^2 (df=1, n=51)=4.25, $\underline{p}= .04$). They made up73% of arthritis sufferers. Within age categories, forty-two percent of older drivers reported having arthritis compared to 16% of younger drivers. Very few of these drivers reported being unable to drive due to any of the health problems reported. The data were as follows: 1) only one of the four drivers who reported having diabetes stated that it sometimes interfered with their driving; 2) two of the sixteen drivers who reported having arthritis mentioned that it sometimes interfered with their driving, and 3) two of the four drivers who reported having blurry vision mentioned it interfering with their driving.

Description of Overhead and Advance Street Name Signs

Before reporting the results of the analyses of overhead street name signs, a brief description of the letter size on these signs will be given. This will permit a better understanding of the results.

Data on the legibility distances of overhead street name signs and advance street name signs were collected on four major roads: Miami Gardens Drive in Miami-Dade County, University Drive, Sheridan St, and Hollywood/Pines Boulevard in Broward County. The original objectives of the research were to measure the effectiveness of large lettering (12” letter size) compared to the conventional sizes (8” & 10” letter sizes). Nevertheless, the large letter sizes (12”) have not yet been widely implemented because they would result in larger overall signs with subsequent issues of support and susceptibility to winds. Our objectives were therefore modified to measure overhead street name signs that used different letter sizes and or series.

Although guidelines exist for the letter sizes for advance and overhead street name signs for both Miami-Dade and Broward Counties, these are not always implemented as required. Furthermore, given that the same agencies (e.g., county or state) do not always produce the signs there are often variations in the latter. Consequently, in order to determine the letter sizes of the signs we were evaluating, we called upon Mr. Stephen Vitiello, the supervisor of the Sign Shop in the Broward County Department of Traffic Engineering to assist us in this endeavor. Mr. Vitiello who has twenty-five years of experience in the making of street name signs accompanied us on the same route followed by the participants and estimated the letter sizes on each of the advance and overhead street name signs we asked the participants to read during the commentary driving.

Based on input from Mr. Vitiello regarding letter height and stroke width of the overhead and advance street name signs, the latter were ranked such that the higher the ranking the larger the letter size. As is shown in Appendix A-1, the letter sizes for the signs may be categorized in the following manner: NW 2nd Avenue has greater letter height overall, in addition to having larger stroke size (D or E series). NW 17th Ave, NW 86th Ave, and NW 83rd Ave come second. They have the same letter height as NW 2nd Ave but narrower stroke width. Johnson Street and Douglas Road come last. As for the advance street name signs, NW 17th Ave has larger letter height overall. The second sign with largest letter height would be NW 2nd Ave, followed by Douglas Rd with wider letter stroke. Johnson Street would be ranked fourth. NW 86th Ave, and finally NW 83rd Ave with shorter letter height overall although letter stroke width is D or E series would be last. The results are as follows:

Legibility Distance for Overhead Street Name Signs

Multivariate Analyses of Variance (MANOVA) were conducted to determine whether there was a significant difference in the legibility distance of overhead street name signs for the locations mentioned.

There were significant differences in the legibility distances of overhead street name signs overall ($\underline{F}(5,39) = 8.44$, $\underline{p} < .0001$) (see Table A-1). As shown by these results, generally, overhead street name signs with greater letter height and stroke width also yield greater legibility distance (see Table 1). Table A-2 shows the significance level of the legibility differences of these overhead street name signs.

Table A-1
Legibility Distance of Overhead Street Name Signs

Order of Administration of Signs	Street Name	Rank based on Letter Height and Series	Mean Legibility Distance (in Ft)
1	NW 2nd Ave	1	254.08
2	NW 17th Ave	2	290.35
3	Johnson St	3	225.87
4	Douglas Rd	3	197.04
5	NW 86th Ave	2	271.47
6	NW 83rd Ave	2	215.05

Based on these figures at a maximum speed of 30MPH, the decision time over all drivers, in the absence of advance street name signs would vary from a minimum of 4.48 seconds (secs) for Douglas Rd Overhead street sign to a maximum of 6.60 secs for NW 17th Ave.

Table A-2
Significance Values for Differences in Legibility Distance of Overhead Street Name Signs

Street Name	NW 2nd Ave	NW 17th Ave	Johnson St	Douglas Rd	NW 86th Ave
NW 2nd Ave					
NW 17th Ave	**P=.179**				
Johnson St	**P=.211**	**P<.001**			
Douglas Rd	**P=.022**	**P<.001**	**P<.185**		
NW 86th Ave	**P=.467**	**P=.388**	**P=.006**	**P<.001**	
NW 83rd Ave	**P=.090**	**P<.001**	**P=.503**	**P<.358**	**P=.001**

Effect of Age on Legibility Distance for Overhead Street Name Signs
There was an age difference in the legibility distance of overhead street name signs ($\underline{F}(1,43)=3.88$, $\underline{p}=.06$). As expected, older drivers on average read the overhead street name signs from a shorter distance than their younger counterparts (see Table A-3). The mean legibility distance for each age category was 267.67 ft for the young and 216.95 ft for the old drivers. There was no significant interaction between age and specific overhead street name signs. This means that the legibility distance for both young and old followed the same trend (see Table A-3). These results are reliable since whatever factor (e.g., letter height, stroke width, etc) impacts upon legibility distance has affected these two age groups in a similar manner.

Table A-3
Age by Legibility Distance of Overhead Street Name Signs

Order of Administration of Signs	Street Name	Rank based on Letter Height and Series	Mean Legibility Distance (in Ft)		Mean Decision Time (in secs)	
			Young	Old	Young	Old
1	NW 2nd Ave	1	286.70	221.46	6.52	5.03
2	NW 17th Ave	2	301.44	***279.27***	6.85	***6.35***
3	Johnson St	3	243.74	***208.00***	5.54	***4.73***
4	Douglas Rd	3	235.26	***158.81***	5.35	***3.61***
5	NW 86th Ave	2	301.17	***241.77***	6.84	***5.49***
6	NW 83rd Ave	2	237.74	***197.36***	5.40	***4.49***

The difference in the legibility distance of old and young drivers also influences their decision time. The minimum decision time allowed to young and old drivers based on the overhead street name sign with the lowest legibility distance (Douglas Rd) is 5.35secs for the young and 3.61 secs for the old (Table A-3). The maximum decision time provided by the street name sign with the greater legibility distance (NW 17th Ave) is 6.85 secs for the young and 6.35 secs for the old (ibid). The average decision time across all overhead street name signs is 6.08 secs for the young drivers and 4.93 secs for the old.

Advance Street Name Signs

As was done for the overhead street name signs, Multivariate Analyses of Variance (MANOVA) were conducted to determine whether there was a significant difference in the legibility distance of advance street name signs for the same locations as the overhead street name signs.

There was a very significant difference in the legibility distance of advance street name signs overall ($F(5,43)=95.46$, $p<.0001$). As shown by Table A-4, except for NW 17th Ave and NW 2nd Ave, ranked 1st and 2nd respectively, for which no significant differences were found in legibility distance, legibility distance was congruent with letter sizes. Consequently, the larger the letter size (i.e., the higher the ranking), the greater the legibility distance. Multiple comparison tests showed these differences to be very significant (see Table A-5). As shown by the table, Advance street name signs with larger letter sizes were generally read further away than signs with smaller letter sizes.

Table A-4
Legibility Distance of Advance Street Name Signs

Order of Administration of Signs	Street Name	Rank based on Letter Height and Series	Mean Legibility Distance (in Ft)
1	NW 2nd Ave	2	773.91
2	NW 17th Ave	1	682.99
3	Johnson St	4	303.26
4	Douglas Rd	3	609.94
5	NW 86th Ave	5	240.41
6	NW 83rd Ave	5	253.30

Table A-5
Significance Values for Differences in Legibility Distance of Advance Street Name Signs

Street Name	NW 2nd Ave	NW 17th Ave	Johnson St	Douglas Rd	NW 86th Ave
NW 2nd Ave					
NW 17th Ave	**P=.104**				
Johnson St	**P<.001**	**P<.001**			
Douglas Rd	**P=.006**	**P=.055**	**P<.001**		
NW 86th Ave	**P<.001**	**P<.001**	**P=.034**	**P<.001**	
NW 83rd Ave	**P<.001**	**P<.001**	**P=.14**	**P<.001**	**P=.626**

Effect of Age on Legibility Distance for Advance Street Name Signs
There was no age difference in the legibility distance of Advance street name signs (Mean distance: Young = 487.093 (SE=18.45); Old = 467.51 (SE=18.83)) nor was there any significant interaction between age and legibility distance of these signs.

Decision Time Allotted by Advance Street Name Signs
The primary role of Advance street name signs is to provide the driver with advance warning about an upcoming intersection to permit enough time for a decision. This is particularly important under heavy traffic conditions, inclement weather or when the driver is unfamiliar with the road environment. Advance street name signs when effective, should be particularly important for older drivers who need more time to react. In this regard, the decision time allowed by the Advance street name signs studied was calculated to determine the decision time they provided apart from the overhead street name sign. This was determined by calculating the distance from which the sign was legible to the middle of the street intersection announced. The data show that the Advance street name signs with larger letter sizes were also read a greater distance from the intersection being announced and thus provided significantly more decision time ($F(5,44)=132.70$, $p<.001$) (see Table A-6).

Table A-6
Decision Time Allowed by Advance Street Name Signs
Based on a Driving Speed of 30 MPH

Order of Administration of Signs	Street Name	Rank based on Letter Height and Series	Mean Distance from Intersection	Decision Time in Seconds
1	NW 2nd Ave	2	1,029.24	23.39
2	NW 17th Ave	1	973.82	22.13
3	Johnson St	4	525.54	11.94
4	Douglas Rd	3	799.08	18.16
5	NW 86th Ave	5	492.2	11.19
6	NW 83rd Ave	5	452.3	10.28

It is evident from these results that Advance street name signs are very effective in giving more decision time to drivers (in the best of circumstances from 4 to 6 times more time than overhead street name signs alone). As shown in Table A-7, the larger the letter size the greater the decision time allotted. On average, younger drivers had a decision time of 17.08 secs compared to 15.29 secs for older drivers.

Table A-7
Decision Time Allowed by Advance Street Name Signs
By Age of Driver Based on a Driving Speed of 30 MPH

Order of Administration of Signs	Street Name	Rank based on Letter Height and Series	Mean Legibility Distance for Young & Decision Time		Mean Legibility Distance for Old & Decision Time	
			Dist	Time	Dist	Time
1	NW 2nd Ave	2	995.76	22.63	1062.7	24.15
2	NW 17th Ave	1	1053.6	23.95	894.04	20.32
3	Johnson St	4	579.6	13.17	471.48	10.72
4	Douglas Rd	3	872.84	19.84	725.32	16.49
5	NW 86th Ave	5	526.56	11.97	457.84	10.41
6	NW 83rd Ave	5	480.16	10.91	424.44	9.65

Characteristics of Drivers and Influence on Legibility Distance of Overhead and Advance Street Name Signs

While aging is associated with certain cognitive, sensory, psychomotor, and other deficits, these deficits may also be found among younger individuals, although at a lower rate. Consequently, designs that facilitate the performance of older drivers would also benefit those drivers with similar deficits as well as those who do not have such deficits. Therefore, such designs would benefit a larger population. An analysis of the relationship (Spearman Rho) of the cognitive and sensory (e.g., attention, memory, visual acuity) characteristics of drivers to age was conducted. As expected, age was generally related to lower performance. Specifically, older drivers were more likely to have poorer performance on both selective and divided attention tasks, to commit more errors on the divided attention task, and to have poorer visual acuity.

Table 8
Relationship of Age to Cognitive & Sensory Characteristics of Drivers

			Age in Years
Spearman's Rho	Time on Selective Attention Task (Trail Making A Time)	Correlation Coefficient	.324*
		Sig. (1-tailed)	.010
		N	51
	Time on Divided Attention Task (Trail Making B Time)	Correlation Coefficient	.378**
		Sig. (1-tailed)	.003
		N	50
	Errors on Selective Attention Task (Trail Making A Errors)	Correlation Coefficient	-.228
		Sig. (1-tailed)	.054
		N	51
	Errors on Divided Attention Task (Trail Making B Errors)	Correlation Coefficient	.254*
		Sig. (1-tailed)	.036
		N	51
	Digit Span Forward	Correlation Coefficient	-.156
		Sig. (1-tailed)	.137
		N	51
	Digit Span Backwards	Correlation Coefficient	.084
		Sig. (1-tailed)	.280
		N	51
	Acuity Right Eye	Correlation Coefficient	.406**
		Sig. (1-tailed)	.002
		N	48
	Acuity Left Eye	Correlation Coefficient	.335**
		Sig. (1-tailed)	.009
		N	49

*. Correlation is significant at the .05 level (1-tailed).

**. Correlation is significant at the .01 level (1-tailed).

Relationship of Age & Cognitive Characteristics to Legibility Distance of Overhead and Advance Street Name Signs

A correlational analysis of the cognitive and sensory characteristics of the drivers and legibility distance was carried out to understand their relationship to legibility distance. In addition, stepwise multiple regression analysis of the above variables and age was conducted to determine their contribution to legibility distance.

Table 9
Characteristics of Drivers and Legibility Distance for Overhead and Advance Street Name Signs

			Average Legibility Distance of Advance Signs	Average Legibility Distance of Overhead Signs
Spearman's rho	Number of Years with Driver's License	Correlation Coefficient	-.302*	-.178
		Sig. (1-tailed)	.016	.121
		N	50	45
	Time on Selective Attention Task (Trail Making A Time)	Correlation Coefficient	-.216	-.596**
		Sig. (1-tailed)	.066	.000
		N	50	45
	Time on Divided Attention Task (Trail Making B Time)	Correlation Coefficient	-.341**	-.567**
		Sig. (1-tailed)	.008	.000
		N	49	44
	Errors on Selective Attention Task (Trail Making A Errors)	Correlation Coefficient	.062	-.116
		Sig. (1-tailed)	.335	.223
		N	50	45
	Errors on Divided Attention Task (Trail Making B Errors)	Correlation Coefficient	-.221	-.527**
		Sig. (1-tailed)	.061	.000
		N	50	45
	Digit Span Forward	Correlation Coefficient	.254*	.299*
		Sig. (1-tailed)	.038	.023
		N	50	45
	Digit Span Backwards	Correlation Coefficient	.240*	.169
		Sig. (1-tailed)	.047	.133
		N	50	45
	Acuity Right Eye	Correlation Coefficient	-.587**	-.448**
		Sig. (1-tailed)	.000	.001
		N	47	42
	Acuity Left Eye	Correlation Coefficient	-.409**	-.387**
		Sig. (1-tailed)	.002	.005
		N	48	43
	Age in Years	Correlation Coefficient	-.427**	-.359**
		Sig. (1-tailed)	.001	.008
		N	50	45

*. Correlation is significant at the .05 level (1-tailed).

**. Correlation is significant at the .01 level (1-tailed).

As may be seen from Table A-9, age is significantly related to the legibility distance of advance and overhead street name signs. Nevertheless, a multiple regression analysis of the contribution of driving experience, visual acuity in the better eye, selective, and divided attention, showed aged not to contribute significantly to legibility distance at all. Rather, it is age sensitive characteristics such as measures of attention and visual acuity that were the variables most strongly related to legibility distance. Specifically, poor performance on measures of divided and selective attention (i.e., longer time in Trails A and especially time and errors on Trails B, and poor visual acuity) were associated to shorter legibility distance. This was especially true for overhead street name signs. When these and driving experience were entered into a stepwise multiple regression analysis, the two best predictors of both legibility distance of overhead street name signs and advance street name signs are divided attention and visual acuity. In the case of advance street name signs, visual acuity in the right eye was the single best predictor ($\underline{R}(1,44)=.59$, $\underline{p}<.001$), followed by divided attention ($\underline{R}(1,43)=.65$, $\underline{p}<.001$). For overhead street name signs the relationship was reverse. That is to say, divided attention was the best predictor of legibility distance ($\underline{R}(1,39)=.59$, $\underline{p}<.001$), followed by visual acuity in the right eye (($\underline{R}(2,38)=.65$, $\underline{p}=.025$). The importance of both these variables in legibility distance is not surprising. Visual acuity is evidently the most critical vehicle for gaining information that is relevant to driving. As for divided attention ability, it permits the driver to attend simultaneously to various stimuli that impact upon their driving performance. Therefore, since drivers were instructed to read the signs as soon as they became legible to them, those with better attentional skills also had greater capability for attending to the operational tasks of driving, as well as to other relevant stimuli in the environment. The latter includes identifying and, aided by visual acuity, reading the relevant street name signs. These results support the necessity for facilitating the driving environment for the elderly for this ultimately benefits the larger community of drivers.

Lane Markings

As stated earlier, drivers were also asked to assess the width of lane markings. Specifically, they were asked to compare 4 inch to six-inch lane markings to determine whether they perceived differences in the size of the lane markings and in their visibility. Chi square tests were conducted to examine the differences in the age groups regarding the perceived width and visibility of the lane markings and Friedman tests were conducted to establish the ranking of the lane markings. The Friedman test is based on the average ranking of each of the variables, which in this case are various attributes of the lane markings (i.e., width and visibility). It allows the assessment of the degree of agreement among the drivers regarding their perception of the lane markings along these attributes. The results follow.

<u>Perceived Width of Lane Markings</u>

Drivers were asked to compare 4-inch lane markings (Sheridan Street) to previously encountered 6-inch (somewhat worn) lane markings (University Dr). The data show that in general, they perceived the narrower lane marking as such ($\chi^2 = 48.41$ (50), $p<0.001$). When examined closely, the results show some inconsistencies. For instance, as many young drivers thought the 4-inch wide lane (Sheridan) was as wide as the 6-inch lane (University Dr) as believed the former was narrower than the latter (equal split between young drivers who said the 4" lane was the same width as the 6" lane as those who believe it was narrower). Whereas the old drivers overwhelmingly (77%) reported the 4-inch lane marking as being narrower than the 6-inch lane ($\chi^2 = 3.47$, $\underline{p}<0.06$).

Along their route, drivers also encountered a road with freshly painted 6-inch lane markings (i.e., Douglas Rd). They were also asked to compare these lane markings to previously encountered 4-inch lane markings. Again, while most drivers perceived the wider lane marking as such, a greater proportion of younger drivers correctly identified that difference (80%) compared to older drivers (50%), ($\chi^2 = 5.34$, $\underline{p}<0.02$). The lack of consistency across age groups in the responses regarding the width of lane markings may indicate a number of issues that cannot be readily resolved in an uncontrolled environment. These results might imply that the differences between six and four inch lanes are not readily distinguishable from a moving vehicle. It may also be possible that many drivers do not really pay that much attention to lane markings' size as they drive. Another likely possibility is that there may be differences in the level of contrast between lane marking and pavement (due to sun bleaching) or differences in the level of maintenance of lane markings or pavement that account for these results. Consequently, to obtain more reliable results on drivers' perceptions of various aspects of lane markings would require a more controlled environment.

Ranking of Width of Lane Marking by Age Group

Since young and old drivers seem to perceive the width of lane markings very differently, in order to illustrate these differences better, separate analyses were conducted on their comparisons of these lane markings the results are illustrated in Table A-10.

It is evident that the trend illustrated by the rankings of the 4" and 6" lane markings is consistent for both young and old drivers. Nevertheless, these rankings can best be understood in light of the mean ratings assigned to the lane markings by each group. The latter do show a tendency for younger drivers to more consistently perceive the 6" lane markings on Douglas to be wider than the 4" lane markings on Sheridan while tending to perceive the 4" lane markings on Sheridan as being equal in width to the 6" lane markings on University Drive. The older drivers, however, more consistently tended to perceive the 4" lane markings on Sheridan to be narrower than the 6" lane markings on University Drive while reporting the former to be of equal width to the 6" lane markings on Douglas.

Table A-10
Ranking of Width of Lane Markings

	Young Drivers		**Old Drivers**	
Location	**Mean Rank**	**Mean Rating (SD)**	**Mean Rank**	**Mean Rating (SD)**
Sheridan (4")	1.10	1.56 (.58)	1.15	1.31 (.62)
Douglas Road (6")	1.90	2.80 (.41)	1.85	2.42 (.64)
	Kendall W = 80, Friedman Test: (χ^2 (1, 25) = 20.00, $\underline{p}<.001$).		Kendall W = .57, Friedman Test: (χ^2 (1, 26) = 14.73, $\underline{p}<.001$).	

Mean Rating scale: 1 = narrower, 2 = equally wide, 3 = wider

Visibility of Lane Markings

Drivers were more consistent in reporting the comparative visibility of lane markings. Specifically, when asked about the visibility of four inch lane markings compared to 6 inch lane markings, both young and old drivers consistently rated the six inch lane marking as more visible than the 4 inch lane marking. In fact, their responses were almost identical. Therefore, no significant differences were found between young and old drivers in regard to the visibility of he 4 and 6-inch lane markings. As such, the Friedman test was run as if both groups were one sample. The results show high agreement (75%) across drivers on the visibility of the lane markings (see Table A-11). Specifically, as shown in Table A-11, lane markings on Sheridan Street (4") were correctly reported as being less visible than those on University Dr. (6") and those on Douglas Rd. were reported as more visible than those on Sheridan**.**

Table A-11
Ranking of Visibility of Lane Markings

Location	**Mean Rank**	**Mean Rating (SD)**
Sheridan (4")	1.89	2.69 (.58)
Douglas Road (6")	1.11	1.27 (.53)

Kendall W = .75, Friedman Test: (χ^2 (1,51) = 38.10, p<0.001). Mean Rating scale: 1 = more visible, 2 = equally visible, 3 = less visible

RPM vs. NO RPM

The effectiveness of reflective/raised pavement markings (RPM) was also measured at night with a sub-sample of older drivers (n=12). Lanes with and without RPMs were compared on visibility, clarity, and width. The rationale for using only older drivers is twofold. First since the

elder roadway program specifically targets improvements for older drivers, their perception of some of these improvements is most important. Secondly, from a human factors point of view, since older persons are more likely to have more deficits than younger drivers in characteristics that are relevant to the perception of specific traffic control devices, improvements that facilitate their performance are expected to benefit younger drivers as well. The results of these analyses follow.

Perceived Visibility of Lane Markings With and Without RPMs

Chi Square (Friedman tests) were conducted to determine the ranking of lane markings with and without RPMs on visibility. Significant ranking differences were found between lane markings with and lane markings without RPMs for the 6-inch lane markings. As shown in Table A-12, the 6" lane markings without RPM was ranked as less visible than the 6" lane markings with RPMs. Note that the 4" lane markings with RPMs on N. Miami Avenue and the 6" lane markings on NE 6th Avenue are ranked as "equally visible". Nevertheless, the former were also seen as equal in visibility to the 4" lane markings without RPM on NE 2nd Avenue. These results are similar to those found for the comparison on the width of these lane markings. The superiority of RPMs over no RPMs was evident in the two last locations. The lack of difference in visibility between the lane markings on NE 2nd Avenue and North Miami Avenue may be the result of different ambient light conditions. The first (NE 2nd Ave) is a well-lit street in a business district, whereas the second (North Miami Ave) is a sparsely lit street in a residential area. The 6" lane markings, on the other hand, are both on well-lit streets with NE 6th Ave being a residential area. Biscayne Blvd is bordered with businesses throughout. There is a moderately high level of agreement among drivers regarding the ranking of these lane markings in terms of visibility (64%). These results speak to the importance of RPMs as well as to that of good lighting conditions in the presence or absence of RPMs. This is evident in the drivers' report of the 4" lane marking with RPMs being equally visible to same width lane markings without RPMs on a well-lit street, while under similar lighting conditions, lane markings with RPMs are more visible.

Perceived Clarity of Lane Markings With and Without RPMs

The responses on the clarity of the lane markings with and without RPMs were congruent with the presence of the latter. Specifically the lane markings with RPMs were judged as clearer than those without. Again Biscayne Blvd (6", no RPM) which was also ranked as being less visible was also ranked the lowest in clarity. As shown by the Friedman test, the responses regarding the ranking of the lane markings with and without RPMs were in agreement 70% of the time.

Table A-12
Ranking of Visibility of Lane Markings
With and Without RPMs

Location	Mean Rank	Mean Rating (SD)
N Miami Avenue (RPM, 4")	1.58	1.92 (.51)
NE 6th Avenue (RPM, 6")	1.67	1.92 (.79)
Biscayne (no RPM, 6")	2.75	2.92 (.29)

*locations are presented in the order the driver encountered them

Kendall W = .64; Friedman Test: (χ^2 (2,12) = 16.25, p<0.001). (Mean Rating scale: 1= more visible, 2 = equally visible, 3 = less visible)

Table A-13
Ranking of Clarity of Lane Markings
With and Without RPMs

Location	Mean Rank	Mean Rating (SD)
N Miami Avenue (RPM, 4")	2.50	3.42 (.67)
NE 6th Avenue (RPM, 6")	2.33	3.25 (.97)
Biscayne (no RPM, 6")	1.17	1.92 (.51)

Kendall W= .70; Friedman Test: (χ^2 (2,12) = 16.89, p<0.001) (Mean Rating scale: 1= Very poorly, 2 = poorly, 3 = Clearly, 4=Very Clearly)

Lane Width

While lane markings by themselves might not necessarily be visible at night, drivers were also asked their perception of the width of the various lane markings encountered. Although ambient light conditions may have been less favorable than in the daytime, drivers tended to classify lane markings' width correctly, except in the case of N. Miami Avenue (see Table A-14). Drivers reported the 4-inch wide lane markings with RPMs on N. Miami Avenue as being narrower than lane markings on NE 2nd Avenue which also were 4 inches wide (see Mean Rating). No such difference was found for the six-inch lanes, which were correctly classified in comparison to their previously encountered target. This may be due to the greater perceptibility of wider lane markings. However, the greater amount of street lighting may have also helped in that perceptibility. The drivers' low agreement (53%) as to the width of the lane markings highlights the greater importance of RPMs especially when these results are considered along the previous on the perceived clarity and visibility of lane markings with and without RPMs.

Other factors, however, seem to be at play in influencing the visibility and clarity of lane markings. These may, at least in this study, include ambient lighting conditions. Maintenance of lane markings and RPMs might also play a role.

Table A-14
Ranking of Width of Lane Markings
With and Without RPMs

Location	Mean Rank	Mean Rating (SD)
N Miami Avenue (RPM, 4”)	2.50	2.50 (.52)
NE 6th Avenue (RPM, 6”)	1.33	1.50 (.67)
Biscayne (no RPM, 6”)	2.17	2.25 (.75)

Kendall W = .53, Friedman Test: (χ^2 (2,12) = 12.61, p=0.002) Mean Rating scale: 1 = wider, 2 = equal width, 3 = narrower

Additional Comments of Older Drivers About Lane Markings

The dynamic nature of data collection during commentary driving on the road prevents soliciting detailed information from drivers in order to avoid distractions that might compromise the safety of the occupants. While objective data were collected during the focus group, such data are by their very nature more qualitative and thereby can yield richer information. Consequently, a focus group was conducted with seven older drivers to obtain detail information about their perceptions and attitude regarding lane markings and left turn lanes. The results of the focus group applicable to the older drivers' perceptions of lane markings will be reported in this section. Comments about left turn lanes will be reported at the end of the section on that design characteristic.

Older Drivers' Perception of Lane Markings (Focus Group)

Two short videotapes of a road strip with lane markings of different lane sizes (6 inch and 4 inch) were presented to the drivers. These markings were filmed from inside the vehicle from the passenger side. The camera was fixed at the same distance and angle above the road.

Following projection of the videotapes, drivers were asked to compare the size of these markings. All the drivers were able to distinguish the 6-inch lane markings as being wider.

Drivers were also asked whether they pay attention to lane markings while driving. Again, all the drivers responded in the affirmative. As to whether the lane markings delineate well the part of the road the driver should be on, the drivers responded that as long as the lane markings on the road were well-maintained, they delineated the road well. Nevertheless, there were, according to the participants, conditions that made it difficult to perceive the lane markings on the road. Among the conditions listed were: worn out and/or unclear lane markings, poorly lit roads at night, and, rainy weather. Finally, the participants were asked about ways they think would improve lane markings. They mentioned the following: good contrast between marking and pavement (i.e., White and black contrast is more visible instead of white on gray pavement), the use of reflective markings, especially at night, wider and whiter markings especially for night driving, better street lighting, longer lasting lane markings, and better maintenance.

The effectiveness of the latter suggestions (e.g., wider lane markings and RPMs) in facilitating the performance of older drivers is well supported by the results of the commentary driving and the focus group. It was shown that wider lane markings are reported as more visible and lane markings with RPMs to have more clarity and be more visible especially when they were wider.

Offset Left Turn Lanes

Offset left turn lanes were also compared to conventional left turn lanes on clarity of oncoming traffic, ease of judgment of gaps in traffic, and comfort in making the left turn. Initially, a comparison of the two age groups' perception of these left turn lanes on the various attributes was conducted.   No significant differences were found between the two age groups. Consequently, analyses of the level of agreement of the drivers regarding their perceptions of these attributes as illustrated by their ranking of the left turn lanes along these attributes was also carried out (Table A-15). The results follow.

Clarity of Oncoming Traffic

A significant difference was shown in the ranking of the clarity of oncoming traffic at the two offset left turns compared to the conventional left turns. The offset left turns were ranked as providing greater clarity for oncoming traffic than the conventional left turns.

Table A-15
Ranking of Clarity of Oncoming Traffic
At Offset and Conventional Left Turn Lanes

Location	**Mean Rank**	**Mean Rating (SD)**
191st Street (Full offset)	2.79	3.71 (.46)
207th Street (Full offset)	2.80	3.71 (.46)
Pines (Conventional)	2.17	3.34 (.64)
64th Avenue (Conventional)	2.24	3.43 (.50)

Kendall W= .14; Friedman (χ^2 = 14.77 (3,35), p = 0.002). Mean Rating scale: 1= very poorly, 2 = poorly, 3 = clearly, 4 = very clearly

One may note that generally, drivers perceived oncoming traffic from "Clearly" to "Very clearly" in both the offset left turn lanes and the conventional left turns. However, more drivers mentioned seeing the oncoming traffic "Very clearly" in the offset left turn lanes compared to the conventional left turns. Nevertheless, these differences have to be treated with caution. As indicated by the Kendall W statistic, the level of agreement between drivers regarding the ranking of these left turns is very low (14%).

Identification of Gaps in Offset Vs Conventional Left Turns

Drivers were also asked their opinion about the ease of identification of gaps in oncoming traffic from the offset left turn lanes compared to the conventional left turns. As in the previous two findings, while drivers tended to report on average seeing gaps

"Very well" in offset left turn lanes compared to "Well" for conventional left turns, the difference was not significant.

Perceived Comfort at Offset Vs Conventional Left Turn Lanes

Finally, drivers were asked about their level of comfort in making a left turn at an offset left turn compared to a conventional left turn lane. A significant difference was found in the drivers' rating of their perceived comfort level at these turns. Specifically, as shown in Table A-16, most drivers reported feeling comfortable making a left turn at all the left turns except at Pines Blvd. The latter was not only a very wide and busy intersection, there was also some construction underway close to the intersection. Furthermore, as found in the comparison of left turns, on every attribute mentioned so far, the level of agreement of drivers regarding the ranking of the offset left turn lanes and the conventional left turns was also very low (10%). These results seem to imply that the advantages provided by the offset left turn lanes compared to the conventional left turns are not systematically evident across drivers thus the low agreement on the ranking of these turn lanes on every attribute.

Table A-16
Ranking of Comfort in Making a Left Turn
At Offset and Conventional Left Turn Lanes

Location	Mean Rank	Mean Rating (SD)
191st Street	2.69	3.38 (.83)
207th Street	2.63	3.31 (.82)
Pines	2.06	3.06 (.62)
64th Avenue	2.63	3.31 (.90)

Kendall W= .10; Friedman Test: ($\chi^2(3,32) = 9.9$, $\underline{p} = 0.019$). Mean Rating scale:
1= very uncomfortable, 2 = uncomfortable, 3 = comfortable, 4 = very comfortable

Some issues regarding the potential benefits of offset left turn lanes over conventional left turn should be explored. Offset left turn lanes may indeed offer definite advantages in cases where there is high vegetation on the median or high riding vehicles (e.g., trucks, vans) that obstruct the line of sight of drivers waiting to turn left against oncoming traffic. However, when such conditions do not exist, at least in the eyes of the driver, offset left turn lanes are not superior to conventional left turn lanes. A focus group conducted with seven older drivers to understand their perception of these left turn lanes better corroborated these results. Specifically, seven older drivers who had participated in the commentary driving, were shown videotapes (from the driver's view) of vehicles approaching a left turn, either in an offset left turn lane or a conventional left turn lane. Oncoming traffic at each of these intersections was moderate. Analysis of the drivers responses show the following: 1) they were equally split on which of the left turn lanes provided a clearer view of oncoming traffic. 2) Six out of the seven believed that the conventional left turn (i.e., 64th Ave) offered a better view of gaps between vehicles than the offset left turn lane. 3) Six of the seven felt more comfortable making a left turn in the conventional left turn because the median strip offered more protection against oncoming traffic.

Let us revisit the issue of gap assessment from the conventional left turn and the offset left turn lanes. Offset left turn lanes were specifically designed to increase the visibility of opposing through lanes (Staplin, 1997). This design modification is particularly helpful when left turning vehicles (e.g., trucks, or other high riding vehicles) in the opposing through lanes, obstruct sight distance. Offset left turn lanes are also helpful for older drivers who have been reported in the literature to have difficulty judging the approach speed of vehicles and selecting acceptable gaps.

As mentioned earlier, the offset left turn lanes as well as the conventional left turn lanes used in this study did not provide the conditions for which offset left turn lanes are designed (e.g., obstructed sight distance, large percentage of left turning trucks in opposing through lanes). Consequently, the data obtained during the commentary driving and the focus group did not show a substantive advantage for the offset left turn lanes. While some participants in the focus group mentioned preferring the conventional left turn lane for the protection accorded them by the median and being away from opposing through traffic, the commentary data does not support a greater comfort level for drivers in the conventional left turn lanes.

Since the commentary driving were conducted in actual road traffic, we had no control over some of the factors (e.g., left turning trucks) that could have helped to determine the perception of the drivers in general and older drivers in particular regarding this intersection design. Consequently, a more systematic evaluation of this intersection design can be done using a controlled environment. This might also include simulation.

Conclusion

Phase I of this study, supports the effectiveness of larger lettering (i.e., letter height & stroke width) in both overhead and advance street name signs. As was shown above signs with larger lettering tended to be read from greater distances. Moreover, advance street name signs proved extremely important in providing more decision time to the driver than overhead street name signs alone. This is particularly beneficial to older drivers who require more time to process information.

Wider lane markings were also found to be more visible in the daytime and lane markings with RPMs were generally more visible at night especially in combination with wider lane markings. Focus group data has shown older drivers to support the use of RPMs and also better street lighting, better contrast between lane marking and pavement, and better maintenance of the lane markings.

Offset left turn lanes were not found to provide a significantly greater advantage over conventional left turns in this study. This may be because the conditions for which these offset left turn lanes are most appropriate were not encountered in this study.

Recommendations

The evaluation of the effectiveness of the traffic control devices reported above has implications for ways of enhancing the effectiveness of these TCDs as well as for more effective methods for studying some of these TCDs. A list of these recommendations follows.

1 – The results of the legibility distance of larger letter sizes compared to smaller ones supports the effectiveness of larger letter sizes on advance and overhead street name signs in facilitating the performance of older drivers as well as younger drivers. It is expected, based on these results, that 12" letter height C series as was initially recommended under the Elder Roadway Program for overhead and advance street name signs would greatly increase the legibility distance and decision time for older drivers. Consequently, it is recommended that these be implemented wherever feasible. Such an approach would especially be critical in communities with large numbers of older drivers (as residents or especially tourists) and heavy and or complex traffic conditions.

2 – Advance street name signs were found to give significantly more decision time to drivers generally. Furthermore, older drivers stand to benefit more from advance street name signs based on their poorer performance in the absence of these. It is, therefore recommended that advance street name signs, especially those with larger letter size, be installed whenever possible to facilitate older drivers. It is especially recommended that such advance signs be kept free of obstructions (e.g., foliage, other signs) if they are to be useful to any driver. One of the advance street name signs (i.e., Taft Street) in our study area had to be eliminated from analyses. Although it was new and of large letter size, it was so obstructed by foliage that it was usually missed by drivers or perceived only when the driver was within a few feet of it.

3- Six-inch lane markings were generally distinguished as wider by most of the drivers in the study and they were perceived as more visible than four-inch lanes markings. However, while these findings support the continued implementation of six-inch lane markings to facilitate older drivers, our results and focus group have shown that maintenance of these lane markings and pavements is as important. This is in order to secure the integrity of these lane markings and most especially to ensure that good contrast between them and the pavement be kept. Furthermore, lighting on the streets is another factor that will favorably influence the perception of such lane markings. It is, therefore, recommended that six-inch lane markings be implemented wherever possible and especially in community with large elderly populations. Furthermore, the state may wish to review its policies regarding maintenance priorities. These recommendations support those made by the Traffic Engineering Office in their proposed plan for "The Older Road-User Program

4- Reflective Pavement Markings were found to be very helpful in delineating lanes. The recommendations regarding RPMs are identical to those made for lane markings. Specifically in addition to implementing this improvement, it is critical that they be consistently maintained.

5 – In this study, drivers did not find the offset left turn lanes to offer any significant benefit over the conventional left turn lanes in terms of improved perception of oncoming traffic, gaps between oncoming vehicles, or level of comfort in making a left turn. The results, however, in no way determined that offset left turn lanes are unnecessary. Rather, it was surmised that the difficulties which offset left turn lanes are supposed to address were not present in this study. These would include heavy volume of left turning trucks in the oncoming traffic, and obstructions on the median (e.g., foliage, signs) that compromise sight distance. We had no control over the pattern,

types of vehicles, and activities of these vehicles at the intersection. Consequently we could not systematically vary them to determine the impact of these. We, therefore, recommend conducting such tests under more controlled conditions. This includes the use of simulation.

Task 2 (A): Evaluation of New Improvements

Evaluation of Clearview Font

Objective

The primary objective of the present task was to evaluate the legibility distance of Clearview font compared to fonts currently in use on Advance street name signs and Ground-mounted street name signs in Miami-Dade and Broward Counties.

Given the extensive use of highway series C & D in Advance street name signs and highway series C for ground-mounted cross street name signs, it was deemed appropriate to evaluate whether Clearview font offered a clear advantage in legibility distance over those fonts.

Methodology

Variables

While the principal objective of this study was to assess the legibility distance of specific fonts for older drivers, it was important not only to determine how different fonts affect legibility but also how drivers' characteristics affect the legibility of such signs. Consequently we identified a number of variables that were deemed relevant to the legibility of signs during driving. The main variables studied were the following:

Signage Variables

1) Font type (Highway Series C, D, and Clearview)
2) Character size
3) Sign type (i.e., Advance street name sign and ground-mounted street name signs)

Driver Variables

1) Age
2) Static visual acuity
3) Driving experience (# of years of driving)
4) Attention (time on Trails Making A & B

Performance Variable

Legibility distance

Protocol

In order to conduct these evaluations under realistic conditions, the assessment was conducted on roads open to regular traffic at Opa-Locka Airport in Miami-Dade. All participants drove a Toyota Tercel 1994, with automatic transmission and equipped with dual brakes. Before, starting the scenario, participants were shown the location of various controls (e.g., ignition, signal stalk, light switch) to familiarize them with the vehicle. When the drivers were ready to start, they were told the following:

" As was mentioned in your consent form, your task today is to help us evaluate various street name signs, specifically ground-mounted street signs and advance street name signs. In order to do so, you are going to drive on various roads where we will call your attention to the traffic control devices we want you to read to us.

For instance, as will be the case on various occasions during this drive, if we ask you to tell us the name of streets on the street name signs we point out to you, as soon as you are able to read the sign, you are to do so aloud as quickly as possible.

All the street name signs we want you to read are written in white font on green background. The ground-mounted street name signs will be located at the corner of the street on your right side and the advance street name signs will be located in the median of the street on your left side. We will let you know the location of the signs you will be asked to identify as you approach them." (See Appendix B-1)

Drivers were accompanied by a driving instructor who was responsible for ensuring the safety of the vehicle's occupants and gave directional instructions to the driver and by a research assistant who collected data on the legibility distance of signs using a Nu-Metrics distance-measuring instrument. All evaluations were conducted after sunset with the vehicle's headlamps on high beam.

Whenever a driver was guided to the location of a sign, as soon as the driver read the sign, the research assistant would measure the distance from which the driver read the sign and record it on the data collection forms. All the drivers were administered the six signs and were randomly assigned to fonts for specific signs.

Sampling

In order to accomplish the objectives stated above, thirty-seven drivers ranging in age from 65 to 92 years old (Mean age=76.7, SD= 6.67) participated in this evaluation. The participants were recruited using advertisement in community bulletins (e.g., church bulletin), flyers in stores, direct solicitations. The only requirement for participation in the study was for the participant to have a valid drivers' license.

The sample size (i.e., 37) was selected to reflect a large effect size with an alpha of .10 and a power between .70 and .80 (see Stevens, 1992). This power analysis was used for two reasons: a) to ensure that if indeed Clearview font is significantly more legible than the other fonts to which it is being compared, we have a high probability of finding that difference. Furthermore, any recommended change in current practice (e.g., changing current fonts to Clearview) could incur large costs. Consequently, such costs are only justifiable if the differences in legibility between Clearview and the fonts under examination are significant.

Test Site

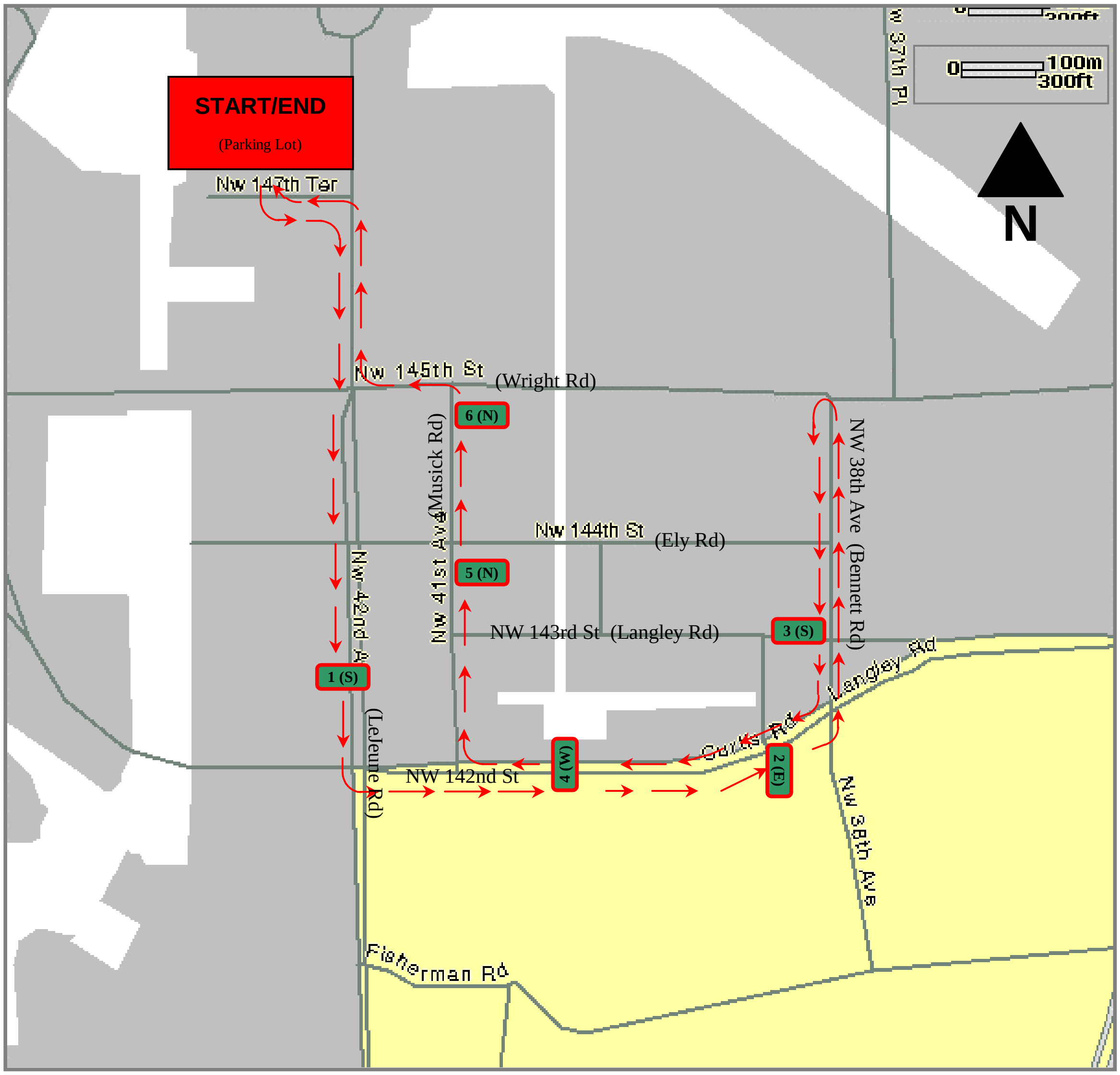
We obtained permission from Mr. Chris MacArthur, Airport Manager, to conduct the field test of Clearview font compared to Highway Series C and Highway Series D for Advance Street Name signs and Highway C series for Ground Mounted Street Name signs at Opa-Locka Airport. The area of the site selected consisted of approximately two miles of roads. The roads upon which the advance street name signs were displayed consisted of four-lane arterials with a median with a speed limit of 30 miles per hour. They were Lejeune Road and Curtiss Road. The roads where the ground-mounted street name signs were displayed (i.e., Bennett Rd. and Musick Rd.) were two lane roads (see Figure 1).

Signs

Six signs were used for the field test: three advance street name signs and three ground-mounted street name signs. The signs were made under the supervision of Mr. Stephen Vitiello, Sign Shop Supervisor at the Broward County Department of Public Works in the Traffic Engineering Division. Dr. Susan Chrysler of 3M provided Mr. Vitiello with the software used for generating Clearview font. As mentioned earlier, three advance street name signs and three ground-mounted street name signs were designed. The three advance street name signs were: Curtiss Rd., Bennett Rd., and Musick Rd. and the ground-mounted street name signs were: Langley Rd., Ely Rd., and Wright Rd. Most of the signs, except for Ely, had about the same number of letters (6 or 7 letters) in order to control for the length of the words. Each advance street name sign was produced in 8 inch high, upper case letters, using 3M VIP with green 3M overlay (retro-reflective materials) and 24X48 blanks. The specific Clearview font used was ClearviewOneCD-45.

Only Clearview (i.e., ClearviewOneUC-35) and Highway C fonts were developed for the ground-mounted street name signs. These were printed on 9X36 blanks (except Ely for which 9X24 blanks were used) using 6 inch letters. As was done for the advance street name signs, the ground mounted street name signs were also pressed using 3M VIP with green 3M overlay (retro-reflective materials). Five of the six signs made were placed where none existed before except for Ely for which a sign indicating the intersection was present. That sign displayed two lines of text as follows: ”ELY RD (1st line) NW 144th ST (2nd line). Ely was written in 4” high white letters on green overlay on a 12X30 blank (see Appendix B-2 for photos of signs). However, the material used for that sign was not retro-reflective. All signs evaluated were developed according to relevant guidelines and current usage (Highway C & Highway D).

Figure 1. MAP SHOWING PLACEMENT OF SIGNS



1. **"Curtiss Rd"** – (Advanced Street Sign) Sign placed on median of LeJeune Rd *Southbound* before Curtiss Rd
2. **"Bennett Rd"** – (Advanced Street Sign) Sign placed on median of Curtiss Rd *Eastbound*
3. **"Langley Rd"** – (Ground Mounted Street Sign) Sign placed on Bennett Rd *Southbound* before Langley Rd
4. **"Musick Rd"** – (Advanced Street Sign) Sign placed on median of Curtiss Rd *Westbound*
5. **"Ely Rd"** – (Ground Mounted Street Sign) Sign placed on Musick Rd. *Northbound*
6. **"Wright Rd"** – (Ground Mounted Street Sign) Sign placed on Musick Rd *Northbound*

Data Collection and Analyses
All data were collected and entered into an SPSS database. Analyses were conducted to identify which fonts were more legible and also which driver characteristics best predicted legibility distance. Both univariate and multivariate analyses were applied as appropriate.

Results

Legibility Distance Among Advance Street Name Signs
Analyses of the legibility distance among advance street name signs across all fonts showed significant difference among the signs ($F(2,35)=19.76$, $p \leq .0001$). Specifically, Curtiss was legible from a greater distance than Bennett ($p=.002$) and Musick ($p< .0001$). Bennett was also significantly more legible than Musick ($p=.02$).

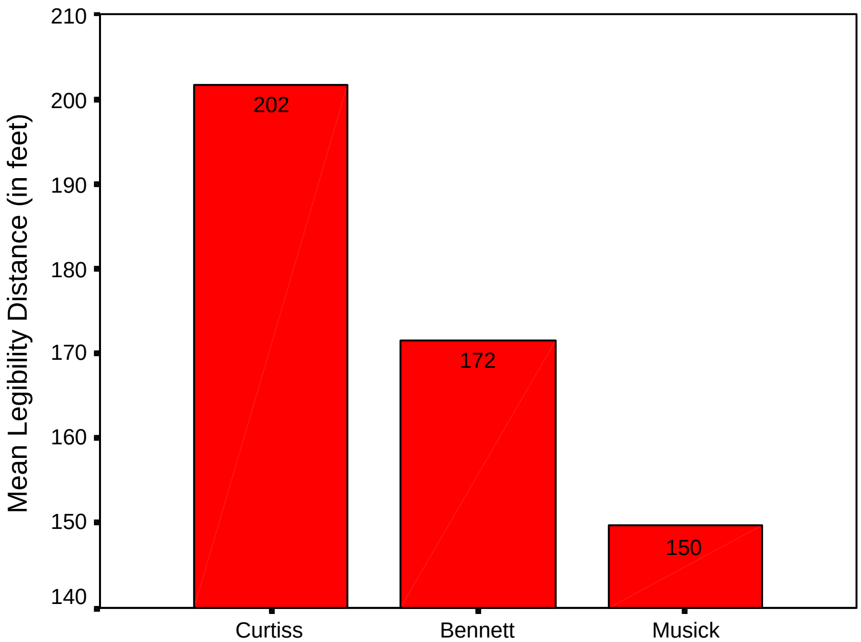


Figure 2: Legibility Distance of Advance Street Name Signs

The significant difference in legibility distance between the Advance street name signs may be due to their location in relation to the driver as the latter was approaching them. For instance, Curtiss was on the median of LeJeune Rd, a well-lit, straight road, leading to Curtiss Rd. Lights were placed along both sides of Lejeune, and the drivers approached the sign from the inside lane. Bennett and Musick on the other hand were advance signs both placed on the median of Curtiss Rd. That road had lighting on its north side only. The approach to Bennett Rd. was from the inside lane; the sign was placed at the beginning of a curve. As stated earlier, the advance sign “Musick” was also on Curtiss Rd; the sign was approached from the outside lane (i.e., the lane furthest from the median) and may have made more difficult to see and read the sign.

The differences among the advance street name signs represent a small sample of the variety of conditions a driver encounters in the real world. Since our interest is to determine whether Clearview font fared better than Highway series D and Highway series C across the signs, the observations for legibility distance collected for each font across signs were analyzed. An analysis of variance was conducted to determine differences in the legibility distance of the three fonts. The results show that there is a significant difference in the legibility distance of the three fonts ($F(2,34)=5.00$, $p= .01$ (Power=.78)). Specifically, Clearview font was found to be legible at a greater distance than Highway series D or C (see Table B-1, Figure 3). However, this difference was greatest between Clearview font and Highway Series C ($p=.004$) for which the mean difference was 47 feet (see Table B-2).

TABLE B-1. LEGIBILITY DISTANCE BY FONT

FONT	Mean Legibility Distance	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Clearview Font	198.083	11.199	175.347	220.819
Highway Series D	178.056	10.997	155.731	200.380
Highway Series C	151.097	11.073	128.618	173.577

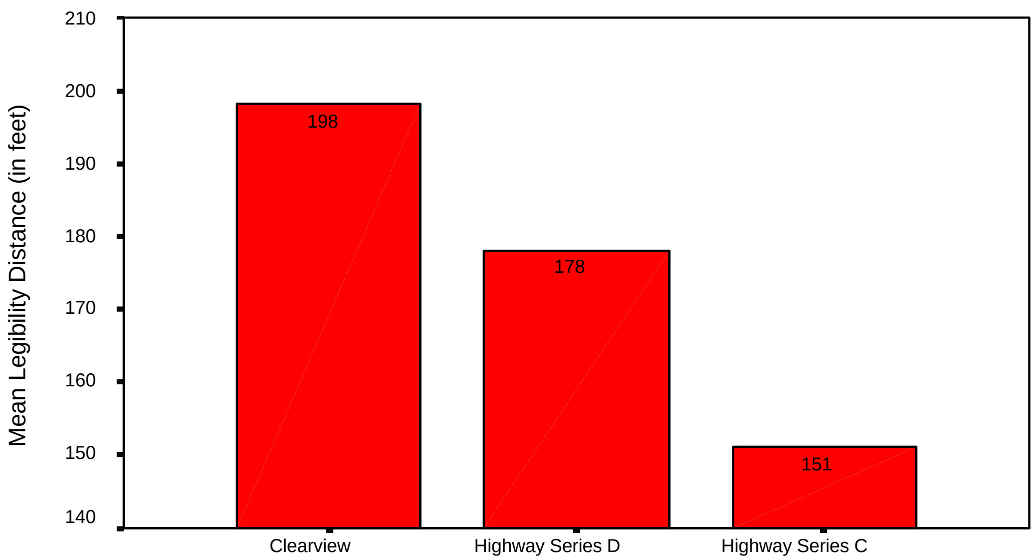


Figure 3. Font Type of Advance Street Name Signs

The mean difference in legibility distance between Clearview font and Highway series D was 20 feet ($p=.09$), and 47 feet ($p=.004$) between Clearview and Highway series C.

TABLE B-2. Pairwise Comparisons

(I) FONTS	(J) FONTS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference Lower Bound	Upper Bound
Clearview	**Highway D**	20.028	11.354	.087	-3.073	43.129
	Highway C	46.986*	14.992	.004	16.484	77.488
Highway D	**Clearview**	-20.028	11.354	.087	-43.129	3.073
	Highway C	26.958	14.357	.069	-2.251	56.167
Highway C	**Clearview**	-46.986*	14.992	.004	-77.488	-16.484
	Highway D	-26.958	14.357	.069	-56.167	2.251

Based on estimated marginal means
* The mean difference is significant at the .05 level.

As may be seen in Appendix B-3, in everyone of the Advance street name signs the relationship described above is consistently found. The legibility distance of Clearview font is greater than that of Highway D, and Highway C. The latter's legibility distance was consistently shorter than that of the other two fonts.

Ground-Mounted Street Name Signs

As was done for the Advance street name signs, three ground-mounted street name signs were also evaluated. However, since Highway series D font is not customarily used on these signs due to the size of the blanks, two fonts were compared: Clearview and Highway series C. For one of the signs (i.e., Ely), three fonts were compared: Clearview (6") and Highway series C (6") both on retro-reflective sheeting, and an existing sign that was in use there. That sign was in 4" letter sign on non retro-reflective sheeting (see Appendix B-4).

An analysis of variance of legibility distance of the three signs was conducted. The results show a significant difference in the legibility distance of the three signs ($F(2,35)= 8.12$, $p = .001$) (see Figure 4). Specifically, the legibility distance of Wright Rd. was significantly greater than that of Ely ($p<.0001$) and of Langley ($p=.02$). The legibility distance between Ely and Langley was not significantly different ($p=.32$). As was shown for the advance street name signs, ambient light may have contributed to the difference in legibility distance. Wright Rd. was on a better light road than the other two. Furthermore, as may be seen in the photo of the ground-mounted street name sign for Ely (Appendix B-2), the post bore two street name signs, one, Musick Rd., above and perpendicular to Ely Rd. This arrangement which was different from that of other ground-mounted street name signs that bore only one sign, may have made Ely Rd. more difficult to see and read.

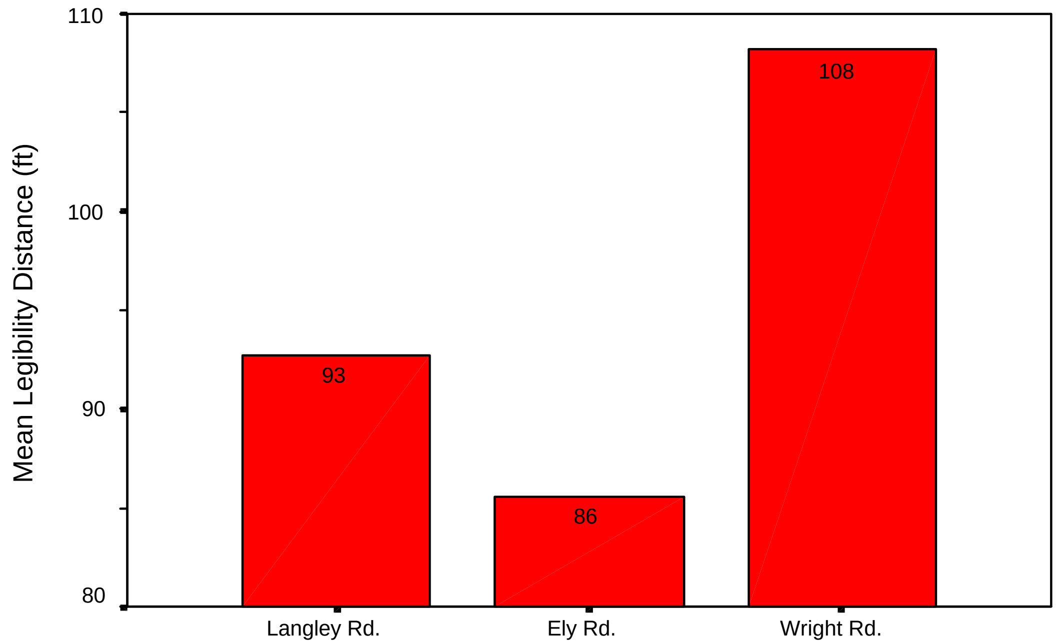


Figure 4. Ground-Mounted Street Name Signs

As was done for the Advance street name signs, the observations on the legibility distance of Clearview font and Highway Series C across the three signs were analyzed using ANOVA. The results showed no significant difference between Clearview font and Highway series C for the Ground-Mounted street name signs (i.e., 6" letter height) ($F(1,46) = 1.22$, $p = .27$) (see Figure 5).

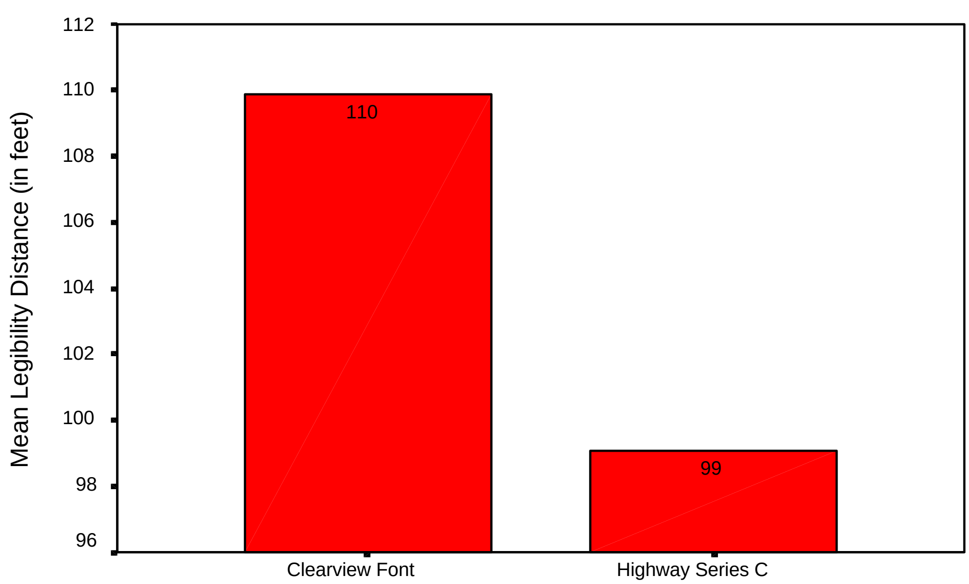


Figure 5. FONT for Ground-Mounted Street Name Signs

The data on each of the Ground-mounted street name signs were looked at separately to assess the trends in legibility distance of Clearview and Highway C series fonts. As seen in the histograms below, Clearview font has a greater legibility distance than Highway series C for both Langley Rd and Ely Rd., that trend is reversed for Wright Rd (see Figures 6 to Figure 8). While eliminating Wright Road from the analysis would have yielded a significantly greater legibility distance for Clearview font than for Highway C) ($F(1,26) = 4.86$, $p = .04$), there is no justification for such an approach. The roads upon which these Ground-mounted street name signs were placed as well as the lighting conditions upon these roads were comparable. Consequently, we conclude that there is no significant difference in the legibility distance of Clearview font compared to Highway series C.

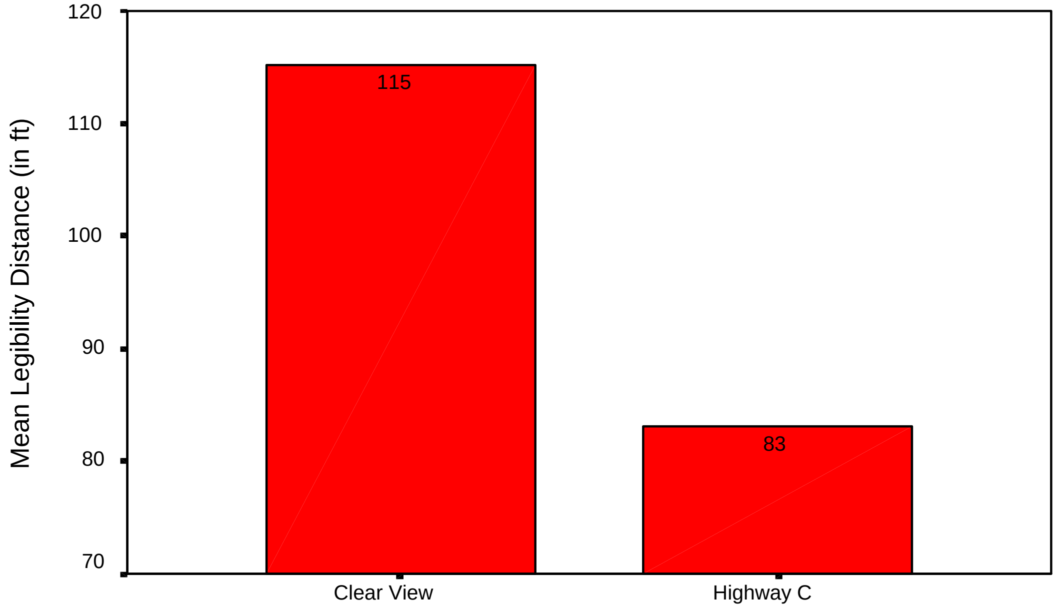


Figure 6. Font Type of Langley

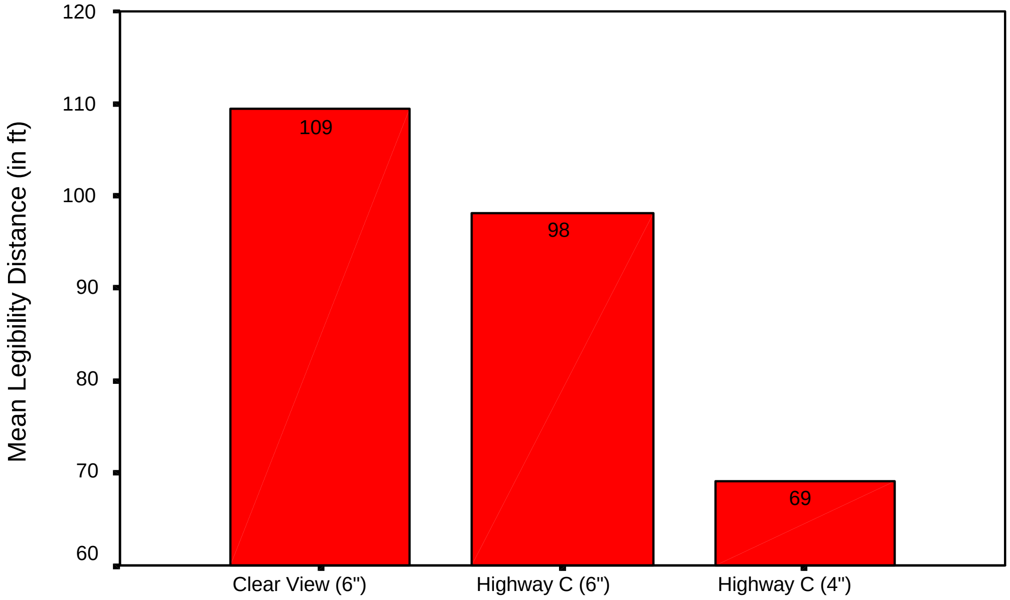


Figure 7. Font type of Ely

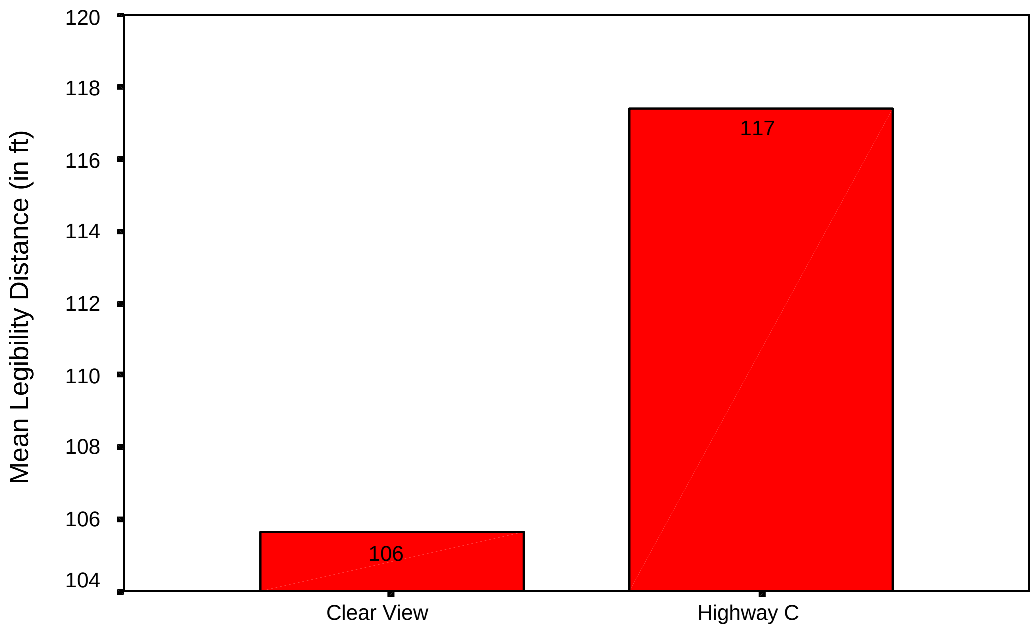


Figure 8. Font type of Wright

Characteristics of Older Drivers that Predict Legibility Distance
As shown above, the characteristics of the roadway environment do affect the legibility distance of signage. This, of course, is important information from an engineering point of view. However, specific driver related factors also may influence the legibility

of these signs. Understanding the influence of these factors will not only help in knowing which drivers are at risk, but will also inform us as to roadway designs that can address these factors. In this regard, three characteristics of the drivers were assessed for their relevance to legibility distance: age, static visual acuity (i.e., measured with the Snellen chart), and attention (i.e., Trail Making B, a measure of attention shift/divided attention). The latter were found in phase I of this project to be predictive of legibility distance. Stepwise regression analyses were conducted to measure the influence of these characteristics of drivers on the average legibility distance of Advance street name signs and Ground-mounted street name signs. The results show that both for Advance street name signs and for Ground-mounted street name signs, attention skills as measured by Trail Making B was the single best predictor of legibility distance ($R(1,33) = .48$, $p = .004$) and ($R(1,33) = .43$, $p = .01$) respectively. A hierarchical regression was conducted to determine what contributions if any attention, and visual acuity made to age in determining legibility distance. In the analysis of the relationship of these variables to mean legibility distance of Advance street name signs, we found that age contributes nothing to the legibility distance. Attentional skills add 25% to the variance explained of legibility distance and visual acuity adds an additional 11% to the variance (see Table B-3).

Table B-3. Model Summary of Influence of Driver Characteristics on Average Legibility Distance of Advance Street Name Signs

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R^2 Change	F Change	df1	df2	Sig. F Change	Standardized Beta
Age	.146	.021	-.007	60.7176	.021	.757	1	35	.390	-.170
Attention (Trails B)	.518	.268	.225	53.2674	.247	11.475	1	34	.002	-.498
Visual Acuity	.611	.373	.316	50.0535	.105	5.506	1	33	.025	-.329

a Predictors: (Constant), AGE
b Predictors: (Constant), AGE, Trail B Time
c Predictors: (Constant), AGE, Trail B Time, RIGHTEYE

In the hierarchical regression analysis of the drivers' characteristics mentioned above and the average legibility distance of Ground-mounted street name signs, the results show that for Advance street name signs, age contributes virtually nothing to legibility distance. Attentional skills add about 23% to the variance of legibility distance, and visual acuity adds an additional 6% to the total variance (see Table B-4). It is evident that the drivers' characteristics mentioned have a differential impact upon the legibility of Advance street name signs compared to Ground-mounted street name signs. Factors that might explain these differences are explored below.

Table B-4. Model Summary of Influence of Driver Characteristics on Average Legibility Distance of Ground-Mounted Street Name Signs

Model	R	R^2	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change	Standardized Beta
Age	.016	.000	-.028	46.6414	.000	.009	1	35	.927	-.028
Attention (Trails B)	.478	.228	.183	41.5760	.228	10.048	1	34	.003	-.478
Visual Acuity	.539	.290	.226	40.4742	.062	2.876	1	33	.099	-.253

a Predictors: (Constant), AGE
b Predictors: (Constant), AGE, Trail B Time
c Predictors: (Constant), AGE, Trail B Time, RIGHTEYE

Summary of Results for Advance and Ground-Mounted Street Name Signs and Implications of Results

One of the purported advantages of Clearview font is greater legibility of signage than other currently used fonts under conditions of high reflectance. Research by Garvey, Pietrucha, and Meeker (1998) showed Clearview font to yield greater legibility distance than mixed case Highway series E(M). Our study was to compare the legibility distance of Clearview font to Highway series C and D on Advance street name signs and Clearview font and Highway series C for Ground-Mounted street name signs. The study was conducted under realistic conditions with older persons (65 and older) driving on regular roadways located at an airport at night. The participants were asked to drive as they would normally and to read specific road signs whose location was indicated to them as soon as these signs became legible to them. This was a recognition task. The vehicle used for the study was driven with the high beams on to increase the chances of halation/irradiation on these signs. The participants evaluated six signs: three Advance street name signs with 8 inch uppercase letters and three Ground-mounted street name signs with 6 inch letters with the exception of one for which a 4 inch letter height sign was also evaluated. Based on the analysis of the legibility distances recorded for the signs, It is evident that the Clearview font was superior to Highway C and D series (8") for Advance street name signs under the conditions tested. Clearview yielded on average 47 feet above the legibility distance of Highway C and 20 feet above the legibility distance of Highway D. Given that the roads traveled had a speed limit of 30 miles per hour, these differences in legibility distance translate to an average gain of 1.07 seconds in decision time for the difference between Clearview and Highway series C and .45 seconds for the difference between Clearview and Highway series D. It goes without saying that any improvement in traffic control devices that provides more time to older drivers to make decisions on the road will increase the safety of that group of driver in particular but will be equally beneficial to younger drivers as well.

No significant difference was found for the legibility distance of Clearview and Highway series C for the Ground-mounted street name signs. There could be many reasons for the lack of difference in the legibility distance for Clearview font compared to Highway C. For instance, the streets on which the Ground-mounted street name signs were located had few lights and were therefore darker. Furthermore, both the letter size (6") and the size of the sign itself or a combination of the lack of lighting and the size of the signs and the letters may have made it difficult to perceive these signs. In fact the differential results of the characteristics of the drivers that influence legibility distance of the Advance street name signs and the Ground-mounted street name signs might offer some support for this. One will note that while the same drivers saw Advance and Ground-mounted street name signs, the relationship of these characteristics to legibility distance decreases from Advance street name signs to Ground-Mounted street name signs. For instance, the variance accounted for by visual acuity diminishes by 41% while that of attention diminishes only by 8% (see Table B-3). The standardized Beta for these drivers' characteristics shows that while attention plays the most important role in the legibility distance of Advance street name sign (Β= -.50), vision also plays a significant role (Β= -.33) (Table B-3). However, for Ground-mounted street name signs, attention remains the most important (Β= -.48) factor in the legibility distance of these signs, but visual acuity does not add significantly to that (Β= -.25). This would seem to indicate that while vision is necessary in legibility of signs, under difficult visual conditions (e.g., low light, small target) attentional skills (e.g., scanning) remains a critical driver skill. This information, while informing us about drivers who will likely have difficulties reading signage or navigating through other traffic control devices, highlights the importance of more legible and more visible signage because the latter reduce attentional loads on the drivers by providing more information earlier.

Conclusion

These data compellingly show that Clearview font on Advance street name signs does yield significantly greater legibility distance than Highway series C and D at night. The superiority of Clearview font to Highway C is especially important in that it is very widely used in Advance street name signs in Florida. One may wonder about the practical significance of the greater legibility distance of Clearview font for the population of elderly drivers in Florida. As was shown in the first phase of this project, Advance street name signs were found to be beneficial to both younger and older drivers by providing them with more decision time than overhead street name signs alone. The results of the present phase of the project show that the use of Clearview font would further increase the effectiveness of Advance street name signs in giving all drivers more decision time by rendering the signs legible from a greater distance. Such improvement could translate into greater safety for drivers in general and older drivers in particular. Clearview font (i.e., 6" letters) did not seem to yield any advantage over Highway series C (i.e., 4" or 6") for Ground-mounted street name signs. This may have been the result of the conditions under which these signs were tested in this study. Therefore, it may be necessary to conduct further tests of Clearview font using Ground-mounted street name signs.

Recommendations

Among the principal objectives of the Florida Elder Roadway User Program to enhance the safety of older drivers and facilitate their mobility is the improvement of traffic control devices. In keeping with these objectives, we make the following two recommendations:

a) Implement Clearview font on Advance street name signs, especially where new signs are being deployed or old signs replaced.

b) Further study the effectiveness of Clearview font for Ground-mounted street name signs.
c) Assess the effectiveness of Clearview font for other types of signage (e.g., highway guide signs, tourist oriented directional signs)

Task 2(B): Evaluation of New Pavement Markers

Evaluation of 3M 380I series, 3M 820 series, and Thermoplastic Lane Markers

Objective of Present Phase

The objective of the current Task (Task 2) of the study is to evaluate promising technologies that may improve the design of TCDs. In the first part of this task the University of Miami evaluated the effectiveness of Clearview font. In this part of the task, three pavement marking treatments, 3M's series 820 and series 380I (high ridge/ceramic beads), and thermoplastic, were evaluated for their comparative visibility.

Methodology

In order to determine the effectiveness of the lane markers, identical delineation treatments will be applied to roads with similar features. Specifically, skip marks, will be applied to tangent roads and curves for each of the products being tested. For instance, treatment of a road section using a specific product will be interspersed such that a tangent road section treated with 380I series may be followed by treatment of a road section of identical length with similar features using 820 series or thermoplastic lane markers. In order to keep conditions equivalent, amount of road lighting will also be taken into consideration. Treatments will be applied such that they will provide opportunities for comparison with one another under similar conditions as much as possible.

Test Site

The test site made available for this evaluation is a 3.5 mile section of the Florida Turnpike northbound, starting from Milepost 48 to Mile Marker 51.5 in Broward County (see Table C-1 and Figure 1 below).

Table C-1

Layout of Pavement markings as of November 2001.

Mile Marker	Lane Marker Treatment	Distance from Toll Booth
MP 48 – 48.5	380 Tape	3.5 – 4.0 miles
MP 48.5 – 49.5	Thermoplastic	4.0 - 5.1 miles
MP 49.5 – 50	820 Tape	5.1 – 5.6 miles
MP 50 – 50.5	380 Tape	5.6 – 6.1 miles
MP 50.5 – 51	Thermoplastic	6.1 – 6.6 miles
MP 51 – 51.5	820 Tape	6.6 – 7.1 miles

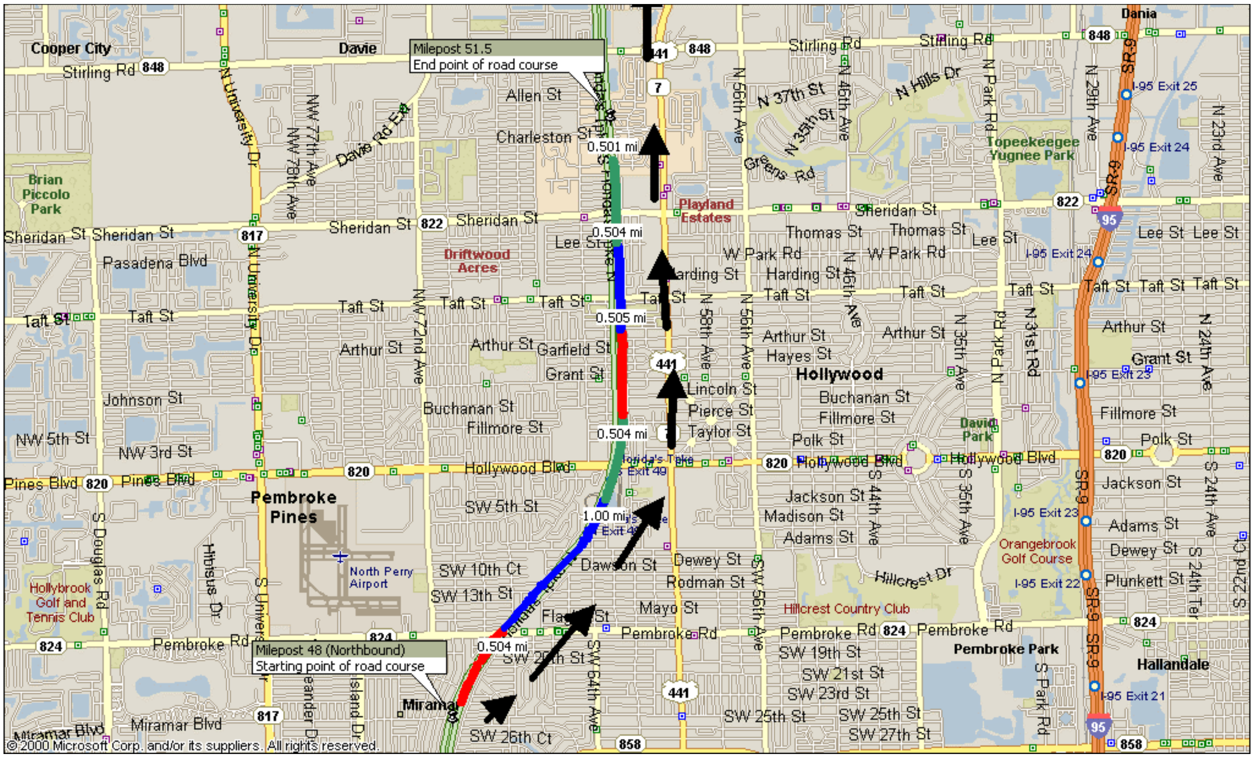


Figure 1. Test Site for Evaluation of Pavement Markers. Location: Milepost 48 to 51.5 Northbound Florida Turnpike (red=380I, blue=thermoplastic, green=820)

One mile each of the 380I and the 820 series treatment were provided by 3M. In order to provide each driver the opportunity of assessing each treatment twice and to compare each to another, each of the 3M treatments was laid on half mile sections. 3M had initially committed to provide three miles of each treatment in order to permit testing of each treatment on a northbound and southbound course. However, the amount was reduced yielding the course shown above.

Sample

Twenty-two older drivers were recruited for this phase of the project. This sample size was derived from a power analysis based on the following premises: 1) the justification for using the newer lane markings would require a large effect size since their cost is also higher than that of the thermoplastic. This means that the advantages of the new treatments along the dimensions evaluated had to be substantive. Consequently, statistical significance alone should not be sufficient but difference should also have practical significance. 2) A view toward economy. Since resources for recruiting participants and compensating them are limited, the power analysis conducted permits the recruitment of the requisite number of persons to conduct a valid assessment. Based on these analyses, a sample size of 22 participants was called for. This sample size would permit the testing of three types of pavement markings, with attention to large differences in the performance of these products. The power estimate for this sample is 82%.

All participants were at least 65 years of age, had a valid driver's license, and drove at night.

Protocol

All participants completed a consent form, paper and pencil tests of attention and memory, and completed a driving habit questionnaire (see Appendix C-1). In addition, their static visual acuity was measured. Since this assessment was carried out on an expressway at night, after sunset, the older person participant was not permitted to drive the vehicle. Rather, all participants sat in the front passenger seat while the driving instructor drove the vehicle at 50 MPH, using low beams to illuminate the road. All the road sections tested were also illuminated by street lights evenly distributed across the road course. Having the participants conduct their evaluations as passengers permitted them to concentrate better on the task at hand than would have been the case had they been driving. During the ride through the course described, using a structured approach, the participants were asked to evaluate the absolute visibility of each treatment, their comparative visibility, and their direction.

The vehicle used was a Toyota Corolla 2001. This vehicle allowed even participants of short stature to have a good view of the roadway.

Prior to their ride through the course, participants were instructed about the manner in which they were to evaluate the lane markers. Specifically, they were told: "As you look down this lane as far as you can see, does it go straight, curve right, or left." You would answer according to the way they seem to you. Then, we will ask: "How visible are these lane markings to you? Very visible, visible, barely visible, not visible." And finally, we will also ask you: "Compared to the lane markings you just saw, are these: More visible, equally visible, less visible". Again, whenever you are asked a question about the lane markings, make the choice that you feel is appropriate as quickly as possible. There are no wrong answers to these questions. We are interested in your evaluation of these lane markers." (See protocol & Data Collection sheet in Appendix C-2).

A toll booth located 3.5 miles south of the first treatment was used as the calibration point for the vehicle's odometer (odometer set at zero). As the vehicle proceeded through the course, the driving instructor would indicate imminent entry into a section by calling out the mileage 1/10 of a mile and at its beginning. This permitted the data collector to start the sets of questions exactly at the beginning of each treatment. Each participant had the opportunity of seeing each treatment twice over the course of the evaluation.

Variables

Both objective and subjective data will be collected. The variables that will be measured will include the following:

Lane Markers – Three lane markers were assessed for their subjective visibility and for their comparative visibility. They are: two treatments by the 3M company: the 380 and 820 series, and what is currently used, the thermoplastic tape.

According to 3M advertisement, the 820 series lane marker is a reflective tape especially designed for wet and rainy weather. It also "…appears as bright in the rain as it does when dry" (see Appendix C-3). The 380 series is a retroreflective, patterned, pavement marking tape containing microcrystalline ceramic beads. Both tapes are purported to offer superior guidance due to their reported brightness. In this evaluation, we were only provided stripes for evaluation (no edgelines for the different treatments were provided). As such, any mention of "lane markers" in this text will refer to strips since they were the only treatments evaluated.

Objective measures of the lane markers were also collected. These consisted of levels of retroreflectivity of each of the treatments being evaluated.

Driver's Characteristics

a) Static visual acuity – Visual Driver's static visual acuity will be measured to determine the visual skills of the participants.
b) Measure of attention and memory – measures of attention and memory (e.g., Trails A&B) have been found to be significant predictors of driving performance and perfomance in the assessments of TCDs. Their influence on the present tasks will also be assessed.

The types of lane markers and driver characteristics mentioned above will constitute the independent variables in this evaluation. Dependent variables will include the following:

Visibility of lane markers

Three components of visibility will be measured. They are the absolute visibility of the lane mark:

a) The absolute visibility of the lane markers for each treatment
b) The comparative visibility of the each lane marking treatment
c) Perception of directional shift

These are subjective measures representing the driver's perception of the specific qualities of the lane markers mentioned. It had initially been planned that directional shift and distance from which shift (if any) is perceived would be measured, however, due to a reduction in the amount of lane marking material provided by 3M, only perceived directional shift as a measure of the lane markers to delineate the lane brightly is measured.

Design of the Study

This study is a repeated design approach. As such, each participant evaluated all the lane markers. As such they served as their own control.

Analyses

The data obtained was analyzed using nonparametric statistical methods or multivariate approaches as applicable.

Results

Relevant Demographic Characteristics of Sample

As mentioned above, twenty-two persons participated in this study. They ranged in age from 65 to 93 years old (Mean =75.45 years old, SD=6.19). These elderly persons lived independently in the community and, most, responded to a newspaper ad about the study. All the participants had retained valid drivers licenses from 30 to 72 years, with an average of 52 years (SD=8.95). The measured visual acuity of these drivers in their better eye ranged from 20/15 to 20/70 with most participants (75%) with 20/40 vision or better in the better eye.

Directional Shift

There was very high consistency in the determination of directional shift for each of the treatments. Specifically, in their first exposure to the 380I, Thermoplastic, and 820, participants were in high agreement (i.e., 96%) regarding the direction of the lanes highlighted by these treatments (Kendall W = .96, (χ^2 (2,23) = 44, p<0.0001). This level dropped somewhat (87%) but still remained significant during the participants' second encounter with the treatments (Kendall W = .87, (χ^2 (2,23) = 40.1, p<0.0001) (see Table C-2).

Table C-2

Frequency for Perception of Specific Lane Direction for Each Treatment During First and Second Exposure

Direction Perceived	First Exposure to Treatments			Second Exposure to Treatments		
	380I Series	Thermoplastic	820 Series	380I Series	Thermoplastic	820 Series
Straight	0	0	0	2	*23*	*22*
Right	*23*	*23*	1	0	0	0
Left	0	0	*22*	*21*	0	1

* *Correct responses in italics*

The very high, significant consistency in agreement among the participants regarding the directional clarity of specific lane markers, no matter the treatment used, might be attributable to their newness since all the treatments within the course sections were laid during the same time frame (November 2001). Likewise, given that raised pavement markers (RPM) were present in all sections, since the participants were asked to look far ahead of the vehicle to determine direction of the lanes, they may have been responding to a combination of the brightness of the RPMS and also of the lane markers.

Visibility of Treatments

As mentioned earlier, participants were also asked to report the absolute visibility of each treatment as they encountered these. No significant difference was found in the rating of the visibility of any of these treatments (F(2,21) = .21, p=.82). As seen in Table C-3, all the treatments were rated as visible to very visible (Very visible =4, visible=3, Barely visible=2, Not visible=1). Likewise, during the participants' second exposure to these treatments there was no significant difference in the absolute visibility of treatments as reported (F(2,21) = 2.82, p=.082) (see Table C-4).

Table C-3

Absolute Visibility Rating for Each Treatment (1st Exposure)

Visibility of each Applications (1st	Mean	Std. Deviation	N
380I	3.2826	.7203	23
Thermoplastic	3.2391	.7668	23
820	3.3043	.7498	23

Table C-4

Absolute Visibility Rating for Each Treatment (2nd Exposure)

Applications	Mean	Std. Deviation	N
380I	3.0870	.6511	23
Thermoplastic	3.4130	.7485	23
820	3.3696	.6779	23

Comparative Visibility of Treatments

Participants had two opportunities for comparisons between the 380I, 820 series from 3M and a thermoplastic application. In both instances they reported the treatment to be evaluated to be equally visible to its target. As such there were no significant differences reported among the lane markers. The Chi Square analyses of the comparisons between the 3M applications and a thermoplastic application or even between the 380I and 820 were (χ^2 = 2.24 (2,23), p=.33) and (χ^2 = 1.625 (2,23), p=.44) for the first and second sets of evaluations respectively. As shown by the coefficient of concordance in these analyses in the first set of comparisons, there was only about 5% agreement (Kendall W = .049) about a specific rating of any particular lane marker compared to another, while in the second comparison, the level of agreement about specific ratings for any lane marker(s) was about 4% (Kendall W = .035) (see Tables C-5 & C-6).

Table C-5

Ranks of Comparative Visibility for380I, 820I, and Thermoplastic (1st Comparison)

	Mean Rank
380 compared to thermal	1.85
820 Compared to Thermal	2.17
380 compared to 820	1.98

(χ^2 = 2.24 (2,23), p=.33, Kendall W=.049)

Table C-6

Ranks of Comparative Visibility for380I, 820I, and Thermoplastic (2nd Comparison)

	Mean Rank
Second comparison of Thermal to 380I	2.11
Second Comparison of 820 to Thermal	2.04
380 compared to 820	1.85

(χ^2 = 1.625 (2,23), $\underline{p}$=.44, Kendall W=.035)

Reflectivity of Treatments Evaluated
Minimum levels of retroreflectivity have been recommended to facilitate older drivers; however, there does not seem to be much agreement regarding these levels. For instance, Zwahlen and Schnell (2000) using the 62 year old driver as the age limit that accomodates 95% of nighttime drivers in the U.S. have recommended minimum retroreflectivity levels for speeds of 55MPH, on low beams, in the absence of RPMs,.that range from 170.1 mcd/lux/ m^2 to 283.5 mcd/lux/ m^2 depending of the type of low beam light source used . Carnaby (2000) reports a survey by Migletz, Graham, Bauler and Harwood which recommended a minimum retroreflectivity level of 150mcd/lux/m^2 for speeds above 80km/hr and 180mcd/lux/m^2 for nighttime wet-pavement conditions. It is also the policy of the FDOT that the minimum in-service reflectivity level is 150mcd/lux/ m^2. To find out if the treatments tested met these minimum values, data were collected on their retroreflectivity level by Mr. Prager the Florida Turnpike Traffic Services Manager. Using a Delta LTL2000 Retrometer which simulates a driver's viewing distance of the lane markers from 30 meters (see Appendix C-4), random readings of these lane markers were taken. The data show average readings for the 820 Series lane markers by 3M to be from 650 to 750 mcd/lx/m^2, average reading for the 380I Series were from 480 to 500 mcd/lx/m^2 and for the thermoplastic from 270 to 280 mcd/lx.m^2. These retroreflectivity levels either exceeded the minimum levels mentioned above or met them. The data also show that the two treatments by 3M recorded higher luminance than the thermoplastic. Specifically, the luminance ratio between the lower and higher values for each pair of these applications was as follows: about 1:2.68 for the 820 vs thermoplastic; about 1:1.79 for 380I vs thermoplastic, and 1:1.50 for 820 vs 380I. Nevertheless, the older drivers did not seem to perceive any difference. This seeming insensitivity to the different levels of retroreflectivity may be either the result of low contrast sensitivity of the subjects, a visual deficit related to normal aging or a result of low contrast ratio between the lane markers and the pavement (Staplin, L., Lococo, K., Byington, S., and Harkey, D., 2001) have said in that regard: "The human visual system is less sensitive to contrast as the ambient light level decreases and the human visual system is less sensitive to contrast as a consequence of normal aging … This means that the contrast of critical safety targets such as lane contrast and road boundaries must be maintained at higher levels to accommodate the needs of older drivers, especially at night" (pp. 75-76). While the contrast sensitivity of drivers in this sample is not known; data on the retroreflectivity of the pavement immediately adjacent to the various lane markers was collected to determine the contrast ratio for the different treatments.

Luminance Contrast of Lane Markers

Staplin, L., Lococo, K., Byington, S., and Harkey, D. (2001) in their "Guidelines And Recommendations To Accommodate Older Drivers And Pedestrians" have recommended minimum in-service contrast levels for pavement markings under various demands. These contrast levels vary according to the ambient light level such that the requirements tend to decrease with ambient lighting. While not specifically addressing stripes, they have recommended minimum in-service contrast for white edgelines on horizontal curves to be 5 where there is no median separation and 3.75 where the median can block the drivers' eyes from oncoming vehicles' headlights.

The luminance contrast levels recorded for the different treatments evaluated far exceed those recommended for edgelines on horizontal curves for everyone of the treatments (see Table C-7). Furthermore, as stated earlier, these roads were well lit, a condition commented about by the participants. These high luminance contrast levels can be explained by the fact that the road sections used for this evaluation were part of a ten mile section of the Florida Turnpike that had been restriped and resurfaced at the same time the treatments to be evaluated were installed.

Table C-7

Contrast Ratio of Lane Markers It is

Lane Marker Type	Reflectivity of Stripes (in mcd/lx/m^2)	Reflectivity of Pavement (in mcd/lx/m^2)	Luminance Contrast
380I Series	500	4	124
Thermoplastic	280	4	69
820 Series	750	5	149
380I Series	480	4	119
Thermoplastic	270	4	66.5
820 Series	650	4	161.5

Conclusion

The evaluation of the 380I, 820, and thermoplastic lane markers showed that these applications were all considered very visible by a group of older persons. Furthermore, the elderly participants did not detect any difference in the comparative visibility of the lane markers. This was likely due to the relative newness of the lane markers, as well as the good lighting conditions on the roadway. These conditions are similar to those one would find following resurfacing and restriping. These results support comments made by participants in the focus group held during Task 1 that the most important factor for older drivers at night regarding lane markings is that they be well maintained.

The results have not shown any advantage in the visibility of the 380I and 820 series over the Thermoplastic treatments evaluated. However, this does not imply that they are inherently equivalent to one another. Since this study did not include young participants as raters of the lane markers, while a possible contributor, one cannot attribute the failure of the elderly participants to detect differences among the lane markers to age-related reduction in contrast sensitivity. Rather, it could be that greater differences in luminance contrast among the treatments would be required for young or old driver to see and report a difference.

The benefits of the 3M products tested for a particular jurisdiction would depend on a cost benefit analysis that would include among its elements not only the cost (e.g., per linear foot) of the various products, their durability, visibility under various conditions, but also such variables as the reduction in crashes or other loss of life, injury attributable to the application (Deacon, 1988).

Important Considerations

A study by the Texas Transportation Institute (TTI) (Gates, 2001) investigating the loss in reflectivity of certain pavement markings over time according to the thickness of the application found that lane markers of standard thickness lost their reflectivity at a an average daily rate of .9 mcd for their first seventy days of service while thicker applications only suffered an average daily loss of .4mcd. While many factors affect the rate of loss in retroflectivity, it is evident that, under comparable conditions, for the same thickness and at the same rate of loss of reflectivity, both the 380I and the 820 would retain their reflectivity much longer. This would have important implications for these or other lane marking treatments over time. Given the graying of our population and the projected increase in the old old (85+), a trend that will have great impact on Florida, it would be critical to determine at what point these lane markers fail to provide positive guidance for the older driver. A starting point would be retesting these identical treatments after 12 months. Such an approach may help redefine “in-service” life of lane markers and would benefit all drivers.

Task 3: Potential Use of Simulation in the Evaluation of Traffic Control Devices

Simulation in Research

The use of simulation in transportation/driving has existed for a long time but has really been more widely used with the advent of the personal computer (Wachtel, 1993). Simulators have been used in human factors research to investigate various driving safety issues, especially in the assessment of driver performance (i.e., driver judgment) under a variety of conditions. Examples of the variety of of uses of simulators include: testing the safety implications of sleep deprivation of commercial truck drivers (Ranney, Simmons, Boulos, and Macchi (1999)), investigating the impact of the format of changeable message signs and traffic conditions on driver' performance (Guerrier, Wachtel, and Budenz, 2002), the benefits of medication and influence of attention deficit disorder on driving (Cox DJ, Merkel, RL, Hill RJ, Kovatchev BP, Seward, R (2000)). These are but a handful in a multitude of studies in this arena.

Simulation in Assessment of Traffic Control Devices

Simulation offers many advantages among which experimental control over the environmental, very precise data collection regarding behaviors prior to, during, and following critical events, and the possibility of evaluating drivers under very rigorous conditions which, on the road, might result in injury or death (Nilsson, 1993). These very advantages, are also appealing in considering the use of simulation in the assessment of traffic control devices (TCD). The ability to simulate specific traffic control devices potentially offers the advantage of savings in determining the effectiveness of materials, signage, and designs without the associated costs of purchasing and installing materials that may prove unsatisfactory. Furthermore, as stated earlier, simulation may shield workzone workers from exposure to injury or death while involve in the installation and maintenance of such products.

Simulation has also been used to test traffic control devices. Alicandri and Walker (1993) tested the effectiveness of two versions of a construction and maintenance flagger sign using simulation. Likewise, simulation has been used to evaluate different pavement marking treatments (Pietrucha, Hostetter, Staplin, and Obermeyer, 1996), drivers' responses to different implementations of retroreflective raised pavement markers (Bartelme, Watson, Dingus, and Stoner, 1995), as well as drivers' behaviors in response to simulated traffic signals of different luminous intensities (Bullough, Boyce, Bierman, Conway, Huang, O'Rourke, Hunter, and Nakata (2000). It is evident based on these studies that simulation does indeed have a place in the evaluation of traffic conrol devices; however, in this endeavor, all simulators are not equal. It will be noted that most of the studies cited in the evaluation of TCDs have been carried out relatively recently. This has been made possible by advances in computer technology including processing speed and graphics. These have resulted in a wide range of technologies available for conducting research and evaluation and have generated some confusion in identifying which technologies are appropriate for specific applications.

Which Simulators Are Appropriate for the Job

Simulators vary in cost, and, relatedly in fidelity. The issue of fidelity has been and continues to be debated in simulation. Suffice it to say that while, most often desirable in simulation, fidelity is not always necessary to establish the validity of an evaluation. Nevertheless, results obtained using high fidelity simulation have a higher likelihood of acceptance. Simulators can also be categorized as part-task, meaning that they represent one task or a very narrow set of tasks. These are often non-interactive, that is to say they do not respond to ranges of driver inputs. There are also full-task simulators which represent the broad range of driving and are also interactive. Since a substantive amount of input in driving is visual, another important aspect of simulation is image resolution. The latter has improved extensively and has, thereby broadened the use and usefulness of simulators. While most researchers might wish to have the highest fidelity simulator possible, limitations in budget are a sobering influencing in helping those considering using simulation to define their needs prior to using the technology.

Relevant to the use of simulation for the evaluation of TCDs are the following issues:

- What are the critical characteristics of the TCD that need to be represented?
  - These could include shape, size, reflectivity, and texture of these TCDs. This is very important since there are wide ranges of display technologies, display resolution, and graphics speed that will affect the rendition of these characteristics. High resolution is generally a must where visual components play such a large role. Graphics speed becomes extremely important with moving images. Again, great strides in the computer industry make both these components accessible at a lower cost than was the case previously.

- What are appropriate behaviors expected of the driver upon encountering the TCD.
  - Since TCD are designed for specific purposes (e.g., positive guidance), it is important to determine beforehand the behavior or range of behaviors that would be considered appropriate in order to select simulation technology that will allow measurement of these behaviors. For instance, if the FDOT wanted to evaluate offset left turn lanes through simulation, one could do so using part-task simulation or fully interactive simulation. However, in the case of the interactive simulator, depending of its type), the only behaviors that might be expected are qualitative data/subjective reports (e.g., how well drivers see oncoming traffic), whereas in the case of an interactive simulator, one might not only be able to gather qualitative data but objective data as well (e.g., gap selection).

- Under what conditions do these TCDs need to be evaluated?
  - These can include weather condition, time of day (ambient light), road characteristics (e.g., vertical, horizontal curves), static vs. dynamic conditions (i.e., moving vs. stationary on road), speed.

- Whose behaviors, relative to these TCDs, need to be evaluated?
  - These include age of persons, demographic characteristics, language mastery, perceptual sensory skills.

- What are available simulation technologies that can address the problem?
  - This involves: a) closely examining the claims of simulation technologies in addressing the issue at hand, b) ease of programming, c) method used

to generate/represent the TCD being considered for evaluation, d) capability for electronic data collection, e) range of data elements that can be collected.

This latter consideration has implications for the validity of the evaluation.

- How much can I afford?
    - One's budget is evidently a major factor in determining what type of simulation technology to acquire; however, while budget is the limiting factor, the rapid evolution in computer technology places several systems at one's disposal. Consequently, a judicious choice will be informed by the preceding questions.

Relevant Characteristics of TCD for Evaluation
It is evident that the first set of issues to be considered, namely the critical characteristics of the TCD (e.g., reflectivity, size, shape) are mostly dependent on resolution. For instance, in both the Pietrucha et al. (1996) and the Bartelme et al (1995) studies, the simulators use very high resolution. While the former used film (35mm cinematic projector) projected onto a large screen, the latter used computer generated images derived by an Evans and Sutherland Image Generator (ESIG) 2000. The visual database was described as consisting of " over 500,000 polygonal surfaces, and may use 256 color pairs for color blending of polygon surfaces and 128 unique texture maps" (p. 26). The advances in computer technology make high resolution computer generated images more accessible at a lower cost than was the case a few years ago.

Conditions For Evaluation
As was the case for the first set of issues, resolution in the simulation of the elements to be evaluated is very important. Furthermore, the algorithms used for representing these conditions (e.g., rain, snow, rate of approach to TCD) must be close to the experience of these elements in the real world to be of value in the evaluation. For instance, how does a simulated specific rate of rainfall affect visibility/reflectivity of a TCD compared to the same phenomenon in the real world. As importantly is whether static as opposed to dynamic evaluation of a TCD (e.g., using slides vs video, moving image) will suffice to obtain valid evaluations of specific components of a TCD. Research by Zakowska (1999) has shown, for instance, that the evaluation of perception of curves is more sensitive assessed using dynamic simulation (i.e., filming of the road). This has implications for the evaluation of any type of TCD that may have relevance to road curvature (e.g., edgelines, signage in curves).

Target Group For Evaluation
Since all TCDs are by their very nature designed to relay information to the driver, the relevant characteristics of this driver that impact the perception, comprehension, and reaction to these TCDs are important in determining the method of simulation and limitations of the technology. Among the relevant characteristics of the driver that are to be considered are: a) perceptual sensory skills. These include: a) how well the driver sees or hears (e.g., tactile or olfactory senses do not play a big role). These abilities have implications for the type of technology used. For instance, if one's target group consists of older persons, using a simulator with PC/type monitor displays might

cause glare, moreover, the size of the screen or objects displayed may make it difficult to recognize objects. Another issue is that of simulator sickness which is more prevalent in older persons than young persons, and in women more than men (Casali, 1985). These latter concerns, for instance, would call for large screen displays and an implementation of the simulator scenarios that use short scenarios (e.g., method for reducing simulator sickness). Other characteristics to be taken into consideration are the individual's education level or language mastery. This is particularly important for Florida which has a large number of immigrants who may not be proficient in English.

Simulator Survey

Based on the literature reviewed we are confident that existing simulation technology can permit the evaluation of various aspects of traffic control devices. Nevertheless, the range of TCDs that can potentially be evaluated using simulation as well as the breadth in the available simulation technology that can facilitate conduct of such evaluation is beyond the scope of this report. However, in order to gauge which simulators, currently available, could be considered as potential tools for such tasks. A survey of various research laboratories and simulator developers was conducted to identify the types of simulators currently available, their price range, and capability in evaluation of traffic devices (see Appendix C-1 for questionnaire). While the survey questionnaire was sent to 21 institutions, only seven were returned (see Appendix C-5 for list of institutions). Their responses have been summarized in Table C-8 (see Appendix C-6 for detailed responses and other materials). It should be noted that we have not evaluated any of the simulators reported below. Therefore, the responses given, are to be evaluated critically. The respondents to the survey, though among some of the most prominent institutions in the area, are but a few of the laboratories that use/develop simulation. However, their responses present a vignette of the capabilities that currently exist.

Finally, one should note that simulation is not a panacea. It is a tool for understanding complex problems by representing at various levels important components of the real world. Consequently, the use of simulation in the evaluation of TCDs has the potential for testing driver judgment and specific designs economically and safely. The current state of simulation in roadway design/evaluation does not yield a one to one relationship with the real world. Therefore, results obtained from simulation, while helpful as decision aids, are not necessarily definitive. They permit engineers and policy makers to identify variables or issues that may not have been considered and consequently allow a refinement of designs to be carried out in the field.

Table C-8

Summary of Responses of Companies Seven Simulation

Company	Responding / Contacted Person	Contacts	1	2	3	4	5	6			7	
			How many types		Price	Classification	Brief Description	Applications				
					A=Below $5,000 B=$5,000~$10,000 C=$10,000~$15,000 D=$15,000~$20,000 E=$20,000~$25,000 F=$25,000~$30,000 G=$30,000~$35,000 H=$35,000~$40,000 I=$40,000~$45,000 J=$45,000~$50,000	A=Low-end B=Mid-range C=High-end	A=Part-task driving simulator B=Interactive driving simulator C=Other	a engineering	b research	c training	a Fixed-base	b motion base
Paramics	Ewan Speirs	paramics-info@quadstone.com		Paramics is an advanced suite of software tools for microscopic trafiic simulation. Modeller provides the three fundamental operations of model build, traffic simulation (with 3-D visualisation) and statistical output accessible through a powerful and intuitive graphical user interphase. everyaspect of the transpotation network can be investigated in Modeller including: * Mixed urban and freeway networks * Right-hand and left-hand drive capabilities * Advanced signal control * Roundabouts * Public transportation *Car parking * Incidents * Truck-lanes, high occupancy vehicle lanes. Bu modelling individual vehicles Modeller provides the transportation professional with insight into and better understanding of many hundreds of network issues, resulting in a more efficient and effective approach to projects.	B=$5,000~$10,000	C=High-end	C= Other. A micro scopic traffic flow/behavior simulator	Yes	Yes	No	No	No
UCF	Dr. Essam Radwan	aeradwan@mail.ucf.edu	Simulator #1	Fixed base simulator. Home built system. The Image Generator is an SGI multi processor. A 140-degree wrap around screen. 3 Channels. Home developed smart traffic and scenario generation. Visual database created with Multigen.	Too old to estimate	C=High-end	B=Interactive driving simulator	Yes	Yes	Yes	Yes	No
			Simulator #2	Built by GE Capitol I-Sim. Motion base 6 DF with five channels. Interchangeable cab with a truck and passenger car. PC base IG system. Flat panel front screens. Pre-developed scenario generation system developed by GE Capitol I-Sim.	$400,000	C=High-end	B=Interactive driving simulator	Yes	Yes	Yes	No	Yes
Helsinki University of Technology	Iisakki Kosonen	iisakki.kosonen@hut.fi	HUTSIM	HUTSIM is a high=fidelity micro-scopic simulator for urban traffic. It is based on object-oriented modeling and rule-based dynamics.	A=Below $5,000		C= Other. Urban traffic simulator. (Not a driving simulator at all).	No	Yes	No		
GE Capital I-Sim	Fred Craft	Phone: 1.801.303.5670 Fax: 1.801.983.9922 E-Mail: Frederick.Craft@gecapital.com	TranSim	TranSim simulator is a part-task trainer for shifting	J	A=Low-end	A=Part-task driving simulator B=Interactive driving simulator	Yes		Yes	Yes	
			TranSim VS	TranSim VS adds to TranSim a visual system and steering with control force loading	$80,000	B=Mid-range	A=Part-task driving simulator B=Interactive driving simulator	Yes	Yes	Yes	Yes	

Table 8

Summary of Responses of Seven Simulation Companies (Continued)

Company	Responding / Contacted Person	Contacts	1	2	3	4	5	6			7	
			How many types		**Price**	**Classification**	**Brief Description**	**Applications**				
					A=Below $5,000 B=$5,000~$10,000 C=$10,000~$15,000 D=$15,000~$20,000 E=$20,000~$25,000 F=$25,000~$30,000 G=$30,000~$35,000 H=$35,000~$40,000 I=$40,000~$45,000 J=$45,000~$50,000	**A=Low-end B=Mid-range C=High-end**	**A=Part-task driving simulator B=Interactive driving simulator C=Other**	**a engineering**	**b research**	**c training**	**a Fixed-base**	**b motion base**
GE Capital I-Sim	Fred Craft	Phone: 1.801.303.5670 Fax: 1.801.983.9922 E-Mail: Frederick.Craft@gecapital.com	PatrolSim	PatrolSim simulator and variants (car applications) - a fixed base, three-channel visual system with rear view mirror insets; and with a fully intrumented cockpit and law enforcement console	$90,000	B=Mid-range	A=Part-task driving simulator B=Interactive driving simulator	Yes	Yes	Yes	Yes	
			Century Mark II Series	Century Mark II Series is a full motion based, full visual system simulator that can be offered with truck, car and specialty vehicle cabs	$390,000	C=High-end	A=Part-task driving simulator B=Interactive driving simulator	Yes	Yes	Yes	Yes	Yes
CERI of Hokkaido	Motok Asano	m-asano@ceri.go.jp	1	A fixed simulator equipped with computer image generator, central processing unit, car cabin and a database development device	>$75,000	A=Low-end	B=Interactive driving simulator		Yes		Yes	
U. of Michigan	Paul Allan Green	pagreen@umich.edu	http://www.umich.edu/~driving/sim.html	UMTRI Driver Interface Research	>100K	A=Low-end	B=Interactive driving simulator	No	Yes	No	Yes	
				KQ Corp (formerly Hyperion) Vection driving simulator	$130K for hardware and software, much more for building mods, etc.	B=Mid-range	B=Interactive driving simulator	No	Yes	No	Yes	
Systems Technology, INC	Bimal Aponso	Phone: (310) 679-2281 Ext. 61 Email: bimal@systemstech.com	Model 100 - Game Control Interface	Interactive driving simulator with a single driving display and 45 degree driver field-of-view, commercial game-type driving controls and STISIM Drive simulation software	$13000 (Complete System) $5,250 (Self-Installation)		B=Interactive driving simulator	Yes	Yes	Yes	Yes	Yes
			Model 200 - Analog Control Interface with Spring Centered Sttering	Interactive driving simulator with a single driving display and 45 degree driver field-of-view, robust full-size driving controls with analog sensors, and STISIM Drive simulation software	$19,500		B=Interactive driving simulator	Yes	Yes	Yes	Yes	Yes
			Model 300 - Digital Control Interface with Active Steering	Interactive driving simulator with a single driving display and 45 degree driver field-of-view, robust full-size driving controls with high resolution digital sensors and speed-sensitive steering feel, and STISIM Drive simulation software	$33,500		B=Interactive driving simulator	Yes	Yes	Yes	Yes	Yes
			Model 400 - Wide Field-of-View System with Active Steering	Interactive driving simulator with a single driving display and 135 degree driver field-of-view, robust full-size driving controls with high resolution digital sensors and speed-sensitive steering feel, and STISIM Drive simulation software	$50,500		B=Interactive driving simulator	Yes	Yes	Yes	Yes	Yes
			Model 500- Comprehensive Vehicle Dynamics Model with Active Sttering; Model 500W - Wide Field-of-View with Comprehensive Vehicle Dynamics Model and Active Sttering	Interactive driving simulator with a single driving display and 45(Model 500) / 135(Model 500W) degree driver field-of-view, robust full-size driving controls with high resolution digital sensors and speed-sensitive steering feel, and STISIM Drive simulation software with the VDANL Drive comprehensive nonlinear vehicle and tire dynamics model	$43,500 (Model 500) $64,500 (Model 500W)		B=Interactive driving simulator	Yes	Yes	Yes	Yes	Yes

Table 8

Summary of Responses of Seven Simulation Companies (Continued)

Company	8				9		10	11	12			
	How are scenarios generated / programmed				How are scenarios displayed		Video resolution	Width of view (in degrees)	Vehicles types modeled	Dynamic models		
	a Fixed	b Specific modules for combination	c Open architecture: capability for representing any road environment / geometry	d Other	A=PC Monitors B=Forward projection screen C=Back projection	How many?				Parametrically driven	FHWA by Systems Technology	Clarus Drive from Prosolvia
Paramics			Yes		A		N/A	N/A	All			
UCF			Yes		B		1024x768	140	Passenger vehicles		Yes	Yes
			Yes	Use scenario editor	B		800x600	220	Trucks pulling trailers (automatic and stick shift), passenger cars, buses (transit, school), emergence vehicles…etc.			
Helsinki University of Technology			Yes				480x640		HUTSIM is based on rule-based vehicle dynamics. 10 vehicle types are included			
GE Capital I-Sim			No		N/A			30	Originally developed by Eaton Corporation has virtually any drive train for trucks in the U.S.			
			Yes		A	1 forward, with rear view insets	640x480 1240x780	60	cars, jeeps, HMMWV, trucks and several types of specialty vehicles. Adding additional vehicle types is easy given the availability of manufactureres' (or otherwise collected) data about the vehicle	Yes		

Table 8

Summary of Responses of Seven Simulation Companies (Continued)

Company	8				9		10	11	12			
	How are scenarios generated / programmed				How are scenarios displayed		Video resolution	Width of view (in degrees)	Vehicles types modeled	Dynamic models		
	a Fixed	b Specific modules for combination	c Open architecture: capability for representing any road environment / geometry	d Other	A=PC Monitors B=Forward projection screen C=Back projection	How many?				Parametrically driven	FHWA by Systems Technology	Clarus Drive from Prosolvia
GE Capital I-Sim			Yes		A	3 forward with rear view insets	640x480 1240x781	180	cars, jeeps, HMMWV, trucks and several types of specialty vehicles. Adding additional vehicle types is easy given the availability of manufactureres' (or otherwise collected) data about the vehicle	Yes		
			Yes		B	3 with LCD panels for side / rearview mirrors (additional visual channels for each)	640x480 1240x782	180 + rear / side mirrors	cars, jeeps, HMMWV, trucks and several types of specialty vehicles. Adding additional vehicle types is easy given the availability of manufactureres' (or otherwise collected) data about the vehicle	Yes		
CERI of Hokkaido			Yes		B		1024x1000	40	Passenger car type			
U. of Michigan				some b, some c, can only simulate 2 lane curving roads, but can have any types of buildings or traffic (which is scriptable)	B		640x480	30	our own creation, we mostly do cars			
			Yes		B, C	3B 1C	1024x?	120	vender created for cars			
Systems Technology, INC			Yes		A	2 (driving and operator's display)	1280x1024	45	Virtually any vehicle including passenger vehicles, single unit and articulated trucks and busses, there're more than 50 vehicle models			
			Yes		A	2 (driving and operator's display)		45				
			Yes		A	2 (driving and operator's display)		45				
			Yes		A	2 (driving and operator's display)		135				
			Yes		A	2 (driving and operator's display)		45 (Model 500) 135 (Model 500W)				

Table 8

Summary of Responses of Seven Simulation Companies (Continued)

Company	12							13	14	15	16	17	18
	Dynamic models							Specific designs / geometrics	Type of road designs / geometrics	Limitations on specific geometrics	Application on TCD	TCD types	Limitation on TCD
	Truck pulling vehicles	Following	Lane Changing	Gradient	Curvature	Modes of Acceleration	Behavioral influences						
Paramics		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Any	Lane based traffic flow theory must be adhered to	Yes	Any	No limitations
UCF								Yes	Two-lane roads, signalized streets, freeways and urban/suburban streets	IG polygon rendering, Multigen Road Tools cannot be used for intersections. (Visibility of traffic control devices)???	Yes	Signs, markings, traffic signals, and work zones	Resolution of traffic signs and being able to read that in advance
	Yes							Yes	Two-lane roads, signalized streets, freeways and urban/suburban streets	IG polygon rendering, Multigen Road Tools cannot be used for intersections. (Visibility of traffic control devices)???	Yes	Signs, markings, traffic signals, and work zones	Resolution of traffic signs and being able to read that in advance
Helsinki University of Technology								Yes	Lower speed at corners, the effect of vertical alignment for heavy vehicles		Yes	Lane markings, yield and stop signs, lane signals, speed limit signs. Traffic signals:fixed time, vehicle actuated, isolated, coordinated	
GE Capital I-Sim								No	any and all	None	No	All	No limitations
								Yes	any and all	None	Yes	All	No limitations

Table 8

Summary of Responses of Seven Simulation Companies (Continued)

Company	12							13	14	15	16	17	18
	Dynamic models							Specific designs / geometrics	Type of road designs / geometrics	Limitations on specific geometrics	Application on TCD	TCD types	Limitation on TCD
	Truck pulling vehicles	Following	Lane Changing	Gradient	Curvature	Modes of Acceleration	Behavioral influences						
GE Capital I-Sim								Yes	any and all	None	Yes	All	No limitations
								Yes	any and all	None	Yes	All	No limitations
CERI of Hokkaido								Yes	Urban road, Rural road, Expressway	Number of polygons (max 300 polygons)	Yes	Depends on design of polygons. For example, traffic sign, lane marking.	Number of polygons
U. of Michigan								Yes	curves and lane width	only 2 lane curving roads	No		
								Yes	2 lane roads, 4 lane roads, wide range of intersection types and expressway entrances / exits	cannot specify curve radius except from list	Yes	signs, lights of all types	no changeable message signs yet
Systems Technology, INC								Yes	Horizontal and vertical curvature and cross section are arbitrary and can be specified based on roadway design programs such as GeoPac and Inroads	As a practical matter, there are no limitations	Yes	Signs, Signals and Markings, Construction Zone delineation	Limitation have to do with display device selected (monitor, projector, etc.) Special display insets have been used to get higher sign resolution and brightness / contrast.
								Yes			Yes	Signs, Signals and Markings, Construction Zone delineation	
								Yes			Yes	Signs, Signals and Markings, Construction Zone delineation	
								Yes			Yes	Signs, Signals and Markings, Construction Zone delineation	
								Yes			Yes	Signs, Signals and Markings, Construction Zone delineation	

Table 8

Summary of Responses of Seven Simulation Companies (Continued)

Company	19	20	21	22	23
	Best characteristics	**Least characteristics**	**% of simulator sickness**	**Publication**	**Extra information**
Paramics	Easy to use, Flexibility, Extendibility, Customization, Graphics, Speed, Power, Scalability, High level of detail	Dependence on X-Server / X-Windows / Motif technologies	N/A	http://www.paramics-online.com/tech_support/reports.htm	http://www.paramics-online.com
UCF	Testing different stimulus on drivers' reaction in a systematic way including weather changes, light and dark, and different road surfaces	The ability to show objects in high recolution from a distance	N/A	http://www.catss.ucf.edu	
	Testing different stimulus on drivers' reaction in a systematic way including weather changes, light and dark, and different road surfaces	The ability to show objects in high recolution from a distance	N/A	http://www.catss.ucf.edu	
Helsinki University of Technology	It is good for detailed traffic and control planning	It is not very fast and not for large networks			HUTSIM models also the intersection areas and pedestrian traffic in full detail. These features make HUTSIM ideal in combining it with a driving simulator.
GE Capital I-Sim	Fidelity of the system, flexibility of applications. The software characteristics of the system have the oldest heritage of any commercially available driving simulator, and has evolved since the development of the Daimler-Benz research simulator in the late 1980s. the software is arguably the most sophisticated / proven in the industry.	That is very subjective, depending on use. To our knowledge, our product lines are the most successful for their intended function.	With proper screening of subjects, excluding those who have head colds, wear tri-focals, poor attitudinal disposition and with proper work-up in use of the simulators (I.e. allowing time for adaptiation) we have minimal to no debilitating / nauseating occurrences of simulator adaptation syndrome.	By Dr. Richard Grace at Carnegie-Mellon Research Institute for the FHA. Recently, the psychology department at the U. of Utah has purchased one for their research needs.	Nothing other than the findelity of the simulation and the flexibility and breadth of our simulator line in their capabilities. In general, simulators have shown their usefulness in several efforts around the world. At the driving Simulation conference '97 held in France, there was a paper that were presented that might be applicable. I do not know if the following information is current / valid, but fromthe proceedings: Visualization of Road designs for Assessing Human Factors Aspects in a Driving Simulator TNO Human Factors Research Institute, The Netherlands Wytze Hoekstra e-mail: Hoekstra@tm.tno.nl Also, I know that the U. of Leeds had a Dr. Evi Blana who did her doctoral dissertation there on the use of their simulator in validating the design of a highway toll booth. If I can be of further assistance, please do not hesitate to contact me
			With proper screening of subjects, excluding those who have head colds, wear tri-focals, poor attitudinal disposition and with proper work-up in use of the simulators (I.e. allowing time for adaptiation) we have minimal to no debilitating / nauseating occurrences of simulator adaptation syndrome.		

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			With proper screening of subjects, excluding those who have head colds, wear tri-focals, poor attitudinal disposition and with proper work-up in use of the simulators (I.e. allowing time for adaptiation) we have minimal to no debilitating / nauseating occurrences of simulator adaptation syndrome.		
CERI of Hokkaido	Changeability of road design.	Cost of road design database making and limitation of number of polygons	30%	More than thirty papers	Calculating speed, memory volume, simplicity of road design database and cost performance would be essential.
U. of Michigan	easy to use, flexibility, reliability	limited road types	<5%	more than 20	
	wide range of road tiles, scriptable traffic	cost, cannot fully specify road geometry	N/A yet	N/A yet	
Systems Technology, INC	Scenario programmability, transportability	Keeping up with PC technology (e.g. new mother boards every six months or less, causes configuration problems)	5%		PC based, can include a variety of display devices, consoles, cabs and motion bases depending on desired application. Software and display card kit starts at $5,000. Full simulator with console or cab (fix base) about $65,000. With motionbase on the order of $150,000~200,000. 180 degree field of view is provided and could be more with additional display generators. Very flexible in adding TCDs. A relatively complete set of US and European road signs is also available. Easy to add new signs.
	Scenario programmability, transportability	Keeping up with PC technology (e.g. new mother boards every six months or less, causes configuration problems)	5%		
	Scenario programmability, transportability	Keeping up with PC technology (e.g. new mother boards every six months or less, causes configuration problems)	5%		
	Scenario programmability, transportability	Keeping up with PC technology (e.g. new mother boards every six months or less, causes configuration problems)	15%		
	Scenario programmability, transportability	Keeping up with PC technology (e.g. new mother boards every six months or less, causes configuration problems)	5% (Model 500) 15% (Model 500W)		

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Appendix A-1

Overhead and Advance Street Name Signs Evaluated and Letter Sizes

Letter Sizes and Series for Overhead and Advance Street Name Signs
Based on Estimates by Subject Matter Expert

1. NE 2nd Av Overhead

Series C
8" - NE, AV
10" - 2

2. NW 2nd Av Advanced

Series C
8" – NW, AV
10" – 2
5-6" – next signal

3. NW 2nd Av Overhead

Series D or E
8" – NW, AV
12" - 2

4. NW 17th Av Advanced

Series C
10" – NW, AV
12" – 17
5-6" – next signal

5. NW 17th Av Overhead

Series C
8" - NW, AV
10" - 17

6. NW 27th Av Advanced

Series C
8" – NW, AV, Unity Blvd
10" – 27
6" – next signal

Letter Sizes and Series for Overhead and Advance Street Name Signs (Continued)

7. NW 27th Av Overhead

Series C
6" – NW, AV
8" – 27, Unity Blvd

8. NW 215th Street Advanced

Series D
8" – NW, AV
10" – 215
6" – next signal

Series C
8" – County Line Road

9. Johnson Street Advanced

Series C
8" – Johnson Street
4" – next signal

10. Johnson Street Overhead

Series C
8" – Johnson Street

11. Taft Street Advanced

Missing

12. Taft Street Overhead

Missing

13. Douglas Road Advanced

Series D
8" – Douglas Road
6" – next signal

Letter Sizes and Series for Overhead and Advance Street Name Signs (Continued)

14. Douglas Road Overhead

Series C
8" – Douglas Road
4" – NW 89 Ave

15. NW 86th Av Advanced

Series E (Lower and Uppercase)
6" – NW 86th Av, Next Signal

16. NW 86th Av Overhead

Series C
8" – NW, AV
10" - 86

17. NW 83rd Av Advanced

Series D
6" – NW, Ave

Series E
6" – 83, next signal

18. NW 83rd Av Overhead

Series C
8" – NW, AV
10" - 83

19. University Drive Advanced

Series D
6" – University Drive

Series E
6" – next signal

Letter Sizes and Series for Overhead and Advance Street Name Signs (Continued)

20. University Drive Overhead

Series C
10" – University
8" - Drive

21. McArthur Parkway Advanced

Series D
6" – McArthur Parkway

Series E
8" – next signal

22. McArthur Parkway Overhead
Series C
12" – Mc Arthur
10" - Parkway

23. NW 68^{th} Av Advanced

Series C
8" – 68
6" – NW, AV, next signal

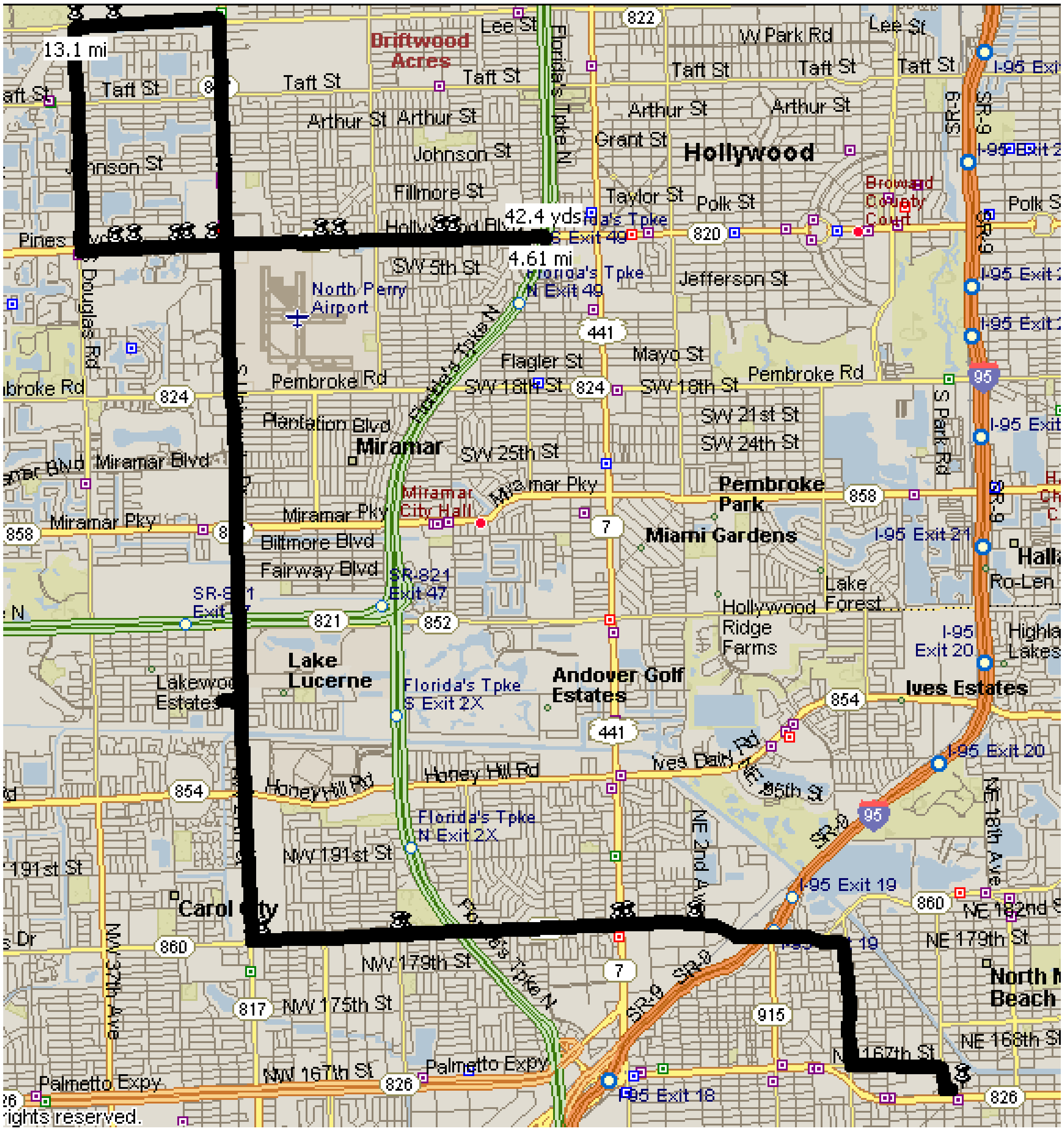
24. NW 68^{th} Av Overhead

Series C
10" – 68
8" – NW, AV

Appendix A-2

Maps of Road Courses Used for Evaluation of
Traffic Control Devices in the Daytime and At Night

Road Course for Assessment of Existing TCD



Road Course for Assessment of Lane Markers and Raised Pavement Markers (RPM) at Night

Appendix A-3

Consent Form
And
Driving Habits Questionnaire

DRIVING QUESTIONNAIRE

Date____/____/____

Name ___________________________________ Date of Birth______/______/______

Height ______Ft______ inch(es) Sex: Male:____ Female:____

Visual Acuity: Snellen: Right___/___ Left___/___

Driver's License #:____________________________________ Restrictions: ____________________

1) Do you currently own a car?

Yes_____ No_____

2) How long have you been driving? _________ Years

3) How long have you had a driver's license? _________ Years

4) Please circle the number that best represents the number of days per week you drive:

1 2 3 4 5 6 7

5) On average, how many miles do you drive per day, roundtrip?

________________ miles

6) List the activities you perform most often with your car. (Rank these activities by order of frequency, from most frequent to least frequent).

____
____
____
____
____
____
____
____
____
____

7) At which time of the day do you usually do most of your driving?
(Please place a check mark by the appropriate response)

6-8AM____ 8-10AM____ 10AM-12Noon___ Noon-2PM___ 2-4PM___

4-6PM____ 6-8PM____ 8-10PM____ 10-12Mldnight____ Other___________

8) If you do not drive at night, what are your reasons for not driving? (Please check all the answers that apply).

Concern for personal safety ____
Inability to see well at night ____
Fear of getting lost ____
Other (Please explain briefly) ____
____
____
____
____

9) Do you have to wear glasses or contact lenses when you drive?
Yes ___ No ___

10) How would you describe your ability to see at night? (Place check mark by appropriate response)

Very good ___ Good ___ Average ___ Not Good ____ Can't see at night ____

11) Have you been involved in any car accidents in the last five years?
Yes ___ No ___

If yes, how many? ________ accidents

14) Have you received any tickets in the last five years?
Yes ___ No ___

If yes, how many? ________ tickets

16) Compared to most drivers on the road, do you consider yourself:

Better than average ____ Average ____ Worse than average ____

17) Compared to drivers in your age group, do you consider yourse1f

Better than average ____ Average ____ Worse than average ____

18) When you are driving, how often do other drivers blow their horn at you?

Never ___ Sometimes ___ Very often

19) How many times a week do drive on the expressway? _______ times per week

20) How anxious do you feel about driving on the expressway?

Very anxious ___ Somewhat anxious ____ Not anxious ____

21) Do you have any difficulties in seeing Street name signs? Yes ___No ___

22) Would you describe the size of letters on street signs as:

a) Large b) Adequate c) Somewhat small ____ Too small ____

23) When driving in the daytime, how often do you have any difficulties seeing lane markings? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

24) When driving at night, how often do you have any difficulties seeing lane markings? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

25) When driving in the rain, how often do you have any difficulties seeing lane markings? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

26) When driving in the daytime, how often do you have any difficulties seeing Reflectorized Pavement Markings? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

27) When driving at night, how often do you have any difficulties seeing Reflectorized Pavement Markings? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

28) When driving in the rain, how often do you have any difficulties seeing Reflectorized Pavement Markings? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

29) How often do you experience difficulties when making a left turn? (Please check the appropriate response)

Most of the time____ Often ____ Rarely ___ Never ____

30) When driving to an unfamiliar destination, how easy is it for you to find your way?
Very easy____ Easy ____ Difficult____ Very difficult ____

31) In the following section, is a table showing various health conditions. In the appropriate column please check "Yes" if you have this condition, or "No" if you don't. Also check in the appropriate column if this condition interferes with your driving.

32) What improvements on the road would make it easy for you to drive in the daytime? (Please list up to five improvements)

____
____
____
____
____
____

33) What improvements on the road would make it easy for you to drive at night? (Please list up to five improvements)

____
____
____
____
____

34) The following section, is a table showing various health conditions. In the appropriate column please check "Yes" if you have this condition, or "No" if you don't. Also check in the appropriate column if this condition interferes with your driving.

Health Condition	Yes	No	Does this condition interfere with your driving?			
			Never	Sometimes	Often	Always
Arthritis						
Heart Problem						
Hypertension						
Parkinson's						
Diabetes						
Limited Range in Neck Movement						
Limited Range in Hip Movement						
Seizures						
Blurry Vision						

Focus Group
FDOT Roadway Improvement Program

Good morning, I have met most of you already. My name is ______ and I thank you for having volunteered to participate in this focus group. In the early phase of this project, you drove through various roads day and night where we asked you to evaluate specific traffic control devices. This morning we are only going to concentrate on two of these devices because we need more details regarding your perception of them. We are going to discuss left turns and lane markings.

The exercise will be as follows: I will show you a video clip of the traffic control device and will ask you specific questions about it. Remember, there are no right or wrong answers, one opinion is as good as the other. We are interested in your sincere perceptions. This is the only way we can make recommendations on how to design these traffic control devices more effectively.

I - I will first show you a vehicle coming to a left turn. I want you to observe the position of your vehicle in the left turn very carefully. I also want you to observe the oncoming traffic to determine how well you see that traffic and how well and from how far you can judge the gaps in the traffic in the oncoming lane closest to you. I will then show you another left turn and would like you to observe it in the same manner as the previous one. Then, I will ask you to compare them. I will prompt you with some questions.

The tapes we are using are actual footage of a driver approaching the left turn. You may have to come close to the screen to see well. As soon as the vehicle stops in the left turn lane, I will ask you similar questions to those you were asked while driving.

A) After showing the two videos, ask the drivers if the videos were clear to them. (You may have to break the group into groups of five to ensure that they see the scree well) (Enter the number of persons who answer each category)

Very Clear ______ Clear_____ Not Clear _____ Other ________________

B) In which of the two left turns could you see the oncoming traffic more clearly? (Enter the number of persons who answer each category)

207________ 64th Ave__________

C) What characteristic of this left turn in your opinion allows you to see the traffic more clearly? (Show the two left turns again) (Enter most frequent reasons mentioned)

____
____
____
____

Roll the video of the two left turns again

D) At which of the two intersections can you tell the gaps between the oncoming vehicles better?

207________ 64th Ave____________

E) What characteristic of this left turn in your opinion allows you to see the gaps in the oncoming traffic more clearly? (Enter most frequent reasons mentioned)

F) At which of these left turns would you feel more comfortable?

207________ 64th Ave____________

G) Why?

H) Do you have any suggestions about ways left turns could be improved?

Now, I am going to show you some lane markings. I would like to ask you some questions about them.

Show video of 4" and 6" lane markings.

I) which of these lane markings appeared wider to you? (Record number who respond in each category)

4 inch ________ 6 inch ___________

J) When you drive, do you usually pay attention to the lane markings? (Record number who respond in each category)

Yes___________ No_________________

K) When you drive, do you notice the difference in the size of lane markings? (Record number who respond in each category)

Yes___________ No_________________

L) Are lane markings usually noticeable to you? (Record number who respond in each category)

Yes___________ No_________________

M) Do they mark well the lane you need to follow? (Record number who respond in each category)

Yes___________ No_________________

N) When do you usually have difficulties seeing lane markings?

____
____
____
____
____
____

O) Do you have any suggestions regarding how lane markings could be improved? (If you are not getting any answers)

Appendix A-4

Attention and Memory Tests
Administered

TRAIL MAKING TEST
ADMINISTRATION INSTRUCTIONS

DIRECTIONS:

Place the sample for Part A in front of the subject so that the bottom of the page is approximately six inches from the edge of the table. Say:

> **On this page (point) are some numbers. Begin at number 1 (point to 1) and draw a line from 1 to 2 (point to 2), 2 to 3 (point to 3), 3 to 4 (point to 4), and so on, in order until you reach the end (point to the circle marked 'END'). Draw the lines as fast as you can without lifting your pencil off the paper. Ready. Begin.**

If the subject completes the sample with no errors, say:

> **Good. Let's try the next one.**

If the subject makes a mistake on the sample, point out the error and explain it. If the subject cannot complete the sample, take his/her hand and guide the pencil using the eraser end through the trial. Then instruct him/her to try it again.

On the Sample, the following explanation of mistakes are acceptable:
1) You started with the wrong circle. This is where you start (Point to '1').
2) You skipped this circle (point to the one omitted). **You should got from number one** (point) **to two** (point)**, two to three** (point)**, and so on, until you reach the circle marked 'END'** (point)**.**
3) Please keep te pencil on the paper, and continue right on to the next circle.

When the sample is completed, place part A in front of the subject and say:

> **On this page are some numbers from I to 25. Do this the same way. Begin at number 1 (point to 1) and draw a line from 1 to 2 (point to 2), 2 to 3 (point to 3), 3 to 4 (point to 4), and so on, in order until you reach the end (point). Remember, work as fast as you can. Ready. Begin.**

If the subject makes an error after starting, DO NOT STOP TIMING. Point out the error immediately by saying:

> **You skipped a circle. Go back to this one (point to the point from which the mistake was made).**

Record time (in seconds) to complete and number of errors. If the subject corrects him/herself, do not count this as an error. When finished with Part A, proceed immediately to part B.

Time limit for Part A: **5 minutes**

DIRECTIONS (Continued):

Place the sample for Part B in front of the subject in the same position as the sheet for Part A and say,

> **On this page are some numbers and letters. Begin at number 1 (point) and draw a line from 1 to A (point), A to 2 (point to 2), 2 to B (point to B), B to 3 (point to 3), 3 to C (point to C), and so on in order until you reach the end (point to the circle marked 'END'). Remember, first you have a number (point to 1), then a letter (point to A), then a number (point to 2), then a letter (point to B), and so on. Draw the lines as fast as you can. Ready. Begin.**

If the subject makes a mistake on the sample, point it out immediately and explain it. Be sure the subject understands the number first, letter second format before proceeding to the test. If the subject cannot complete the sample correctly, take his/her hand and guide them through the sample using the eraser end and then ask them to do it on their own, repeating the instructions. On the Sample, the following explanations of mistakes are acceptable:

> **1) You started with the wrong circle. This is where you start** (Point to '1')**.**
> **2) You skipped this circle** (point to the one omitted)**. You should got from number one** (point) **to A** (point)**, A to two** (point), **two to B** (point), **B to three** (point), **and so on, until you reach the circle marked 'END'** (point).
> **3) You only went as far as this circle** (point). **You should have gone to the circle marked 'END'** (point).
> **4) Please keep the pencil on the paper, and continue right on to the next circle.**

If the subject completes the sample correctly, say,

> **Good. Let's try the next one.**

Proceed to Part B.

For Part B, say

> **On this page are both numbers and letters. Do this the same way. Begin at number 1 (point) and draw a line from 1 to A (point), A to 2 (point to 2), 2 to B (point to B), B to 3 (point to 3), 3 to C (point to C), and so on in order until you reach the end (point to the circle marked 'END'). Remember, first you have a number (point to 1), then a letter (point to A), then a number (point to 2), then a letter (point to B), and so on. Do not skip around, but go from one circle to the next in the proper order. Draw the lines as fast as you can. Ready. Begin.**

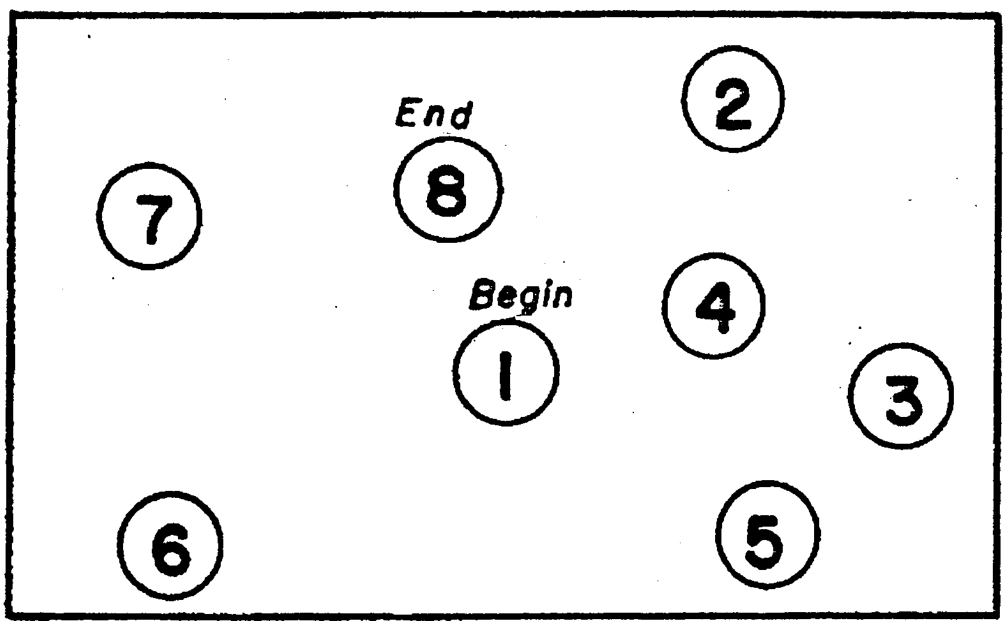
Start timing as soon as the subject is told to begin. If the subject makes a mistake, call it to attention immediately and have him/her proceed from the point the mistake occurred. DO NOT STOP TIMING. Record the time in seconds and number of errors.

Time limit for Part B: **8 minutes**

TRAIL MAKING

Part A

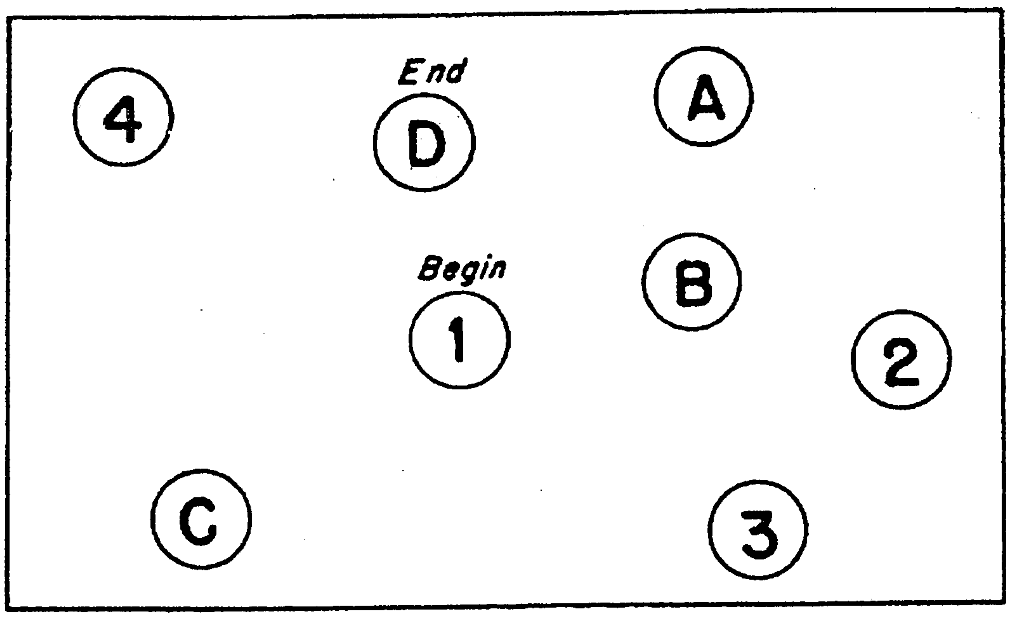
SAMPLE



TRAIL MAKING

Part B

SAMPLE



WAIS-R DIGIT SPAN
ADMINISTRATION INSTRUCTIONS

The two parts of Digit Span - Digits Forward and Digits Backward - are administered separately. Administer Digits backward even if the subject scores 0 on Digits Forward.

DIGITS FORWARD

DIRECTIONS

Start with Item 1. Say,

> **I am going to say some numbers. Listen carefully, and when I am through say them right after me.**

The digits should be given at the rate of one per second. Let the pitch of voice drop on the last digit of each trial. Administer *both* trials of each item, even if the subject passes Trial 1.

DISCONTINUE: After failure on *both* trials of any item.

SCORING: Each item is scored 2,1, or 0, as follows:

2 points if the subject passes both trials
1 point if the subject passes only one trial
0 points if the subject fails both trials

Maximum score on Digits Forward: 14 points

DIGITS BACKWARD

DIRECTIONS:

Start with Item 1. Say,

> **Now I am going to say some more numbers, but this time when I stop I want you to say them backwards. For example, if I say 7-1-9, what would you say?**

Pause for the subject to respond.

If the subject responds correctly (9-1 -7), say,

> **That's right,**

and proceed to Item 1. As with Digits Forward, read the digits at the rate of one per second and administer both trials of each item, even if the subject passes Trial 1.

DIRECTIONS (Continued):

However, if the subject fails the example, say,

> **No, you would say 9-1 -7. I said 7-1 -9, so to say it backwards you would say 9-1 -7. Now try these numbers. Remember, you are to say them backwards. 3-4-8.**

Whether the subject succeeds or fails with the second example (3-4-8), proceed to Item 1. Give no help on this second example or any of the items that follow.

DISCONTINUE: After failure on *both* trials of any item.

SCORING: Each item is scored 2,1, or 0, as follows:

2 points if the subject passes both trials
1 point if the subject passes only one trial
0 points if the subject fails both trails

Maximum score on digits backward: 14 points

Total score for Digit Span test: Sum of scores on Digits Forward and Digits Backward.

Maximum score: 28 points

WAIS-R DIGIT SPAN

Raw Score		**Scaled Score**		**Age-Corrected SS**	

DIGIT SPAN	Discontinue after failure on BOTH Trials of any item Administer BOTH TRIALS of each item, even when subject passes first trial

DIGITS FORWARD		Pass - Fail	Score 2, 1, 0
1.	5 – 8 – 2		
	6 – 9 – 4		
2.	6 – 4 – 3 – 9		
	7 – 2 – 8 – 6		
3.	4 – 2 – 7 – 3 – 1		
	7 – 5 – 8 – 3 – 6		
4	6 – 1 – 9 – 4 – 7 – 3		
	3 – 9 – 2 – 4 – 8 – 7		
5	5 – 9 – 1 – 7 – 4 – 2 – 8		
	4 – 1 – 7 – 9 – 3 – 8 – 6		
6	5 – 8 – 1 – 9 – 2 – 6 – 4 – 7		
	3 – 8 – 2 – 9 – 5 – 1 – 7 – 4		
7	2 – 7 – 5 – 8 – 6 – 2 – 5 – 8 – 4		
	7 – 1 – 3 – 9 – 4 – 2 – 5 – 6 – 8		
		Total Forward	Max=14

DIGITS BACKWARD*		Pass - Fail	Score 2, 1, 0
1.	2 – 4		
	5 – 8		
2.	6 – 2 – 9		
	4 – 1 – 5		
3.	3 – 2 – 7 – 9		
	4 – 9 – 6 – 8		
4.	1 – 5 – 2 – 8 – 6		
	6 – 1 – 8 – 4 – 3		
5.	5 – 3 – 9 – 4 – 1 – 8		
	7 – 2 – 4 – 8 – 5 – 6		
6.	8 – 1 – 2 – 9 – 3 – 6 – 5		
	4 – 7 – 3 – 9 – 1 – 2 – 8		
7.	9 – 4 – 3 – 7 – 6 – 2 – 5 – 8		
	7 – 2 – 8 – 1 – 9 – 6 – 5 – 3		
		Total Backward	Max=14

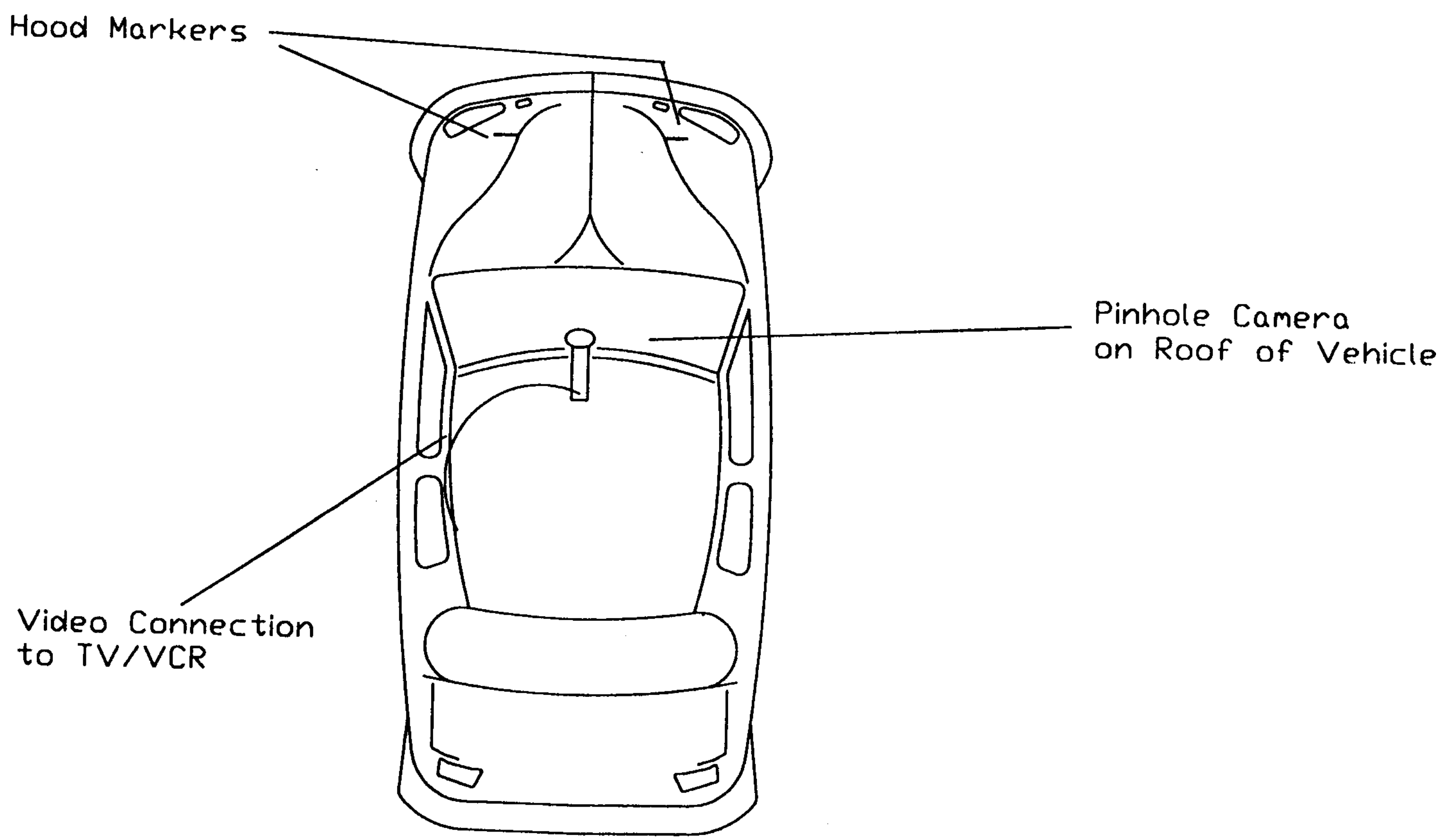
	+		=	
Forward		Backward		Total

* Administer DIGITS BACKWARD even if subject scores 0 on DIGITS FORWARD

Appendix A-5

Vehicle Setup for Commentary Driving
In Task 1

Modification of
Vehicle Setup



Appendix A-6

Data Collection Protocol for Daytime and Nighttime Evaluations
And
Driving Instructor's Assessment Form

Subject Name:
Subject Number:
Date:
Time:
Weather:

PROTOCOL

Experimenter Script

I. <u>Before leaving the parking lot</u>
As was mentioned in your consent form, your task today is to help us evaluate various traffic control devices such as: Overhead street signs, advance street signs, and lane markings. In order to do so, you are going to drive on various roads where we will call your attention to the traffic control devices we want you to tell us about.

For instance, as will be the case on various occasions during this drive, if we ask you to tell us the name of streets you will be crossing as soon as you are able to **<u>read</u>** any sign indicating the name of the street, you are to do so continuously until we ask you to stop.

(Describe overhead street signs, advance street signs, and lane markings.)

You would, as I mentioned earlier, continue in the same manner until I ask you to perform another task. As you report your perception/assessment of the various traffic control devices, if you experience any difficulties let us know. For instance, if you cannot read a sign because the letters on it have faded, you would state so: (e.g., "*... I cannot read the next sign, the letters are faded or ... I have difficulty reading this overhead street sign because of the glare..*"). While we encourage you to report continuously, if you should need to attend to specific traffic conditions and need to stop reporting briefly, please do so, then resume the commentary.

<u>At parking lot exit</u>
Turn right onto 164th St
Turn right onto NE 15th Ave

<u>At Miami Gardens Drive (183rd St)</u>
Make a left at Miami Gardens Drive
Please read all street signs aloud as soon as you are able to clearly read them.

Once the participant has started driving and before reaching the beginning of the test site (i.e., 183rd St and NW 2Ct), you will give him/her an opportunity to practice by asking him/her to name 4-5 Streets.

I. At I95 overpass, Instruct Subject:
Please read all street signs aloud as soon as you are able to clearly read them.

II. 183rd St and NW 2nd Ct.: Beginning of Test site.

Signs to be measured:	Interval (distance in ft)
1) NE 2nd Avenue overhead street sign	
2) NW 2nd Avenue advance street sign	
3) NW 2nd Avenue overhead street sign	
4) NW 17th Avenue advance street sign	
5) NW 17th Avenue overhead street sign	

III. At NW 22nd Ave, Instruct Subject:
Please take a Right at Unity Boulevard/ 27th Ave.

Signs to be measured:	Interval (distance in ft)
6) NW 27th Avenue advance street sign	
7) NW 27th Avenue overhead street sign	

IV. After Participant Makes Right Turn on NW 27th Avenue, Instruct Subject:
a) Please go into the Left Turn Lane at 191 Street **(let them know where it is).**
b) If there is no traffic behind you waiting to make the left turn, stop there briefly until I tell you to proceed, otherwise make the left turn when permitted as soon as you can safely do so.

While Participant is waiting in left turn lane, ask the following questions:

1) How clearly do you see oncoming traffic from this position:
a) very poorly b) poorly c) clearly d) very clearly

2) How well can you judge the gaps in the oncoming traffic from here
a) very poorly b) poorly c) well d) very well

3) How comfortable do you feel about making a left turn here
a) very uncomfortable b) uncomfortable c) comfortable d) very comfortable

c) As soon as you can safely do so, you may turn left here.

<u>V. As soon as Subject makes left turn at 191 street, Instruct Subject:</u>

a. Please take the first Right (onto NW 27th Ct)
b. At Stop Sign, please turn Right (onto NW 199th St)
c. Please turn Left at traffic light (onto NW 27th Ave)

<u>VI. After Participant Passes 203 Street, Instruct Subject:</u>(The protocol here is similar to that executed previously for 191st Street)

a. Please go into the Left Turn Lane at 207 Street (**<u>let them know where it is</u>**).
b. If there is no traffic behind you waiting to make the left turn, stop there briefly until I tell you to proceed, otherwise make the left turn when permitted as soon as you can safely do so.

While Participant is waiting in left turn lane, ask the following questions:

1) How clearly do you see oncoming traffic from this position:
a) very poorly   b) poorly   c) clearly   d) very clearly
2) How well can you judge the gaps in the oncoming traffic from here
a) very poorly   b) poorly   c) well   d) very well
3) How comfortable do you feel about making a left turn here
a) very uncomfortable   b) uncomfortable   c) comfortable   d) very comfortable

c) As soon as you can safely do so, you may turn left here.

<u>VII. On 207th St, Instruct Subject:</u>

a) Make U-Turn as soon as you can (make a left turn and turn around, back onto NW 207th St).
b) Please make left turn at traffic light (onto NW 27th Ave/ University Drive).

<u>VIII. On University Dr (NW 27th Ave), Instruct Subject: (Lane Markings)</u>

Now, I would like you to tell me what you think of the lane markings on this part of the road:

Rate the following issues:

1) How well do you see the lane markings?
a) very poorly   b) poorly   c) clearly   d) very clearly
2) Compared to lane markings you usually encounter, are these:
a) More visible   b) equally visible   c) less visible
3) Compared to lane markings you usually encounter, are these:
a) Narrower   b) of equal width   c) wider
4) Compared to lane markings you usually encounter, are these:
a) Shorter   b) of equal length   c) longer

IX. As driver approaches Pembroke Rd, Instruct Subject:
Please read all street signs aloud as soon as you can read them clearly.

Signs to be measured:	Interval (distance in ft)
10) Johnson St. advance street sign	
11) Johnson St. overhead street sign	
12) Taft St. advance street sign	
13) Taft St. overhead street sign	

X. At Pasadena, Instruct Subject:
Please turn left at Sheridan St.

XI. After Driver turns left on Sheridan, Instruct Subject: (Lane Markings)
Now, I would like you to tell me what you think of the lane markings on this part of the road:

Rate the following issues:

1) How well do you see the lane markings?
a) very poorly b) poorly c) clearly d) very clearly
2) Compared to lane markings we asked you to judge previously, are these:
a) More visible b) equally visible c) less visible
3) Compared to lane markings we asked you to judge previously, are these:
a) Narrower b) of equal width c) wider
4) Compared to lane markings we asked you to judge previously, are these:
a) Shorter b) of equal length c) longer

XII. On Sheridan, (After Billboard "Abundant Life Ministries") As driver approaches Douglas Road, Instruct Subject:

Please read all street signs aloud as soon as you can clearly read them
Please go into the Left Turn Lane at next traffic light.

Signs to be measured:	Interval (distance in ft)
14) Douglas Road advance street sign	
15) Douglas Road overhead street sign	

XIV. After Driver turns left on Douglas Road, Instruct Subject: (Lane Markings)
Now, I would like you to tell me what you think of the lane markings on this part of the road:

Rate the following issues:

1) How well do you see the lane markings?
a) very poorly b) poorly c) clearly d) very clearly
2) Compared to lane markings we asked you to judge previously, are these:
a) More visible b) equally visible c) less visible
3) Compared to lane markings we asked you to judge previously, are these:
a) Narrower b) of equal width c) wider
4) Compared to lane markings we asked you to judge previously, are these:
a) Shorter b) of equal length c) longer

BONUS

XV. As Driver approaches Pines Blvd, Instruct Subject:

a. Please go into the Left Turn at Pines Blvd.
b. If there is no traffic behind you waiting to make the left turn, stop there briefly until I tell you to proceed, otherwise make the left turn when permitted as soon as you can safely do so.

While Participant is waiting in left turn lane, ask the following questions:

1) How clearly do you see oncoming traffic from this position:
a) very poorly b) poorly c) clearly d) very clearly
2) How well can you judge the gaps in the oncoming traffic from here
a) very poorly b) poorly c) well d) very well
3) How comfortable do you feel about making a left turn here
a) very uncomfortable b) uncomfortable c) comfortable d) very comfortable

c) As soon as you can safely do so, you may turn left here.

XVI. On Pines Blvd, Instruct Subject:
Please get into the middle lane.
Please read all street signs aloud as soon as you can clearly read them.

Signs to be measured:	**Interval (distance in ft)**
16) NW 86 Avenue advance street sign	
17) NW 86 Avenue overhead street sign	

Signs to be measured:	**Interval (distance in ft)**
18) NW 83 Avenue advance street sign	
19) NW 83 Avenue overhead street sign	
20)University Dr. advance street sign	
21) University Dr. overhead street sign	
22) MacArthur Pkwy advance street sign	
23) MacArthur Pkwy overhead street sign	
24) NW 68th Avenue advance street sign	
25) NW 68th Avenue overhead street sign	

XVII. At 68th Avenue, Instruct Subject:

a. Please move to the Left-most lane
b. Please go into the Left Turn Lane at 64th Ave.
c. If there is no traffic behind you waiting to make the left turn, stop there briefly until I tell you to proceed, otherwise make the left turn when permitted as soon as you can safely do so.

While Participant is waiting in left turn lane, ask the following questions:

1) How clearly do you see oncoming traffic from this position:
a) very poorly b) poorly c) clearly d) very clearly
2) How well can you judge the gaps in the oncoming traffic from here
a) very poorly b) poorly c) well d) very well
3) How comfortable do you feel about making a left turn here
a) very uncomfortable b) uncomfortable c) comfortable d) very comfortable

d. As soon as you can safely do so, you may turn left here.

XVIII. At High School, Instruct Subject:

Please pull over.
Mr. Riley takes over and returns to the North Miami Beach Public Library via the Florida Tpke

PROTOCOL
Experimenter Script
For
Assessment of Lane Markings and RPMs at Night

Subject ID
Date: ___/___/
Weather:
Time: ___:___PM

I. Before leaving the parking lot

As a continuation of the tasks you performed in evaluating traffic control devices, today you will engage in the second part of this assessment which is to evaluate lane markings and Refectorized pavement markings at night. In order to do so, you are going to drive on various roads where we will call your attention to these traffic control devices we want you to evaluate.

As you did in the daytime, you will be asked to assess the clarity of various land markings. For instances, at specific sections of the road we will ask you:
"How clearly do you see the lane markings?". Your response will be one of the following Very Poorly, poorly, clearly, very clearly" or "I don't see them" if you cannot see them. You will also be asked: "Compared to lane markings you usually encounter, are these "More visible, equally visible, less visible". Another question will be: "Compared to lane markings you usually encounter, are these "Wider, of Equal Width, or narrower", again you will be asked "Compared to lane markings you usually encounter, are these "longer, of Equal length, or shorter".

In addition you will be asked about the reflectorized or raised pavement markings we will refer to them as RPM (you may have to explain what these are) which also delineate lanes: You will be asked: "Do you see RPMs on this road?", "How bright do the RPMs appear to you?" Your response will be one of the following "Very bright, bright, dim, very dim". You will also be asked "How well do they permit you to see the lanes?" Very poorly, poorly, well, or very well". Lastly, we will ask you "Which of the two (lane markings or RPMs) makes it easier for you to see the lanes on this street?

II. Instructions

1) Please follow Park Drive to 101st Street. (After Stop sign, as you approach the bleachers on the right, warn driver about the **speed bump**).
2) Turn left on 101st Street (**be careful as you cross N.W. 6th Avenue**)
3) Please follow 101st Street to N.E. 2nd Avenue

4) After driver passes N.E. 3rd Avenue, tell driver: "Prepared to turn left on N.E. 2nd Avenue **when it is safe to do so**.

N.E. 95th Street, behind church, then left again on Park Drive to return to 96th Street, then turn right on 96th Street. Tell driver to stay (or move into the left lane). After passing N.E. 8th Avenue, tell driver: **"Please turn left on Biscayne Blvd as soon as it is safe to do so"**

Biscayne Blvd. Starting at 107th Street (6" lane markings & no RPMs)

Upon reaching 107th Street, please tell driver: **"As we did previously, I am going to ask you about the lane markings and RPMs on this part of the road"**

1) How clearly do you see the lane markings?".
Very Poorly____, Poorly____, Clearly___, Very Clearly_____, Don't See Them_____

2) Compared to lane markings you encountered earlier, are these
More visible_____, Equally visible_____, Less visible

3) Compared to lane markings you encountered earlier, are these:
Wider_____, of Equal Width_____, Narrower____"

4) Compared to lane markings you encountered earlier, are these:
Longer____, of Equal Length_____, Shorter_____"

5) Do you see RPMs on this part of the road? Yes_____ No

End of Exercise

After passing 116th Street, tell driver to turn right on Sans Souci Blvd. After U turn, go into the Gas station where Mr, Riley will take over and drive back to the Recreation Center.

Driving Instructor's Assessment

Subject ID:__________

1) How would you rate the driver's ability to stay in his/her lane?

Excellent___ Good___ Fair___ Poor___ Very bad___

2) How would you rate the driver's control of vehicle speed?

Excellent___ Good___ Fair___ Poor___ Very bad___

3) How would you rate the driver's compliance with signs or signals?

Excellent___ Good___ Fair___ Poor___ Very bad___

4) How would you rate the driver's ability to make left turns?

Excellent___ Good___ Fair___ Poor___ Very bad___

5) How would you rate the driver's ability to anticipate traffic situations?

Excellent___ Good___ Fair___ Poor___ Very bad___

6) How would you rate the driver's overall control of the vehicle?

Excellent___ Good___ Fair___ Poor___ Very bad___

7) Overall, how would you rate this driver's skills?

Excellent___ Good___ Fair___ Poor___ Very bad___

Appendix B-1

Protocol/Data Collection Form
For
Evaluation of Clearview font

Subject Name:

Subject Number:
Date:
Time:
Weather:

PROTOCOL

Experimenter Script

Before leaving the parking lot

As was mentioned in your consent form, your task today is to help us evaluate various street name signs, specifically ground-mounted street name signs and advance street name signs. In order to do so, you are going to drive on various roads where we will call your attention to the traffic control devices we want you to read to us.

For instance, as will be the case on various occasions during this drive, if we ask you to tell us the name of streets on the street name signs we pointed out to you, as soon as you are able to ***read*** *the sign, you are to do so aloud as quickly as possible.*

All the street name signs we want you to read are written in ***white font on green background****. The ground-mounted street name signs will be located* ***at the corner of the street on your right side****. And the advance street name signs will be located* ***in the median of the street on your left side****. We will let you know the location of the signs you will be asked to identify as you approach them.*

At parking lot exit

When you exit the parking lot, please turn ***right*** *onto Le Jeune Rd. Please remember, there will be* ***some advance*** *street name signs in the* ***median*** *on your* ***left*** *hand side.*

I. On NW 42nd Ave. (Le Jeune Rd.) Southbound

After the driver has turned onto Le Jeune Rd.: *Please* ***read*** *the street name on the advance street name sign in the median on your left hand side* ***aloud*** *as soon as you are able to do so.*

Signs to be measured: Curtiss Rd. **Interval:** _______________

After driver has read NW 142nd St.(Curtiss Rd.): *Please turn* ***left*** *at Curtiss Rd. Please remember, there will be* ***another advance*** *street name sign in the* ***median*** *of the street on your LEFT hand side.*

II. On NW 142nd St. (Curtiss Rd.) Eastbound

Immediately after the driver has turned onto Curtiss Rd.: *Please* ***read*** *the street name on the advance street name sign in the median on your left hand side* ***aloud*** *as soon as you are able to do so.*
Signs to be measured: Bennett Rd. **Interval:** _______________

After driver reads the street name sign: *Please turn* ***left*** *at Bennett Rd.*

Return Trip

After the driver turns left on NW 38th Ave. (Bennett Rd.): *At the end of the street, please turn* ***left****.*
After the driver turns left on NW 145th St. (Wright Rd.): *Now we are going to turn* ***around****.*
Please go right into this driveway and turn around.

After driver turns around and on NW 145th St. (Wright Rd.) again: *Please turn* ***right*** *on Bennett Rd. Please remember, there will be* ***one ground-mounted*** *street name sign on your* ***right*** *hand side.*

III. On NW 38th Ave (Bennett Rd.) Southbound

Immediately after the driver turns right onto Bennett Rd.: *Please* ***read*** *the street name on the ground-mounted street name sign on your right hand side* ***aloud*** *as soon as you are able to do so.*

Signs to be measured: Langley Rd. **Interval:** _______________

After driver has read NW 143rd St. (Langley Rd.): *Please turn* ***right*** *at Curtiss Rd. Please remember, there will be* ***one advance*** *street name sign in the* ***median*** *on your* ***left*** *hand side.*

IV. On NW 142nd St. (Curtiss Rd.) Westbound

After the driver has turned onto Curtiss Rd.: *Please* ***read*** *the street name on the advance street name sign in the median on your left hand side* ***aloud*** *as soon as you are able to do so.*

Signs to be measured: Musick Rd. **Interval:** _______________

After driver has read NW 41st Ave. (Musick Rd.): *Please turn* ***right*** *at Musick Rd. Please remember, there will be* ***some ground-mounted*** *street name signs on your* ***right*** *hand side.*

V. On NW 41th Ave (Musick Rd.) Northbound

After the driver turns right onto Musick Rd.: *Please* ***read*** *the street name on the ground-mounted street name sign on your right hand side* ***aloud*** *as soon as you are able to do so.*

Signs to be measured: Ely Rd. **Interval:** _______________

VI. Continue On NW 41th Ave (Musick Rd.) Northbound

Right after the driver has read Ely Rd.(NW 144th St.): *Please* ***read*** *the street name on the ground-mounted street name sign on your right hand side* ***aloud*** *as soon as you are able to do so.*

Signs to be measured: Wright Rd. **Interval:** _______________

Returning to parking lot

After the driver has read Wright Rd.: *Please turn* ***left*** *at Wright Rd.*
After the driver turn left on Wright Rd.: *Please turn* ***right*** *at LeJeune Rd.*
After the driver turn right on LeJeune Rd.: *Please turn* ***left*** *at NW 147th Ter and enter the parking lot.*

Appendix B-2

Selected Photographs of
Signs Used for Evaluation of Clearview Font

Advance Street Name Sign: “CURTISS RD NEXT INTERSECTION.” This was the first sign encountered by all the drivers (See #1 on the site map above).

Advance Street Name Sign: “BENNETT RD NEXT INTERSECTION.” This was the second sign encountered by all the drivers (See # 2 on the site map above)**.**

Ground-Mounted Street Name Sign: “LANGLEY RD.” This was the third sign encountered by all the drivers (See # 3 on the site map above).

Advance Street Name Sign: “MUSICK RD NEXT INTERSECTION.” This was the fourth sign encountered by all the drivers (See # 4 on the site map above).

Ground-Mounted Street Name Sign: “ELY RD 144 ST”. This was the fifth sign encountered by all the drivers (See # 5 on the site map above). This sign was found on the grounds of Opa-Locka Airport. It is in Highway C series 4” letters (non retro-reflective material. It was compared to Highway C and Clearview fonts using high retro-reflective materials and displaying “ELY RD” in 6” high letters.

Ground-Mounted Street Name Sign: “WRIGHT RD.” This was the sixth sign encountered by all the drivers (See # 6 on the site map above)**.**

Appendix B-3

Supplementary Data on Legibility Distance
Of
Clearview Font, Highway C series, and Highway D
For
Curtiss Rd, Bennett Rd, and Musick Rd.

Advance Street Name Signs

The following histograms represent the legibility distance of Clearview, Highway series D, and Highway series C for each of the Advance street name signs. It is evident that the legibility distance of Clearview font is consistently greater than that of Highway D, and Highway C series. Highway C series consistently shows the lowest legibility distance of the three fonts.

Legibility Distance of Curtiss Rd.

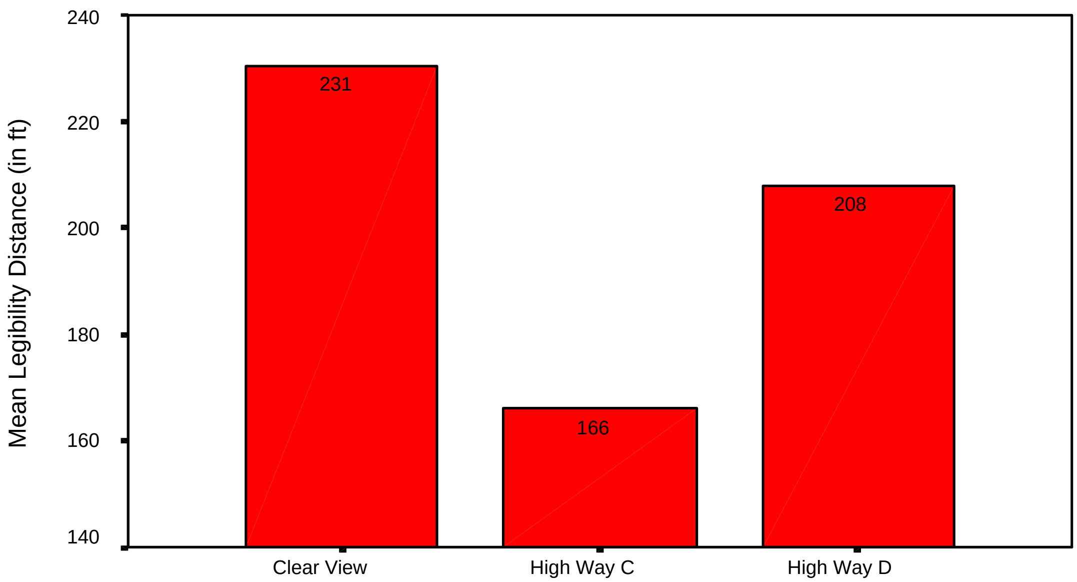


Figure 2. Font Type of Curtiss

Legibility Distance of Bennett Rd.

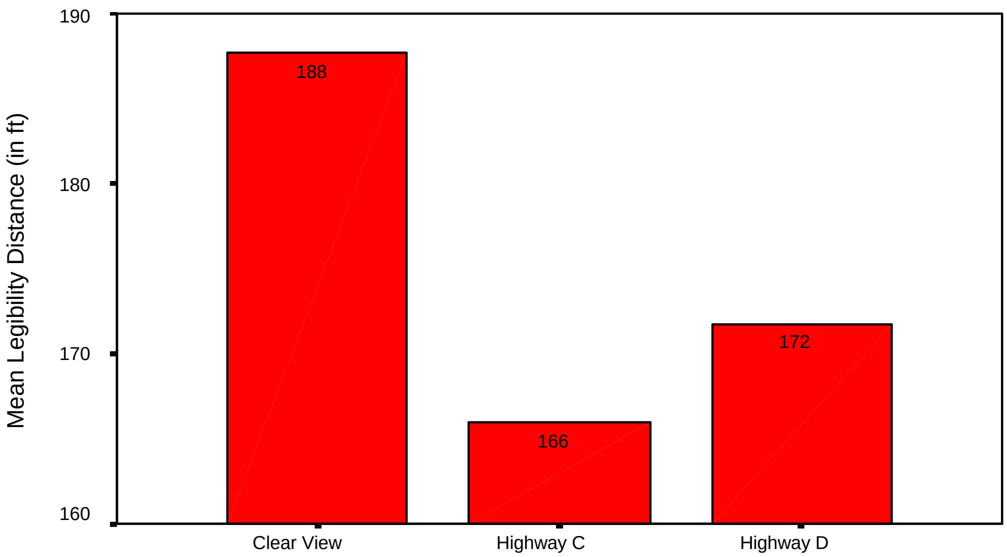


Figure 3. Font Type of Bennett

Legibility Distance of Musick Rd.

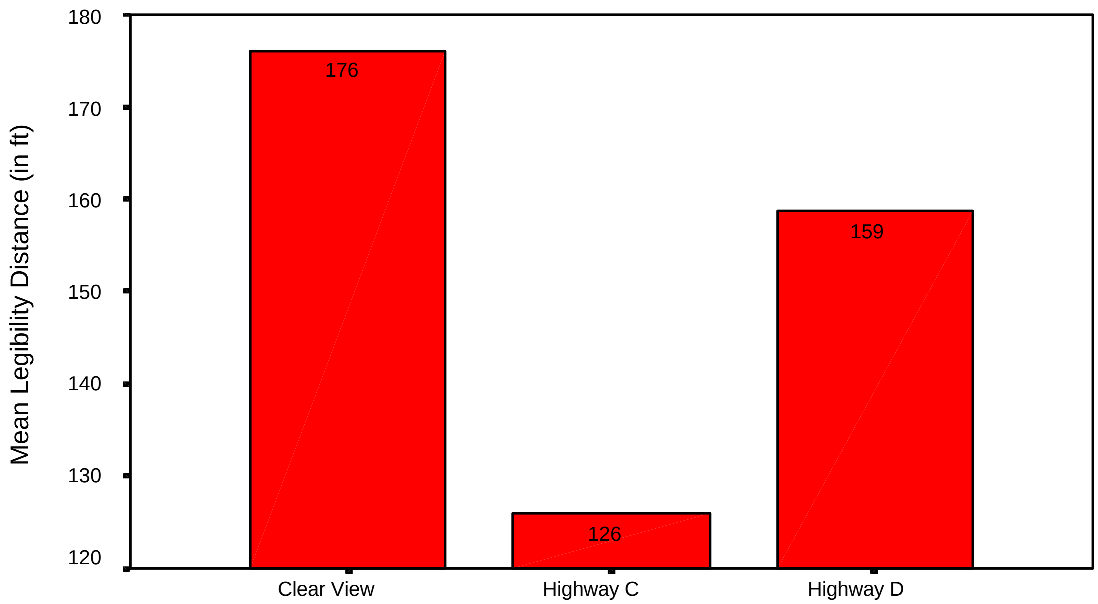


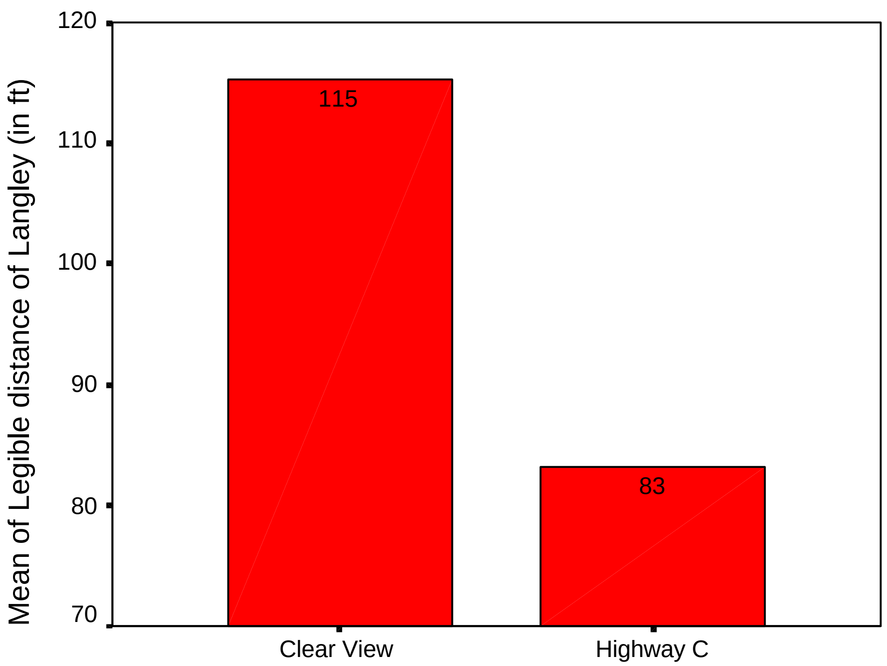
Figure 4. Font type of Musick

Appendix B-4

Supplementary Data on Legibility Distance
Of
Clearview Font, Highway C series, and Highway D
For
Langley Rd, Ely Rd, and Wright Rd.

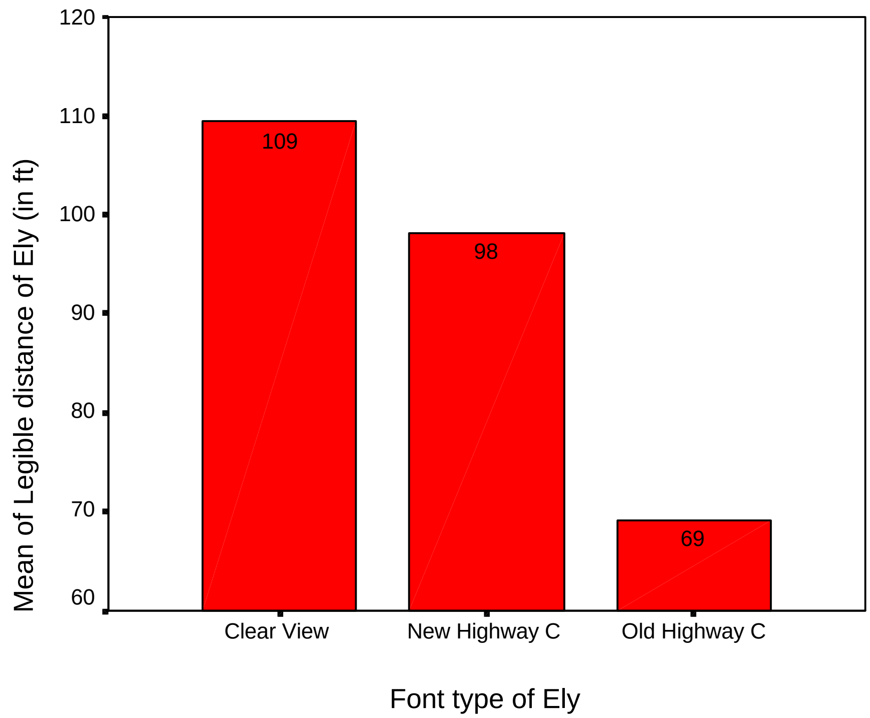
Ground-Mounted Street Name Signs
The following histograms represent the legibility distance of Clearview and Highway series C for each of the Advance street name signs. As stated in the text above, Clearview font was not found to be significantly different in legibility distance from Highway series C. In fact, one may note in the histograms below that whereas Clearview font has greater legibility distance than Highway series C for Langley Rd. and Ely Rd, it has shorter legibility distance for Wright Rd. Analysis of variance including only Langley Rd and Ely Rd do show Clearview font to be legible at a significantly greater distance than Highway C.

Legibility Distance of Langley Rd.

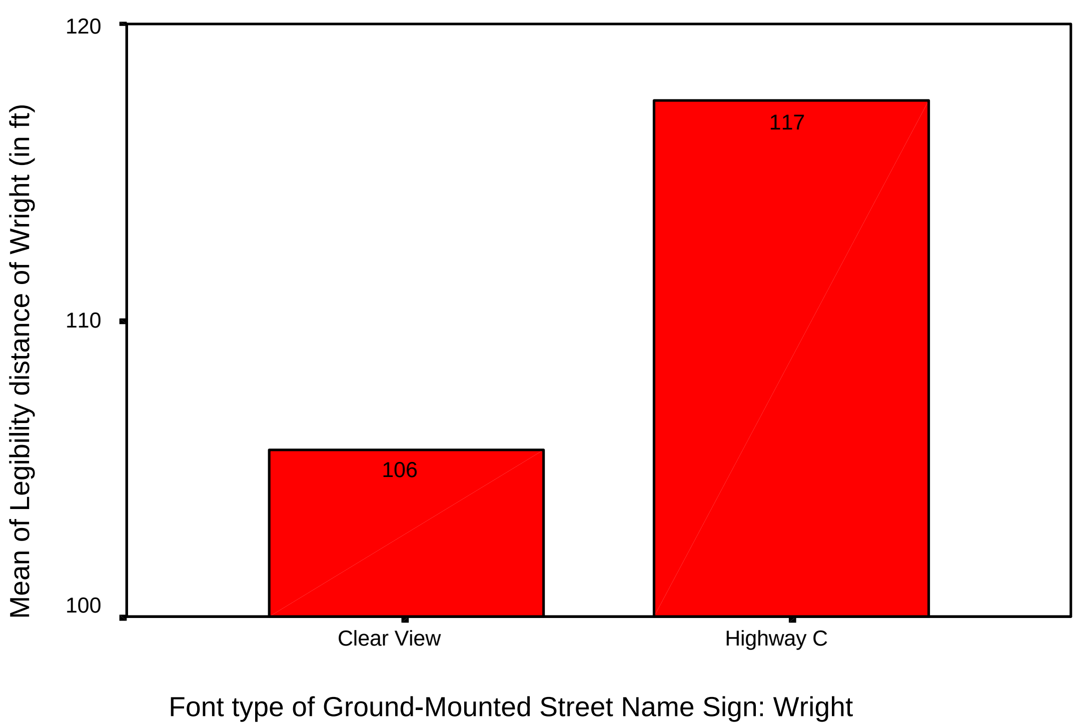


Font Type of Ground Mounted Street Name Sign: Langley

Legibility Distance of Ely Rd.



Legibility Distance of Wright Rd.



Appendix C-1

Consent Form and Driving Questionnaire

CONSENT FORM

Elder Roadway improvement Program

Objective of the Study

We would like you to participate in a study in which you will help us to evaluate different types of pavement markings (white or yellow broken or solid lines that separate lanes or highlight the edge of the road. Participation in this study is voluntary. The study is part of a research effort to find out how drivers who are 65 years old or older see different types of pavement markings. This will help us to look for ways of improving roads for drivers in that age group or younger. Your participation in this study will take about one hour and a half (1hour and 30 minutes).

What You Will be Expected to do

In order for you to tell us how you see the pavement markings, you will be driven in a car on roads where these markings have been placed. Before the drive, we will ask you to fill out a questionnaire. The questionnaire will ask you to give us general information on your driving experience as well as other information that is relevant to this study. You can skip any questions that you do not want to answer. We will also ask you to take some tests of vision and attention to see if you are eligible to be in the study. There will not be any negative consequences if you do not qualify for the study or if you decide that you do not want to participate. After you take these tests, you will get a fifteen-minute break. After the break, we will begin the driving part of the study.

In order to make sure that drivers and other persons in the car are safe, we are using the services of a certified driving instructor who will drive the vehicle in which you will be a passenger. Prior to going out on the road, you will be given instructions about the way in which you will be evaluating the pavement markings and sample questions will be used for illustration. Besides the certified driving instructor and you, there will also be a researcher in the car. He/she will ask you questions about the pavement markings you will be asked to evaluate.

Payment for Participation

You will be given twenty dollars ($20.00) for your participation in this study.

Confidentiality

Your records and results will be kept in a secure area in a locked office. Unauthorized persons will not be permitted access to these records. Any publication based on this study will not identify you by name or any other characteristic that is unique to you. All data published will be grouped data. We will consider your records confidential to the extent permitted by law. The Department of Health and Human Services (DHHS) may review these research records. Your records may also be reviewed, for audit purposes, by authorized University of Miami employees or other agents who will be bound by the same provisions of confidentiality.

Compensation for Injury

You may be exposed to risk of injury from participation in this study. If injury occurs, treatment will in most cases be available. If you have insurance, your insurance company may or may not pay for these costs. If you do not have insurance, or if your insurance company refuses to pay, you will be expected to pay. Funds to compensate for pain, expenses, lost wages and other damages caused by injury are not routinely available.

Risks

All reasonable precautions will be taken to make sure that your participation in this study is carried out safely. However, being an occupant of any car may put you at risk to be in a collision. Therefore, if you do not wish to take these risks, you may choose to stop participation in this study at any time.

Costs

We do not anticipate that you will have to spend any money for participating in this study other than costs for your transportation to out test site.

Benefits

We want to inform you that we cannot promise you any benefits for your participation in this research.

Participant:

I hereby voluntarily consent to participate in this study and to allow the treatment and procedures described above to be performed on me. I am aware that I may stop participating at any time and nothing bad will happen to me. I have read the information contained in the informed consent form, and I have been given answers to all my questions. I hereby freely and willingly consent to participate in this study.

Participant's Name: ____

Participant's Signature: ____ Date:__/___/__

If you have any questions about your rights as a research subject, please contact Maria Arnold, IRB Director, University of Miami, at (305) 243-3327

If you have any questions related to the study or experience a research-related injury, please contact José H. Guerrier at (305) 355-9092.

Name: ________________________________ Date: ____mm/____dd/____yyyy

Driving Questionnaire

Gender: ☐ Male ☐ Female Height:______ft_____in Date of Birth: ____mm/____dd/____yyyy

Currently Own a Valid Drivers License: ☐ Yes ☐ No Restrictions: ☐ Yes________ ☐ No

Q1. Which way do you prefer to get around?

☐ 1 Drive myself
☐ 2 Have someone else drive me
☐ 3 Use public transportation or a taxi

Q2. Do you currently drive?

☐ 1 Yes
☐ 2 No When is the last time you drove? ____mm/____yyyy

Q3. How long have you been driving? __________ Years

Q4. How long have you had a driver's license? ________ Years

Q5. Do you wear a seatbelt when you drive?
Would you say: ☐ 1 Always ☐ 2 Sometimes ☐ 3 Never

Q6. How fast do you usually drive compared to the general flow of traffic?
Would you say: ☐ 1 Much faster ☐ 2 Somewhat faster ☐ 3 About the same
☐ 4 Somewhat slower ☐ 5 Much slower

Q7. Compared to most drivers on the road, do you consider yourself:
☐ 1 Better than average ☐ 2 Average ☐ 3 Worse than average

Q8. Compared to drivers in your age group, do you consider yourself:
☐ 1 Better than average ☐ 2 Average ☐ 3 Worse than average

Q9. How would you rate the quality of your driving?
☐ 1 Excellent ☐ 2 Good ☐ 3 Average ☐ 4 Fair ☐ 5 Poor

NOTE: ALL IDENTIFYING DATA WILL BE STRIPPED AWAY TO ENSURE CONFIDENTIALITY.

Q10. When you are driving, how often do other drivers blow their horn at you?

☐ 1 Never ☐ 2 Sometimes ☐ 3 Very Often

Q11. Do you drive regularly? ☐ 1 Yes ☐ 2 No

If answer 'Yes', please circle the number that best represents the number of days per week you drive:

1 2 3 4 5 6 7 Other ___________

If ansered 'No', please estimate approximately how many days you drive in a year?

___________ Days

Q12. Please consider for a moment, all the places you drive in a typical week. Please follow the formulas below to determine how much you drive a week.

Place	**How many times a week**	**Estimate Miles from home (one-way)**
Store		
Church		
Work/Volunteer		
Relative's House		
Friend's House		
Dine out		
Appointments		
Other		

Q13. At which time of the day do you usually do most of your driving? (Please place a check mark by the appropriate response)

☐ 1 6-8AM ☐ 2 8-10AM ☐ 3 10AM-Noon ☐ 4 Noon-2PM ☐ 5 2-4PM

☐ 6 4-6PM ☐ 7 6-8PM ☐ 8 8-10PM ☐ 9 10PM-Midnight ☐ 10 Other _____

Q14. If you do not drive at night, what are your reasons for not driving? (Please check all the answers that apply).

☐ 1 Concern for personal safety
☐ 2 Inability to see well at night
☐ 3 Fear of getting lost
☐ 4 Other (please explain briefly) ___________________________________

Q15. Do you have to wear glasses or contact lenses when you drive?

☐ 1 Yes ☐ 2 No

Q16. How would you describe your ability to see at night? (Please check mark by appropriate response)

☐ 1 Very good ☐ 2 Good ☐ 3 Average ☐ 4 Not good ☐ 5 Can't see at night

Q17. Has anyone suggested over the past year that you limit your driving or stop driving?

☐ 1 Yes Why? ____

☐ 2 No

Q18. How many car accidents in the past five years have you been involved in when you were the driver?

__________Accidents

Q19. How many times in the past five years have you been pulled over by the police, whether or not you received a ticket?

__________ Times

Q20. How many traffic tickets (other than a parking ticket) in the past five years have you received, whether or not you were at fault?

__________ Tickets

Q21.) In the following section is a table showing various health conditions. In the appropriate column, please check "Yes" if you have this condition or "No" if you do not. If you check "Yes", also mark in the appropriate box how much this condition interferes with your driving.

Health Condition	**Yes**	**No**	**Does this condition interfere with your driving?**			
			Never	**Sometimes**	**Often**	**Always**
Arthritis						
Heart Problem						
Hypertension						
Parkinson's						
Diabetes						
Limited Neck Movement						
Limited Hip Movement						
Seizures						
Blurry Vision						

22) Please list all the medication you take on this page. Use the information written on the medication labels to fill out this list. Be sure to include all the medications prescribed by your doctors and all your over-the-counter medications such as aspirin and anti-acids.

Medications

Name of the Medication	Daily Dosage	Number of Times Taken Each Day	How Long Have You take Medication

NOTE: ALL IDENTIFYING DATA WILL BE STRIPPED AWAY TO ENSURE CONFIDENTIALITY.

23) Do you experience any difficulties reading road signs? (Please check the appropriate response)
No difficulties ______ Some difficulties ______ A lot of difficulties ______

24) Do you ever have any difficulties understanding information presented on Road signs? (Please check the appropriate response)
Never ______ Sometimes ______ Often ______ Always ______

25) How often did you visit a doctor over the past year? (Not necessarily the same doctor each time.)
None ______ One time ______ Two times ______ Three or more times ______

26) The following are items about activities you might do during a typical day. Does your health currently limit you in these activities?

	Limited a lot	**Limited a little**	**No limit at all**
A.) Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.			
B.) Lifting or carrying groceries			
C.) Climbing several flights of stairs			
D.) Climbing on a flight of stairs			
E.) Bending, kneeling, or stooping			
F.) Walking more than one mile			
G.) Walking several blocks			
H.) Walking one block			
I.) Bathing or dressing yourself			

Appendix C-2

Protocol and Data Collection Form for Task 2(B)

Protocol for Road Test
Elder Roadway

Before starting the road test, after thanking the participant for participating in this project, remind participant of the purpose of this phase. Specifically the participant will be told the following:

The objective of this project is to have you assist us in determining if drivers can distinguish between various types of lane markings in order to identify effective traffic control devices that will facilitate older drivers. In order to carry out this evaluation, you will be a passenger in the front seat of a car with dual controls driven by Mr. Lambert Riley, a certified driving instructor. Mr. Riley will drive the vehicle at a fixed speed and will ensure that you have a safe ride. This will permit you to concentrate on the lane markings and answer our questions as soon as possible.

During the ride, you will be asked three questions regarding characteristics of the lane markings you encounter. For instance you will be asked: "As you look down this lane as far as you can see does it go straight, curve right or left." You would answer according to the way they seem to you. Then, we will ask: "How visible are these lane markings to you? very visible, visible, barely visible, not visible." And finally, we will also ask you: "Compared to the lane markings you just saw, are these: More visible, equally visible, less visible". Again, whenever you are asked a question about the lane markings, make the choice that you feel is appropriate as quickly as possible. There are no wrong answers to these questions. We are interested in your evaluation of these lane markers.

In order that you may know what lane markings to evaluate, I will inform you in advance. You will respond as quickly as possible. The road course upon which you will have to judge the lane markings is relatively short. Therefore, in order to avoid distracting you, we will refrain from conversing with you at the evaluation site, other than to ask you questions about the lane markings.

Do you have any questions at this time?

WARNING!! Prior to the vehicle moving, make sure the participant has his/her seatbelt on.

Name: ____ Date: ________________________
_____

Weather: Moony / Cloudy / Sprinkle / Rainy / Shower

Road Condition: Dry / Slightly Wet / Wet

Lane Marker Type	Labels of the Beginning of each Lane Marker			Shape Recognition	*Visibility Impression*	Visibility Comparison
	Distance From Toll Booth	Cue	Mile Marker	Does the lane go straight or curve? **Straight / Curved to (Right / Left) / Not sure**	How visible are these lane markings to you? **0=Not Visible / 1=Barely Visible / 2=Visible / 3=Very Visible**	***Compared to the previous lane markings, are these:*** **More Visible / Equally Visible / Less Visible**
820	3.3	Twin	47.9	S R L NS	0 1 2 3	*M = L*
Thermo	3.8	Red	48.4	*S R L NS*	0 1 2 3	M = L
380	4.9	Twin	49.5	S R L NS	0 1 2 3	M = L
820	5.4	Twin	50	S R L NS	0 1 2 3	M = L
Thermo	5.9	Red	50.5	S R L NS	0 1 2 3	M = L
380	6.4	Twin	50.9	S R L NS	0 1 2 3	M = L
(Thermo)	6.9	Red	51.4	S R L NS	0 1 2 3	M = L
				End of the last Lane Marker (380)		

NOTE: ALL IDENTIFYING DATA WILL BE STRIPPED AWAY TO ENSURE CONFIDENTIALITY.

Appendix C-3

Descriptions of 380I and 820 Series

3M

Stamark™ High Performance Tape

Series A380I Tape, Series L380I Sheeting, and Series SMS-L380I Precut Symbols and Legends

Product Bulletin 380I · December 1996

Description

3M™ Stamark™ High Performance Tape Series 380I can be used as an inlay marking on new asphalt or as an overlay marking on most asphalt and concrete pavement surfaces in good condition.

Series A380I: Used for long lines, edge lines, channelizing lines and gore markings.

Series L380I: Linered. Used to cut symbols and legends.

Series SMS-L380I: Linered. Precut symbols and legends.

Properties

A. Product Features

- Durable, conformable and retroreflective
- Product design that provides long-term reflectivity
- Abrasion-resistant microcrystalline ceramic beads bonded in a highly durable polyurethane topcoat
- Yellow microcrystalline ceramic beads incorporated to improve nighttime yellow color
- Manufactured without the use of heavy metals, lead chromate pigments or other similar, lead-containing chemicals
- Patterned surface that presents a near vertical surface to traffic to maximize retroreflectance
- Precoated with a pressure sensitive adhesive (PSA) on bottom surface
- Nominal thickness of 0.065 in. (1.6 mm) at pattern heights
- White: 380I
- Yellow: 381I

B. Reflectance

Series 380I tape has the following initial minimum retroreflectance values when measured in accordance with ASTM-D4061. The photometric quality to be measured is coefficient of retroreflected luminance (R_L) and shall be expressed as:

English R_L: millicandelas per square foot per foot-candle $[(mcd \cdot ft^{-2}) \cdot fc^{-1}]$ or equivalently as:

Metric R_L: millicandelas per square meter per lux $[(mcd \cdot m^{-2}) \cdot lx^{-1}]$

	White			Yellow		
Entrance Angle	86.0°	86.5°	88.8°	86.0°	86.5°	88.8°
Observation Angle	0.2°	1.0°	1.05°	0.2°	1.0°	1.05°
Retroreflected Luminance* R_L $[(mcd \cdot ft^{-2}) \cdot fc^{-1}]$	1100	700	500	800	500	300

*The quantity of retroreflected luminance (R_L) "relates to the way the effective retroreflective surface is focused on the retina of the human eye and to the visual effect thereby produced. It is recommended for describing the performance of highway signs and striping, or large vehicular markings which are commonly viewed as discernible surface areas." Federal Test Method Standard 370, 3.1.2, Note 6, March 1, 1977.

C. Color

The preformed markings consist of white or yellow films with pigments selected and blended to conform to standard highway colors.

D. Skid Resistance

The patterned surface of the retroreflective pliant polymer shall provide an initial average skid resistance value of 45 BPN when tested according to ASTM E 303 except values will be taken in one direction and at 45° angle from that direction. These two values will then be averaged to find the skid resistance of the patterned surface.

E. Application

All applications should be installed using the instructions in the appropriate section of 3M Information Folder 5.7. 3M does not recommend application of Series 380I tapes in mountainous, heavy snowfall areas above 5,000 feet (1,500 m).

F. Patchability

Heavy traffic and snow plowing may cause wear and damage. New materials can be installed in these areas with minimal surface preparation by following the manufacturer's recommendations. Remove the damaged material and replace the damaged area by following the instructions in "Overlay Applications" of 3M Information Folder 5.7.

General Performance Considerations

Stamark pavement marking tapes are weather resistant and provide excellent reflectivity and color retention. Experience has shown that these materials are highly effective traffic control devices and will show no appreciable fading, lifting, shrinkage or chipping when applied according to 3M's recommendations contained in product literature.

The durability of Stamark pavement markings will depend on traffic conditions, snow removal practices, application techniques used, and pavement and atmospheric conditions at the time of application. It is recommended that the customer thoroughly evaluate Stamark tapes under the conditions in the specified location before making large-scale applications.

Warranty

Minnesota Mining and Manufacturing Company (3M) warrants that 3M™ Stamark™ High Performance Tape Series 380I sold by 3M for pavement marking applications in the United States and Canada will remain effective for its intended use under normal traffic conditions and meet the minimum retained coefficient of retroreflection value of 100 millicandelas per foot squared per foot-candle (measured at 1.0° observation and 86.5° entrance angles) subject to the following provisions:

Table 1

Application*	Warranty Period
Longitudinal markings	4 years
Words and symbols	2 years

*Applications in mountainous, heavy snowfall areas above 5,000 ft. (1500m) are not covered by this warranty.

If Stamark series 380I/381I tape is applied in accordance with all 3M application procedures provided in 3M's product bulletins, information folders and technical memos (which will be furnished to the applier upon request); and fails to retain the minimum reflectance value, fails to adhere to the roadway or fails due to complete wear-through during the warranty period shown above (from the date of installation), 3M's sole responsibility and purchaser's and user's exclusive remedy shall be:

3M will provide the replacement materials to restore the marking to its original effectiveness.

Conditions

Such failure must be solely the result of design or manufacturing defects in the Stamark high performance tape and not of outside causes such as improper installation or substrate failure. Failure to follow recommended application procedures will void this warranty.

Damage to pavement markings caused by snow removal equipment is not covered under this warranty.

A visual night inspection must be made with a 3M representative and a customer representative present to identify areas of the installation which appear to be below the minimum retained reflectance values specified in Table 1. Areas which appear to be below the minimum retained reflectance value shall be identified as "zones of measurement." To qualify for material replacement, a "zone" must be at least 360 feet in road length and consist of either edge lines, center lines or lane lines, but not in combination, or a single word or symbol marking.

3M reserves the right to determine the method of replacement.

Replacement markings will carry the unexpired warranty of the marking it replaces.

Claims made under this warranty will be honored only if the customer has maintained an accurate record of the dates of material installation, which constitutes the start of the warranty period.

Claims under this warranty will be honored only if 3M is notified of a failure within a reasonable time, reasonable information requested by 3M is provided, and 3M is permitted to verify the cause of the failure.

Reflectance Measurement Procedures for Warranty

Step 1: A visual night inspection must be made with a 3M representative and a customer representative present to identify areas of installation which appear to be below the specified minimum retained reflectance values in the Table 1.

Areas which appear to be below the minimum retained reflectance value shall be identified as zones of measurement. To qualify for materials replacement, a zone must be at least 360 feet (108 meters) in road length and shall consist of either edge lines, center lines or lane lines, but not in combination.

Step 2: Within each zone, reflectance measurements must be taken at specified checkpoint areas.

a. Zones Measuring 360 Feet (108 m) to 1,080 Feet (324 m) in Length

No separate checkpoints are required. For continuous lines, reflectance measurements must be made at approximately 20 ft. (6 m) intervals throughout the zone. For skip lines, two measurements must be taken at two random locations on each skip.

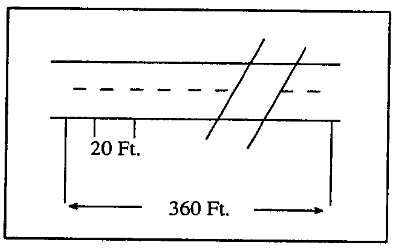


Figure 1

b. Zones Measuring 1,080 Feet (324 m) to 6 Miles (9.6 km) in Road Length

A total of 18 measurements must be made at each of three checkpoints within the zone, including the start point, the mid point and the end point. For continuous lines, reflectance measurements must be made at 20-foot (6 m) intervals throughout each checkpoint. For skip lines, two measurements must be taken at two random locations on each skip.

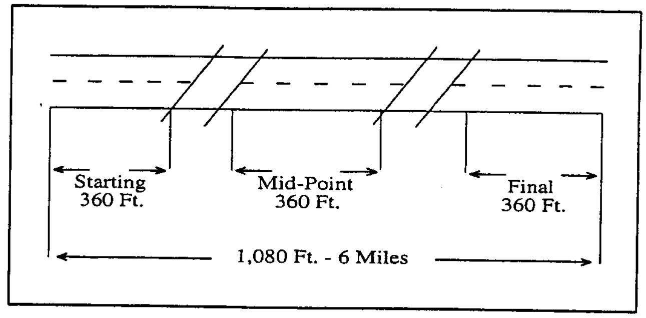


Figure 2: Measure every 20 ft. on continuous lines or 2 measurements per skip for each checkpoint.

c. Zone Greater than 6 Miles in Road Length

A total of 18 measurements must be made in each checkpoint within the zone, including the start point, the end point and at approximately 3-mile (4.8 kilometers) intervals throughout the zone. For measurement intervals on continuous lines, center lines or lane line skips, refer to Section b above.

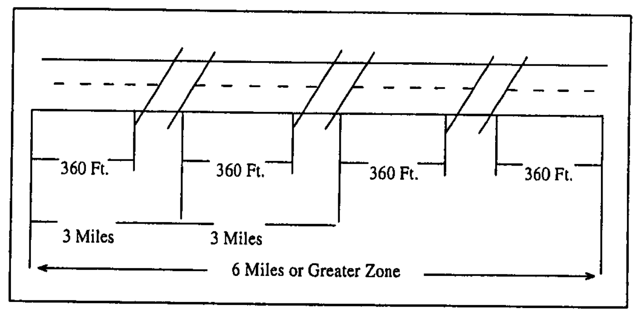


Figure 3: Measure every 20 ft. on continuous lines or 2 measurements per skip for each checkpoint.

Step 3: All reflectance measurements made at the checkpoints shall be made on a clean, dry surface at a minimum temperature of 40° F (4° C). The test instrument shall be an ECOLUX™ Retroreflectometer. This instrument has a measurement geometry of 86.5° entrance angle and a 1.0° observation angle.

Step 4: All reflectance measurements within the zone must be averaged to determine if the minimum retained reflectance values have been met.

Materials Replacement Condition

Markings must be applied according to the instructions in 3M Information Folder 5.7 to qualify for any applicable materials replacement provisions.

Health and Safety Information

Read all health hazard, precautionary and first-aid statements found in the Material Safety Data Sheet (MSDS) and/or product label of chemicals prior to handling or use. Also refer to the MSDS for information about the volatile organic compound (VOC) content of chemical products. Consult local regulations and authorities for possible restrictions on product VOC content and/or VOC emissions.

Storage

Store in a cool, dry area indoors. Use within one year of receipt.

Literature Reference

For additional information on Stamark tapes, application instructions or application equipment, refer to the following publications:

IF 5.1 Information Folder for 3M Manual Highway Tape Applicator - MHTA-1

IF 5.2 Information Folder for 3M Highway Tape Applicator - HTA

IF 5.3 Information Folder for 3M Adhesive Spray Applicator - PS-14

IF 5.7 Pavement Surface Preparation and Application Procedures for Stamark Pavement Marking Tapes

IF 5.8 Application of 3M Stamark and Scotch-Lane™ Precut Symbols and Legends

IF 5.9 Recommended Applications for Stamark Pavement Marking Tapes

IF 5.14 Information Folder for 3M Manual Highway Tape Applicator - MHTA-16 & MHTA-18

IF 5.15 Information Folder for 3M Motorized Manual Highway Tape Applicator - MMHTA-18

For further information, contact 3M Traffic Control Materials Division at 1-800-553-1380 in the U.S. or at 1-800-265-1840 in Canada; select technical service for pavement markings.

3M

Traffic Control Materials Division
3M Center, Building 225-5S-08
P.O. Box 33225
St. Paul, MN 55133-3225

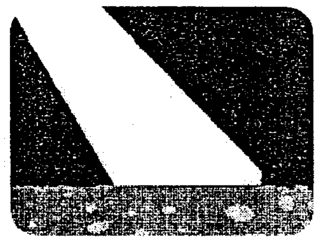
3M Canada
P.O. Box 5757
London, Ontario N6A 4T1

3M Mexico, S.A. de C.V.
Apartado Postal 14-139
Mexico, D.F. 07070

Printed on recycled paper
75-0300-3235-5

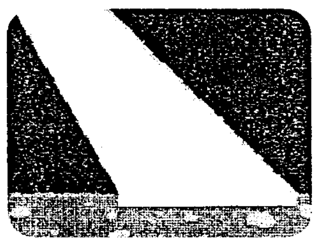
Overlay Application

Series 820 tape can be easily applied to new and existing road surfaces. The newly marked road can be opened to traffic immediately following application.



Grooved Application

Series 820 tape may be applied to freshly grooved pavements. Applying 820 tape into grooves protects the marking from snow plow damage. Because the 820 tape is wet-reflective, the tape will continue to perform even if there is water collection on top of the marking.



Lead the way to safer roadways

Look to 3M to help you lead the way to safer roads. For more than 50 years, we have developed and used 3M technologies that make roads safer. And we go the extra mile to give you the service you need to make your applications successful. 3M offers a full range of pavement marking products, equipment and training to help with your applications.

For more information on our durable pavement marking products and services, please visit our Web site at www.3M.com/tcm, or contact your 3M sales representative, or call 1-800-553-1380. In Canada please call 1-800-265-1840.

3M

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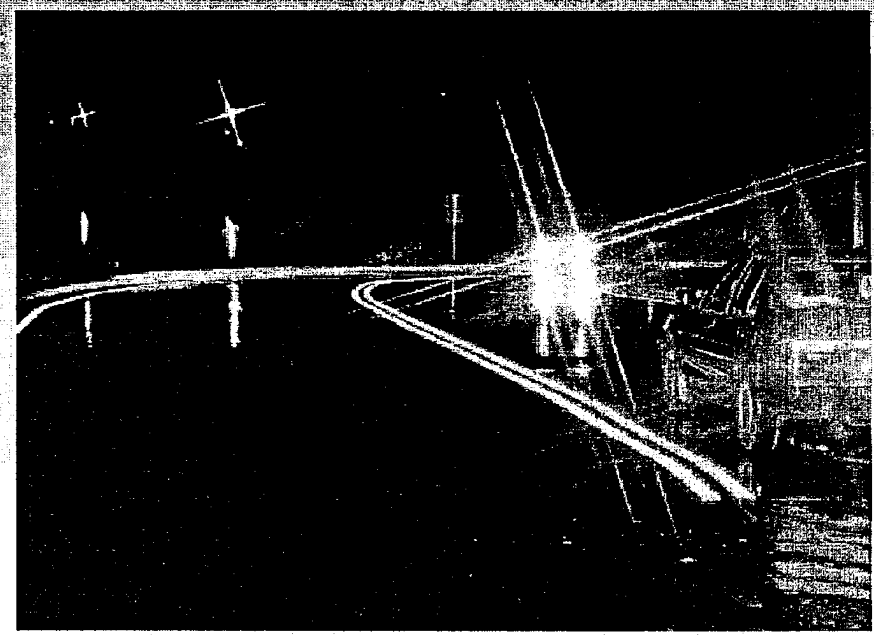
Av. Santa Fe No 55
Col. Santa Fe, Del. Alvaro Obregón
Mexico, D.F. 01210

3M Stamark™
Wet Reflective Pavement Marking Tape Series 820



Keep roadways from disappearing in the rain

Durable pavement markings that provide continuous retroreflective delineation – even in rain!

We have all experienced the distress and uncertainty of driving along the highway on a dark, rainy night. The distracting glare from headlights bouncing off the wet road surface. The difficulty of seeing the pavement markings that tell us where the road is going. There is no denying it, navigating the highway during rainfall is a challenge for even the best drivers. Some drivers decide that pulling off the road is the safest option, but that creates yet another hazard to other drivers. The bottom line – we need to make roads safer.

Highway statistics reveal a nighttime accident rate that is more than three times the daytime rate

In fact, according to the National Highway Traffic Safety Administration, midnight to 3:00 am on Saturdays and Sundays proved to be the deadliest 3-hour periods throughout 1998, with a reported 1,218 and 1,208 fatal crashes, respectively. And while collisions with fixed objects and non-collisions accounted for only 17 percent of all crashes, they accounted for 40 percent

of all fatal crashes. Reduced visibility plays a major role in these types of collisions. Retroreflective traffic control devices are designed to help offset the lack of visual cues in the nighttime driving environment. Implementing this retroreflective technology can put us on the road to safer driving conditions at night and in low lighting conditions.

Surveys conducted by researchers and state DOTs have shown that one of the basic needs of drivers is to have a pavement marking that is visible in wet and rainy conditions. 3M has developed advanced technologies and high performance materials to meet this and other rising needs on today's highways.

Conventional pavement markings disappear in wet weather

Road signs use highly reflective sheetings that incorporate the latest optical technologies to guide the motorist in all weather conditions. Incorporating these technologies for all-weather pavement markings, on the other hand, have proved very challenging.

Attempts at making pavement markings reflective in the rain have generally focused on raising beads above the road surface or simply making them larger. The common denominator among these markings is the need for water to drain away from the beads. Although all pavement markings are reflective when new and in dry conditions, most lose reflectivity when wet. These pavement markings simply disappear on the road when we need them most.

Continuous delineation

Raised pavement markers (RPMs) have been regarded as the ultimate in wet reflective markings. They provide delineation at night and in wet or rainy conditions. However, RPMs need to be supplemented with a continuous line pavement marking to provide adequate daytime delineation. Series 820 tape on the other hand, provides continuous positive guidance *day* and *night, wet* and *dry*.

3M wet reflective technology – performance you can count on

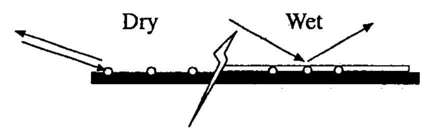
When it comes to making driving safer in all conditions, 3M leads the way. The 3M™ Stamark™ Wet Reflective Tape Series 820 utilizes specially designed optics to provide wet and dry performance. Unlike other durable markings, Series 820 tape appears as bright in the rain as it does when dry. These markings provide positive guidance around the clock, in wet and dry conditions.

Designed for superior reflective performance, Series 820 tape provides drivers with highly visible markings they can rely on. At night in dry conditions, Series 820 tape appears brighter than conventional markings. In rain, while conventional pavement markings disappear, Series 820 tape continues to perform. Whether it rains for 10 minutes or 10 hours, Series 820 tape remains just as bright.

This innovative Series 820 tape is a durable, conformable pavement marking intended for longitudinal line applications on all road surfaces.

How does Series 820 tape do it?

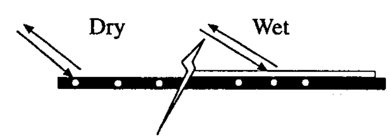
Conventional Pavement Markings Using Exposed Lens Optics



Traditional pavement markings (i.e., paint, epoxy, thermoplastic and tape) use exposed lens technology.

Beads exposed on the surface of the pavement marking return light to its source. But in rain or with standing water, light from headlights hits the water and scatters. The end result: reflectivity is significantly reduced and the marking may disappear.

3M™ Stamark™ Wet Reflective Pavement Marking Tape Series 820



Series 820 tape does not rely on water draining or evaporating to provide reflectivity in wet conditions. 3M has developed a specially designed optic layer to produce an inherently wet reflective pavement marking.

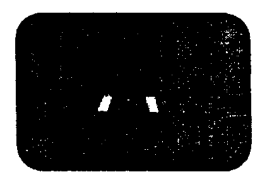
It doesn't take long for pavement markings to lose reflectivity when they become wet. In a matter of seconds they can disappear. Series 820 retains its high level of reflectivity no matter how long the rain lasts. Drivers can count on seeing a line when they most need it. And you will have the assurance that you are doing all you can to make roads safer for all.

Reflectivity Under Rain Conditions

Series 820 vs. Standard Marking

Wetting time 10 seconds

Wetting time 20 seconds



Wetting time 30 seconds

Appendix C-4

Description and Specifications
For
Delta LTL2000 Retrometer

SECTION 2

GENERAL INFORMATION

RI Measurement

LTL2000 Retrometer measures the Rl (coefficient of retro reflected luminance) parameter. The Rl parameter represents the brightness of the road markings seen by drivers of motor vehicles by headlight illumination.

In the LTL2000 the illumination angle is 1.24° and the observation angle is 2.29°, simulating a drivers viewing distance of 30 metres at an eye hight of 1.2 metres. The observation area is app. 45 mm. x 200 mm.

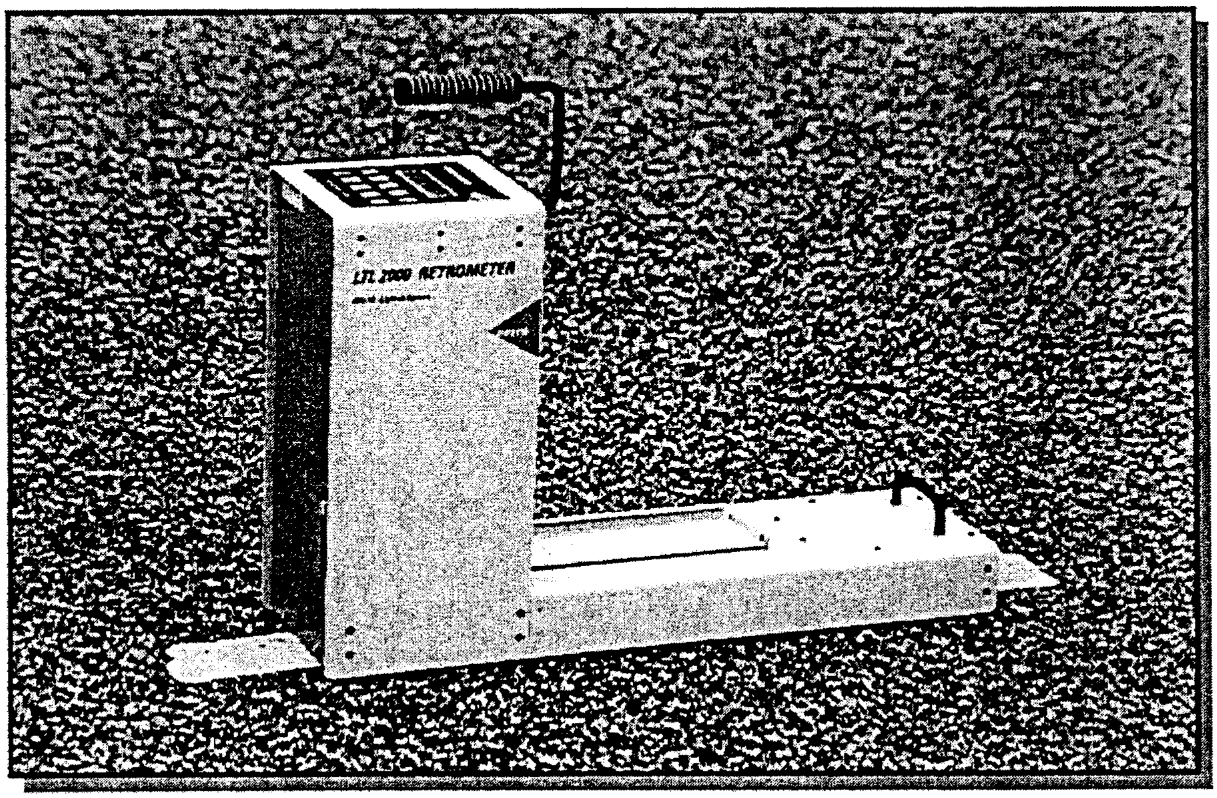


Figure 2 LTL2000 Side Look

Physically the Retrometer is dominated by the 'control' tower. The tower contains the illuminating and observation system and the control electronics. At the bottom of the tower an optical system, with mirrors, directs the beams towards the road surface through a dust-protection window. The measuring area is shielded by an aluminium housing with a rubber skirt and a light trap.

The LTL2000 is controlled by a microprocessor. The microprocessor executes the measurement automatically by the push of a button and presents the result on a display. The result is automatically transferred to an internal non-volatile memory. The result and corresponding time and date can be printed by the built-in printer. The LTL2000 is operated with a small keyboard located at the top of the Retrometer. Further, Retrometer control is possible over a serial communication link (RS232). Stored data can easily be transferred to a host PC for further processing.

Factory calibration

The LTL2000 Retrometer is factory calibrated. This calibration is carried out by using a special calibration unit and a specially designed base frame. The calibration unit's Rl value is measured in the laboratory using traceable methods and equipment.

The enclosed calibration unit and base frame can be used for the control and re-calibration of the Retrometer.

The LTL2000 is powered by a built-in lead acid battery, which under normal operation will keep the Retrometer operating a normal working day. The battery is recharged by use of an external charger.

Optical principle

The light is generated by a halogen lamp placed at the top of the tower, see Appendix C – figure 23. The light is focussed on a rectangular field stop and directed toward the illumination aperture at the front of the lens. Hereafter the beam is collimated by the lens and directed toward the road by a 50% beam splitter. The observation system is equivalent to the illuminating system. The reflected light enters the detection system mirror which deflects the light trough the collimator lens and observation aperture to the detector unit in top of the tower.

Observation field and angle are defined by field stops and apertures. The retro reflected light is collected by the detection mirror and by the lens focussed on an optical fibre bundle. The light is by the optical fibre bundle guided to an photo multiplier. An optical filter is placed in front of the photo multiplier to obtain colour matching.

APPENDIX C

SPECIFICATION

Table 1-1 General Characteristics

Illumination angle …………………………………………………………………… 1.24°
Observation angle …………………………………………………………………… 2.29°
Equivalent observer distance ……………………………………………………..… 30 m

Observation angular spread ………………………………………………………… ±0.17°
Type 30m CEN
Illumination angular spread horisontal ………………………………………………. 0.33°
Illumination angular spread vertical ………………………………………………… 0.17°
Type 30m ASTM
Illumination angular spread horisontal ………………………………………………. 010°
Illumination angular spread vertical ………………………………………………… 0.10°

Field of measurement:
Width ……………………………………………………………………… 45 mm (1.8 in)
Length (typ.) ………………………………………………….... 200 mm (7.9 in)

Min. reading (mcd/m^2/lx) ……………………………………………………………… 0
Max. reading (mcd/m^2/lx) …………………………………………………….. Typ. 2000

Table 1-2 Electrical Characteristics

EMC …………………………………………………………………………… EN 50081-1
EN 50082-1

Power supply:
Battery …………………………………………….. Build in 12 volt 3.5 Ah sealed lead acid
External charger ………………………………….… 230 VAC charging time app. 10 hours
90% capacity after app. 5 hours
Charger fuse (5*20 mm) …………………….…………………………………… T3.15A
Power supply fuse (5*20 mm) ………………..……………………………….... T3.15A

Data memory ……………………………………………………… >1000 measurements
Data retention (from purchase) …………………………………………….... Typ. 5 years

Serial communication mode ……………………………………………….. 9600, N, 8, 1
Data flow control ………………………………………………………………. Xon/Xoff
Interface ……………………………………………………………….. Modified RS 232

Table 1-3 Environmental Characteristics

Temperature:
  Operating ………………………………………………….. 0ºC to + 45ºC (32º F to +114º F)
  Storage*) …………………………………………………… -15ºC to +55ºC (5º F to +131º F)
Humidity …………………………………………………………………… Non condensing

*)Battery must be fully charged

Table 1-4 Mechanical Characteristics

Max. length ………………………………………………………………….. 720 mm (28.3 in)
Max. width …………………………………………………………………. 200 mm (7.9 in)
Max. height ………………………………………………………………….. 570 mm (22.4 in)
Weight ………………………………………………………………….... app. 11 kg (24 lbs.)
Shipping Weight …………………………………………………………... app. 22 kg (49 lbs.)

Construction:
  Housing ……………………………………………………………….……….. Aluminum
  Keyboard ……………………………………………………….……….. Plastic laminated
  Circuit boards ………………………………………………………….…... Epoxy glass

Printer:
  Thermal Paper ……..………………………… with/dia. 57.5mm/35mm (2.26 in/l.38in)

Appendix C-5

List of Institutions to Which Survey was Sent

List of Simulation Labs to Which Surveys Were Sent

Traffic Simulator	Contact/Website	Email/Telephone
HUTSIM	Project leader: Prof. Matti Pursula	matti.pursula@hut.fi
Paramics	nil	paramics-info@quadstone.com
Emme/2 Support Center	Heinz Spiess	heinz@spiess.ch/ (41) 32 373 20 57
TSS-Transport Simulation Systems	nil	info@tss-bcn.com
Massachusetts Institute of Technology (MITSIM TRAFFIC SIMULATOR)	nil	(617) 252-1124
Visual Solutions	Jim Webb	Jim.Webb@vissol.com/978-392-0100 ext 18 (978) 392-0100
DynaSMART	Hani S. Mahmassani, Ph.D.	The University of Texas at Austin Austin, Texas 78712-1076 masmah@mail.utexas.edu (512) 475-6361
TransLink® – Hardware-In-The-Loop	Kevin Balke, Ph.D	k-balke@tamu.edu
Helsinki University of Technology	D.Sc. Iisakki Kosonen	iisakki.kosonen@hut.fi/+358-9-4513804
Civil Engineering Research Institute of Hokkaido	Motok Asano	m-asano@ceri.go.jp/nil
University of Michigan Transportation Research Institute	Mr. Robert Sweet	bsweet@umich.edu/1-734-936-1073
HUT Transportation Engineering		
Helsinki University of Technology	Matti Pursula	Iisakki.Kosonen@hut.fi
CATSS CENTER FOR ADVANCE TRANSPORTATION SYSTEM SIMULATION	Essam Radwan, Ph.D., P.E.	aeradwan@mail.ucf.edu/407-823-2841
Warsaw University of Technology	Zbigniew Lozia	lozia@it.pw.edu.pl/+48 22 6605438

List of Simulation Labs to Which Surveys Were Sent

Traffic Simulator	Contact/Website	Email/Telephone
Carnegie Mellon Research Institute	John Tabacchi	jt08@andrew.cmu.edu/(412) 268-7376
HITLab, U. of Washington	Suzanne Weghorst	weghorst@u.washington.edu/+1.206.616.1487
INRETS,	Stéphane Espié	- espie@inrets.fr
Institute for Transport Studies	Hamish Jamson	hamish@psyc.leeds.ac.uk/++113 233 5730
University of Leeds		
Swedish national road Transportation research Inst	nil	staffan.nordmark@vti.se
The University of Waikato	nil	psycsec2@waikato.ac.nz/+64 7 838-4032
Cardiff University	J.K.McPherson	McPherson@cf.ac.uk/+44 (0) 2920 874007

Appendix C-6

Detailed Responses of Simulator Labs/Institutions

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

1) How many types of simulator do you (have at your site [1]) (build [2]) ? _______.
   (If the respondent has more than one simulator, go to Question 2).

2) Could you describe the simulator/ (**if more than one, complete separate forms:** Could you describe each of these simulators (Up to three))?

____
____
____
____
____

(**If more than one simulator has been mentioned, collect information about each in turn)**

3) What is the estimated price of this simulator?
a) below $5,000 **b**) between $5,000-$10,000 **c**) between $10,000-$15,000 **d**) between $15,000-$20,000 **e**) between $20,000-$25,000 **f**) between $25,000-$30,000 **g**) between $30,000-$35,000 **h**) between $35,000-$40,000 **i**) between $40,000-$45,000 **j**) between $45,000-$50,000 **k**) between $50,000-$55,000 **l**) between $55,000-$60,000 **m**) between $60,000-$65,000 **n**) between $65,000-$70,000 **o**) between $70,000-$75,000
Other:$_________________

4) Would you classify the simulator as a:

a) Low-end_____ b) Mid-range_____ c) High-end_____

5) Would you describe the simulator as:

a) Part-task driving simulator___ b) Interactive driving simulator_____
c) Other (Describe) ____
____

6) (Check all that apply) Is the simulator mostly used as: a) engineering simulator, b) research simulator, c) training simulator

7) Is your simulator:

a) Fixed-base simulator____ b) motion base simulator____

8) How are scenarios generated/programmed on your simulator?

a) Fixed universe (no potential for modification)
b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination
c) Open architecture: capability for representing any road environment/geometry
d) Other: ____
____
____
____
____

9) How are scenarios displayed on your simulator?
a) PC Monitors ______ (How many?____)
b) Forward projection screen _____
c) Back projection _____

10) If your simulator uses video display technology, what is the resolution of the display?
_____ by ______

11) How wide is the field of view provided by the display?

_______ degrees

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?
____
____
____
____
____

13) Can you use this simulator to model and evaluate specific road designs/geometrics?

Yes______ No______

14) What types of road designs/geometrics can you model and evaluate?
____
____
____
____
____

15) What are the limitations of this simulator in modeling specific road geometrics?

____
____
____
____
____

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?

Yes______ No______

17) What types of traffic control devices can be modeled on this simulator?

____
____
____
____
____

18) What are the limitations of this simulator in modeling specific components of traffic control devices (e.g., brightness, texture)?

____
____
____
____
____

19) What characteristics of this simulator do you like best?

____
____
____
____
____

20) What characteristics of this simulator do you like least?

____
____
____
____
____

21) What percentage of people tested on this simulator experience simulator sickness?

____

22) Could you list some publications on your work with this simulator?

____
____
____
____
____

23) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

____
____
____
____
____

Thank you, very much for your time.

Responses from

Civil Engineering Research Institute of Hokkaido (CERI)

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

1) How many types of simulator do you have at your site / build ___1___.
(If the respondent has more than one simulator, go to Question 2).

2) Could you describe the simulator/ (**if more than one, complete separate forms:** Could you describe each of these simulators (Up to three))?

A fixed simulator equipped with computer image generator, central processing unit, car cabin and a database development device.

(If more than one simulator, give information about each in turn)

3) What is the estimated price of this simulator?

a) Below $5,000 **b)** between $5,000-$10,000 **c)** between $10,000-$15,000 **d)** between $15,000-$20,000 **e)** between $20,000-$25,000 **f)** between $25,000-$30,000 **g)** between $30,000-$35,000 **h)** between $35,000-$40,000 **i)** between $40,000-$45,000 **j**) between $45,000-$50,000 **k)** between $50,000-$55,000 **l)** between $55,000-$60,000 **m)** between $60,000-$65,000 **n)** between $65,000-$70,000 **o)** between $70,000-$75,000
over $75,000

4) Would you classify the simulator as a:
a) Low-end__V___ b) Mid-range_____ c) High-end_____
as of now

5) Would you describe the simulator as:
a) Part-task driving simulator______ b) Interactive driving simulator__V____
c) Other (Describe) ______________________________

6) (Check all that apply) Is the simulator mostly used as: a) engineering simulator, b) research simulator, c) training simulator

7) Is your simulator:
a) Fixed-base simulator__v__ b) motion base simulator____

8) How are scenarios generated/programmed on your simulator?

a) Fixed universe (no potential for modification)
b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination
c) Open architecture: capability for representing any road environment/geometry
d) Other: ____

9) How are scenarios displayed on your simulator?
a) PC Monitors ______ (How many? ____)
b) Forward projection screen __v___
c) Back projection _____

10) If your simulator uses video display technology, what is the resolution of the display?
1024 By 1000

11) How wide is the field of view provided by the display?
40 degrees

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)¿

Passenger car type.

13) Can you use this simulator to model and evaluate specific road designs/geometrics?
Yes___v___ No______

14) What types of road designs/geometrics can you model and evaluate?

Urban road, Rural road, Expressway.

15) What are the limitations of this simulator in modeling specific road geometrics?

Number of polygons(max 300 poligons)

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?

Yes__v____ No______

17) What types of traffic control devices can be modeled on this simulator?

It depend on design of polygons. For example, traffic sign, lane marking.

18) What are the limitations of this simulator in modeling specific traffic control devices?

Number of polygons.

19) What characteristics of this simulator do you like best?

Changeability of road design.

20) What characteristics of this simulator do you like least?

Cost of road design database making and limitation of number of polygons.

21) What percentage of people tested on this simulator experience simulator sickness? 30%

21) Could you list some publications on your work with this simulator?

More than thirty papers.

23) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

Calculating speed, memory volume simplicity of road design database and cost performance would be essential.

Thank you, very much for your time.

Responses from

Helsinki University of Technology

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

<u>Characteristics of Simulator</u>

1) How many types of simulator do you have at your site 1______.
   (If the respondent has more than one simulator, go to Question 2).

2) Could you describe the simulator/ (**if more than one, complete separate forms:** Could you describe each of these simulators (Up to three))?

HUTSIM is a high-fidelity micro-scopic simulator for urban traffic. It is based on object-oriented modeling and rule-based dynamics.

(If more than one simulator, give information about each in turn)

3) What is the estimated price of this simulator?

   <u>a) Below $5,000</u> b) between $5,000-$10,000 **c)** between $10,000-$15,000 **d)** between $15,000-$20,000 **e)** between $20,000-$25,000 **f)** between $25,000-$30,000 **g)** between $30,000-$35,000 **h)** between $35,000-$40,000 **i)** between $40,000-$45,000 **j)** between $45,000-$50,000 **k)** between $50,000-$55,000 **l)** between $55,000-$60,000 **m)** between $60,000-$65,000 **n)** between $65,000-$70,000 **o)** between $70,000-$75,000

4) Would you classify the simulator as a:
   a) Low-end_X__ b) Mid-range_____ c) High-end_____

5) Would you describe the simulator as:
   a) Part-task driving simulator_____ b) Interactive driving simulator_____
   <u>c) Other (Describe)</u>
   Urban traffic simulator (not a driving simulator at all)

6) (Check all that apply) Is the simulator mostly used as: a) **engineering simulator**, **<u>b) research simulator</u>**, c) training simulator

7) Is your simulator:
   a) Fixed-base simulator____ b) motion base simulator____

8) How are scenarios generated/programmed on your simulator?
   a) Fixed universe (no potential for modification)
   b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination

c) **<u>Open architecture: capability for representing any road environment/geometry</u>**
d) Other: ____

9) How are scenarios displayed on your simulator?
   a) PC Monitors ______ (How many? ____)
   b) Forward projection screen _____
   c) Back projection _____

10) If your simulator uses video display technology, what is the resolution of the display?
   _480_ By 640____

11) How wide is the field of view provided by the display?
   _______ degrees

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?

HUTSIM is based on rule-based vehicle dynamics
10 vehicle types are included

13) Can you use this simulator to model and evaluate specific road designs/geometrics?
   Yes __X____ No______

14) What types of road designs/geometrics can you model and evaluate?

Lower speed at corners, the effect of vertical alignment for heavy vehicles

15) What are the limitations of this simulator in modeling specific road geometrics?

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?
   Yes___X___ No______

17) What types of traffic control devices can be modeled on this simulator?

Lane markings, yield and stop signs, lane signals, speed limit signs
Traffic signals: fixed time, vehicle actuated, isolated, coordinated

18) What are the limitations of this simulator in modeling specific traffic control devices?

19) What characteristics of this simulator do you like best?

It is good for detailed traffic and control planning

20) What characteristics of this simulator do you like least?

It is not very fast and not for large networks

21) What percentage of people tested on this simulator experience simulator sickness? __________

22) Could you list some publications on your work with this simulator?

See enclosed list

23) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

HUTSIM models also the intersection areas and pedestrian traffic in full detail. These features make HUTSIM ideal in combining it with a driving simulator.

Thank you, very much for your time.

Responses from

I-SIM

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

1) **How many types of simulator do you (have at your site [1]) (build [2]) ?**
___4____. **(If the respondent has more than one simulator, go to Question 2).**

2) **Could you describe the simulator/ (if more than one, complete separate forms: Could you describe each of these simulators (Up to three))?**

Please see our website http://www.i-sim.com

We have our TranSim simulator - http://www.i-sim.com/transim.htm which is a part-task trainer for shifting.

We have our TranSim VS - http://www.i-sim.com/transimvs.htm which includes all the functionality of the TranSim, and adds to it a visual system and steering with control force loading.

We have our PatrolSim - http://www.i-sim.com/patrolsim.htm simulator (and variants – car applications) – a fixed-base, three-channel visual sytem with rear view mirror insets; and with a fully instrumented cockpit and law enforcement console.

And we have our Century Mark II Series - http://www.i-sim.com/century.htm simulator which is a full motion based, full visual system simulator that can be offered with truck, car and specialty vehicle cabs

(If more than one simulator, give information about each in turn)

3) **What is the estimated price of this simulator?**

a) below $5,000 **b**) between $5,000-$10,000 **c**) between $10,000-$15,000 **d**) between $15,000-$20,000 **e**) between $20,000-$25,000 **f**) between $25,000-$30,000 **g**) between $30,000-$35,000 **h**) between $35,000-$40,000 **i**) between $40,000-$45,000 **j**) between $45,000-$50,000 **k**) between $50,000-$55,000 **l**) between $55,000-$60,000 **m**) between $60,000-$65,000 **n**) between $65,000-$70,000 **o**) between $70,000-$75,000

TranSim – j
TranSim VS - > j $80,000
PatrolSim - $90,000
Century Series - >$390.000

4) **Would you classify the simulator as a:**
a) Low-end_____ b) Mid-range_____ c) High-end_____

TranSim – a
TranSim VS – b
PatrolSim – b
High End - c

5) **Would you describe the simulator as:**
a) Part-task driving simulator______ b) Interactive driving simulator_____
c) Other (Describe)

TranSim – a, b
TranSim VS – a, b
PatrolSim – a,b
Century – a,b

6) **(Check all that apply) Is the simulator mostly used as: a) engineering simulator, b) research simulator, c) training simulator**

TranSim – a, c (technology is being used in the Nat'l Advanced Driving Sim)
TranSim VS – a, b, c
PatrolSim – a,b, c
Century – a,b, c

7) **Is your simulator:**
a) **Fixed-base simulator____ b) motion base simulator____**

TranSim – a
TranSim VS – a
PatrolSim – a
Century – a, b

8) **How are scenarios generated/programmed on your simulator?**

a) **Fixed universe (no potential for modification)**
b) **Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination**

c) **Open architecture: capability for representing any road environment/geometry**
d) **Other:**

For all our simulators except for the TranSim, we have the capability to generate scenarios/environments for any situation.

We offer several standard driving environments: suburban, rural, freeway, desert, etc. ... With our Scenario Editing Tools, which have a Windows 'point and click'/'drag and drop' feel, vehicles, traffic control devices, railroads, pedestrians and other fixed, moving models can be placed and controlled either with commanded behaviors or with 'intelligent, dynamic' behaviors in which they will autonomously function with consideration for other traffic and rules of the road.

9) How are scenarios displayed on your simulator?
a) **PC Monitors ______ (How many?____)**
b) **Forward projection screen _____**
c) **Back projection _____**

TranSim – N/A
TranSim VS – a (1) forward, with rear view insets
PatrolSim – a (3) forward with rear view insets
Century – b (3) with LCD panels for side/rearview mirrors (additional visual channels for each

10) If your simulator uses video display technology, what is the resolution of the display?

640 by 480 ➔ 1240 x 780

11) How wide is the field of view provided by the display? _______ degrees

There are two considerations for the field of view: the physical size and the electronic image that can be displayed.

The physical size is determined by the eye-point and the physical dimensions; the electronic image can be adjusted (compressed or expanded to give any field of view).

The following answers focus on the physical size and are approximate:

TranSim – 30 deg

TranSim VS – 60 deg
PatrolSim – 180 deg
Century – 180 deg plus the fields of view in the rear/side mirrors

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?

The TranSim (originally developed by the Eaton Corporation for engineering research has virtually any drive train for trucks in the U.S.)
The TranSim VS, PatrolSim and Century use the same vehicle dynamics model that is parametrically driven. We have data files loaded in standard configurations for cars (several models), jeeps, HMMWV (humvees), trucks (several models) and several types of specialty vehicles. Adding additional vehicle types is easy given the availability of manufacturers' (or otherwise collected) data about the vehicle.

13) Can you use this simulator to model and evaluate specific road designs/geometrics?

Yes______ No______

TranSim - no
TranSim VS - yes
PatrolSim - yes
Century - yes

14) What types of road designs/geometrics can you model and evaluate?

any and all

15) **What are the limitations of this simulator in modeling specific road geometrics?**

None - our architecture has a very detailed tire – road interface model in which all aspects of the road are modeled at a very high degree of fidelity.

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?

Yes______ No______

Yes (all simulators except the TranSim)

17) What types of traffic control devices can be modeled on this simulator?

All types

18) What are the limitations of this simulator in modeling specific traffic control devices?

None – other than resolution (our simulators do not offer eye-limited resolution; however, that is a constraint that can be worked around either in the research design or by exaggerating the characteristics in the database to compensate for the resolution limitations.

19)What characteristics of this simulator do you like best?

Fidelity of the system, flexibility of applications. The software characteristics of the system have the oldest heritage of any commercially available driving simulator, and has evolved since the development of the Daimler-Benz research simulator in the late 1980s. The software is arguably the most sophisticated/proven in the industry.

20)What characteristics of this simulator do you like least?

That is very subjective, depending on use. To our knowledge, our product lines are the most successful for their intended function.

21)What percentage of people tested on this simulator experience simulator sickness? __________

Simulator adaptation is a phenomenon inherent in all human – simulator interactions. We have found that with proper screening of subjects, e.g. excluding those who have head colds, wear tri-focals, poor attitudinal disposition and with proper work-up in use of the simulators, i.e. allowing time for adaptation, we have minimal to no debilitating/nauseating occurrences of simulator adaptation syndrome. (in all simulators there is some adaptation, which is why I phrased the last sentence the wav I did).

22)**Could you list some publications on your work with this simulator?**

To my knowledge, the only published research done with our simulator was by Dr. Richard Grace at Carnegie-Mellon Research Institute for the Federal Highway Administration. Recently, the psychology department at the University of Utah has purchased one for their research needs.

23) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

There is nothing specific that I would add about our capabilities other than the fidelity of the simulation and the flexibility and breadth of our simulator line in their capabilities.

In general, simulators have shown their usefulness in several efforts around the world. At the Driving Simulation Conference '97 held in France, there was a paper that were presented that might be applicable. I do not know if the following information is current/valid, but from the proceedings:

Visualization of Road Designs for Assessing Human Factors Aspects in a Driving Simulator TNO Human Factors Research Institute, The Netherlands
Wytze Hoekstra e-mail: Hoekstra@tm.tno.nl

Also, I know that the University of Leeds had a Dr. Evi Blana who did her doctoral dissertation there on the use of their simulator in validating the design of a highway toll booth.

If I can be of further assistance, please do not hesitate to contact me:

Fred Craft
GE Capital I-Sim
Phone: 1.801.303.5670
Fax: 1.801.983.9922
E-mail: Frederick.Craft@gecapital.com

GE Capital I-Sim

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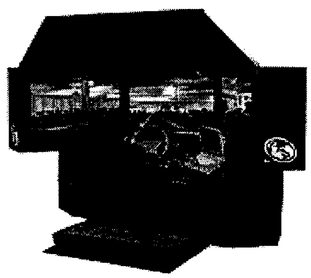
I-Sim offers a **complete line** of simulation systems. Starting with systems such as the TranSim truck transmission simulator through **completely immersive** car/truck simulators in our new PatrolSim and Century series.

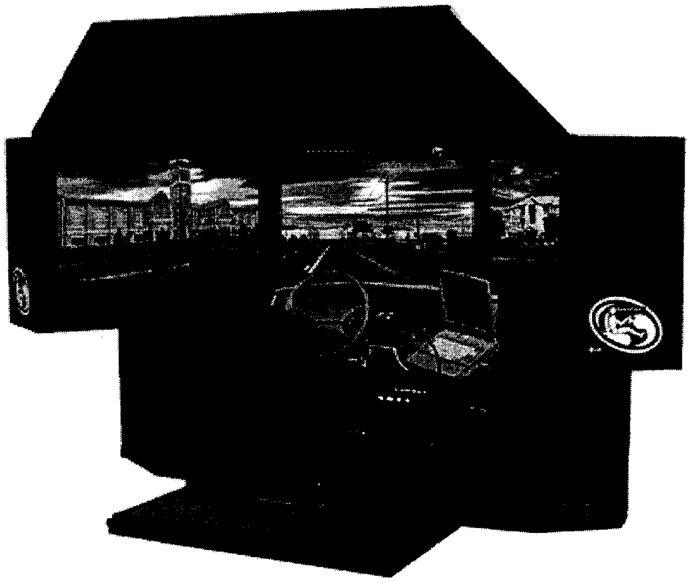


I-Sim's PatrolSim™ is a compact, high-performance driving simulator for the law enforcement and government marketplace, which utilizes I-Sim's state-of-the-art simulation technology, providing a highly realistic and immersive training environment. The PatrolSim is available with CA POST certified driving scenarios.

GE Home| GE Businesses| Small Business| Industry Solutions|Home Solutions| Personal Finance| Corporate Info

GE Capital I-Sim

PatrolSim™ Driver Training Simulator



PatrolSim™ Driving Simulator provides an open seat driving station in a low-cost, high-fidelity, driving environment that is suitable for training and research applications. It includes an Operator Console that provides interactive, real-time control of the driving environment. The PatrolSim incorporates I-Sim's proprietary vehicle dynamics, traffic scenario, and road surface software that provide accurate stimuli to the simulator driver.

The PatrolSim is a stand alone, expandable and upgradeable driver training simulator system capable of simulating conditions for police vehicles, fire trucks, ambulances, pickups and public works vehicles. Some of the highlights of the PatrolSim include:

Open seat driving configuration with typical police cruiser dash including all instrumentation and controls.
Expanded horizontal field of view (FOV) provides up to 270 degrees
Advanced graphics
Powerful scenario creation editing tools that allow instructors to quickly create and edit scenarios and run them within minutes on the driver simulator
Scenario traffic incorporates artificial intelligence; vehicles behave as in real life or can be controlled in real time
Open architecture Windows™ based software running on off-the-shelf commercially available PC computer platforms

GE Capital I-Sim

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Contact US

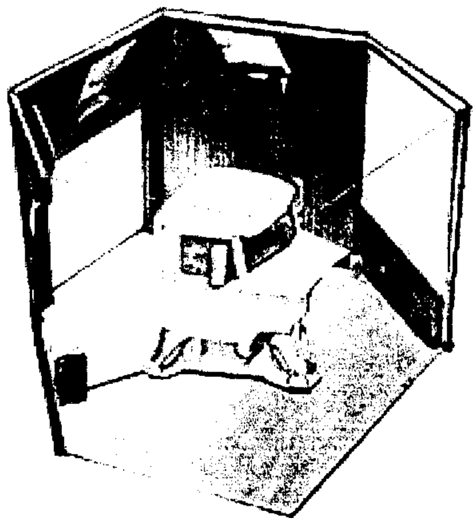
I-Sim, LLC
2961 W. California Avenue
Salt Lake City, UT 84104

Phone (801) 983-9900
Fax (801) 983-9901 9922
Or email us, info@i-sim.com

For current customers in need of technical support please email support@i-sim.com

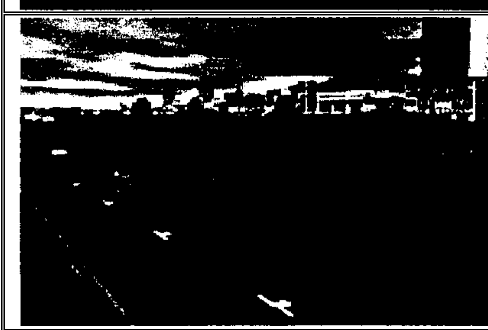
GE Capital I-Sim

Image Gallery



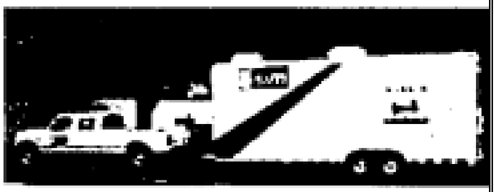
Century Series
I-Sim's line of Century simulators (Mark I & Mark II) is modular and upgradeable. This allows customers to adapt their simulators to meet their specific training needs.

TruckSim
Exterior view of the Mark II Trucksim located at Carnegie Mellon University.



Suburban Database
I-Sim offers various databases, including city, freeway, and rural driving scenes. Geo typical and geo specific modeling allows a customer to customize their scenes to replicate their speific city or town.

Mobile Simulator



Mobile Simulator
The Mobile configuration allows you to bring the training to your students. Using the Alpha or Century series technology trainers will be able to support multiple sites in a regional area to further increase system usage.

Freeway Database – Fog Scene
The databases allow instructors the ability to change weather patterns, time of day, traffic density, and bring various training situations to the trainee. Customers have the ability to develop scenarios and databases to better train their students.

OpCon center
The operator/trainer sits at the Operator's Console(OpCon). The OpCon at Carnegie Mellon Research Institute is shown.

Humvee Simulator
The Mark II Humvee driving simulator debuted at the 1998 I/ITSEC Show in Orlando, FL..

Responses from

Paramics

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

1) How many types of simulator do you have at your site / build _______.
   (If the respondent has more than one simulator, go to Question 2).

2) Could you describe the simulator/ (**if more than one, complete separate forms:** Could you describe each of these simulators (Up to three))?

Paramics is an advanced suite of software tools for microscopic traffic simulation. Modeller provides the three fundamental operations of model build, traffic simulation (with 3-D visualisation) and statistical output accessible through a powerful and intuitive graphical user interface. Every aspect of the transportation network can be investigated in Modeller including:

- Mixed urban and freeway networks
- Right-hand and left-hand drive capabilities
- Advanced signal control
- Roundabouts
- Public transportation
- Car Parking
- Incidents
- Truck-lanes, high occupancy vehicle lanes

By modelling individual vehicles Modeller provides the transportation professional with insight into and better understanding of many hundreds of network issues, resulting in a more efficient and effective approach to projects.

(If more than one simulator, give information about each in turn)

3) What is the estimated price of this simulator?

   b) between $5,000-$10,

4) Would you classify the simulator as a:

   c) High-end

5) Would you describe the simulator as:

   A microscopic traffic flow/behavior simulator.

6) (Check all that apply) Is the simulator mostly used as:

a) engineering simulator & b) research simulator

7) Is your simulator:

neither

8) How are scenarios generated/programmed on your simulator?

Open architecture: capability for representing any road environment/geometry

9) How are scenarios displayed on your simulator?

PC Monitors

10) If your simulator uses video display technology, what is the resolution of the display?

N/a

11) How wide is the field of view provided by the display?

N/a

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?

Car Following, Lane Changing, Gradient, Curvature, Modes of Acceleration, Behavioral influences. Any Vehicle type can be modeled.

13) Can you use this simulator to model and evaluate specific road designs/geometrics?

Yes

14) What types of road designs/geometrics can you model and evaluate?

Any type

15) What are the limitations of this simulator in modeling specific road geometrics?

Lane based traffic flow theory must be adhered to.

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?

Yes

17) What types of traffic control devices can be modeled on this simulator?

Any type used in the real world.

18) What are the limitations of this simulator in modeling specific traffic control devices?

No limitations.

19)What characteristics of this simulator do you like best?

Easy of use, flexibility, extendibility, customization options, graphics, speed/power/scalability, high level of detail

20)What characteristics of this simulator do you like least?

Dependence on X-Server/X-Windows/Motif technologies

21) What percentage of people tested on this simulator experience simulator sickness?

N/a

22) Could you list some publications on your work with this simulator?

http://www.paramics-online.com/tech_support/reports.htm

23)Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

Visit www.paramics-online.com for more information about the Paramics software.

Responses from

STISIM

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

1) How many types of simulator do you (have at your site [1]) (build [2]) ?
__5_____. (If the respondent has more than one simulator, go to Question 2).

2) Could you describe the simulator/ (**if more than one, complete separate forms:** Could you describe each of these simulators (Up to three))?
__PC based, can include a variety of display devices, consoles, cabs and motion bases depending on desired application.
____
____
____

(If more than one simulator has been mentioned, collect information about each in turn)

3) What is the estimated price of this simulator?
   a) below $5,000 **b**) between $5,000-$10,000 **c**) between $10,000-$15,000 **d**) between $15,000-$20,000 **e**) between $20,000-$25,000 **f**) between $25,000-$30,000 **g**) between $30,000-$35,000 **h**) between $35,000-$40,000 **i**) between $40,000-$45,000 **j**) between $45,000-$50,000 **k**) between $50,000-$55,000 **l**) between $55,000-$60,000 **m**) between $60,000-$65,000 **n**) between $65,000-$70,000 **o**) between $70,000-$75,000
   b) **Other**: Software and display card kit starts at $5,000. Full simulator with console or cab (fixed base) about $65,000. With motionbase on the order of $150,000-200,000.
   $_________________

4) Would you classify the simulator as a:

a) Low-end_kit____ b) Mid-range_fixed base__c) High-end_Motionbase____

5) Would you describe the simulator as:

a) Part-task driving simulator___ b) Interactive driving simulator__X___
c) Other (Describe) ____
____

6) (Check all that apply) Is the simulator mostly used as: a) engineering simulator X, b) research simulator X, c) training simulator X

7) Is your simulator:

a) Fixed-base simulator__X_ b) motion base simulator__X_

8) How are scenarios generated/programmed on your simulator?

a) Fixed universe (no potential for modification)
b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination
c) *Open architecture: capability for representing any road environment/geometry* X
d) Other: ____
____
____
____
____

9) How are scenarios displayed on your simulator? *Whatever is desired by customer.*
a) PC Monitors ______ (How many?____)
b) Forward projection screen _____
c) Back projection _____

10) If your simulator uses video display technology, what is the resolution of the display?
__1280___ by _1024_____

11) How wide is the field of view provided by the display?

__180__ degrees (could be more with additional display generators)

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?
___*Virtually any vehicle including passenger vehicles, single unit and articulated trucks and busses, we have over 50 vehicle models*____
____

13) Can you use this simulator to model and evaluate specific road designs/geometrics?

Yes__X____ No______

14) What types of road designs/geometrics can you model and evaluate?
___*Horizontal and vertical curvature and cross section are arbitrary and can be specified based on roadway design programs such as GeoPac and InRoads*

15) What are the limitations of this simulator in modeling specific road geometrics? *As a practical matter there are no limitations.*

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?

Yes__X____ No______

17) What types of traffic control devices can be modeled on this simulator?
____*Signs, Signals and Markings, Construction Zone delineation*

18) What are the limitations of this simulator in modeling specific components of traffic control devices (e.g., brightness, texture)?
___*Limitations have to do with display device selected (monitor, projector, etc) We have used special display insets to get higher sign resolution and brightness/contrast.*___

19) What characteristics of this simulator do you like best? ___*Scenario programmability, transportability*___

20) What characteristics of this simulator do you like least? ___*Keeping up with PC technology (e.g. new mother boards every six months or less, causes configuration problems*___

21) What percentage of people tested on this simulator experience simulator sickness? ___*5% (narrow field of view), 15% (wide field of view)*___

22) Could you list some publications on your work with this simulator?
___*See reference list*___

23) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

____*Very flexible in adding TCDs. We have a relatively complete set of US and European road signs. Easy to add new signs.*____
____
____
____
____
_

Thank you, very much for your time.

SYSTEMS TECHNOLOGY, INC

13766 S. HAWTHORNE BOULEVARD • HAWTHORNE, CALIFORNIA 90250-7083 • PHONE (310) 679-2281
http://www.systemstech.com/ FAX (310) 644-3887

STISIM *Drive*™ DRIVING SIMULATOR CONFIGURATIONS AND PRICES

Prices are for sales within the USA only. Prices include shipping within the Continental United States. Prices do not include applicable sales taxes. ***Prices are subject to change without notice.***

Model 100 - Game Control Interface

(Interactive driving simulator with a single driving display and 45 degree driver field-of-view, commercial game-type driving controls and **STISIM *Drive*™** simulation software)

Complete System .... **US $ 13,000**

Includes: Pentium® computer[1] and interface cards (sound/game and graphics cards) with simulation software, Windows 2000 operating system, 17" driving display, 15" operator's display, game-type driving controls, amplified audio speakers, electronic Software User's Manual (HTML files) and 10 hours of phone/fax/email support. System will be configured and tested at STI before shipping.

System Kit (Self-Installation) .... **US $ 5,250**

Includes: Simulation software, electronic Software User's Manual (HTML files), and 10 hours of phone/fax/email support. Requires computer and interface cards, Windows 2000 operating system, driving controls, monitor, and installation by user[2]. Recommended only for users with a thorough knowledge of PC hardware and configuration.

Model 200 - Analog Control Interface with Spring Centered Steering ... US $ 19,500

(Interactive driving simulator with a single driving display and 45 degree driver field-of-view, robust full-size driving controls with analog sensors, and **STISIM *Drive*** simulation software)

Includes: Pentium computer[1] and interface cards (sound/game, graphics, and analog control interface cards) with simulation software, Windows 2000 operating system, 17" driving display, 15" operator's display, modular steering unit with a spring centered full-size steering wheel, modular accelerator and brake pedal unit, robust analog control input sensors, audio speakers,

---

[1] 1 GHz Pentium or better, 256 MB RAM, 13.0 GB Hard Disk, 1.44 MB Floppy, CD-RW, Keyboard, and Mouse.

[2] Due to the real-time nature of this application, installation requires thorough familiarity with PC hardware configuration and the Microsoft Windows® operating system. Systems Technology, Inc. (STI) will provide limited phone support (10 hours) to assis t with installation. Only STI recommended hardware should be used.

electronic Software User's Manual (HTML files) and 10 hours of phone/fax/email support. System will be configured and tested at STI before shipping.

Model 300 - Digital Control Interface with Active Steering …… **US $ 33,500**

(Interactive driving simulator with a single driving display and 45 degree driver field-of-view, robust full-size driving controls with high-resolution digital sensors and speed-sensitive steering feel, and **STISIM *Drive*** simulation software)

Includes: Pentium computer[1] and interface cards (sound/game, graphics, and digital control interface cards) with simulation software, Windows 2000 operating system, 17" driving display, 15" operator's display, modular steering unit with speed-sensitive steering feel provided by a computer controlled torque motor through a full-size steering wheel, modular accelerator and brake pedal unit, high-resolution digital-optical control input sensors, audio speakers, electronic Software User's Manual (HTML files) and 10 hours of phone/fax/email support. Price includes on-site installation, testing and training (one day).

Model 400 - Wide Field-of-View System with Active Steering ………….. **US $ 50,500**

(Interactive driving simulator with three driving displays and 135 degree driver field-of-view, robust full-size driving controls with high-resolution digital sensors and speed-sensitive steering feel, and **STISIM *Drive*** simulation software)

Includes: Pentium computers[1] and interface cards (sound/game, graphics, and digital control interface cards) with simulation software, Windows 2000 operating systems, Three 17" driving displays, 15" operator's display, modular steering unit with speed-sensitive steering feel provided by a computer controlled torque motor through a full-size steering wheel, modular accelerator and brake pedal unit, audio speakers, electronic Software User's Manual (HTML files) and 10 hours of phone/fax/email support. Price includes on-site installation, testing and training (one day).

Systems Technology, Inc.
www.systemstech.com
(310) 679-2281

Model 500 - Comprehensive Vehicle Dynamics Model with Active Steering... **US $ 43,500**

(Interactive driving simulator with a single driving display and 45 degree driver field-of-view, robust full-size driving controls with high-resolution digital sensors and speed-sensitive steering feel, and STISIM Drive simulation software with the **VDANL *Drive***™ comprehensive non-linear vehicle and tire dynamics model)

Includes: Pentium computers1 and interface cards (sound/game, graphics, and digital control interface cards) with simulation software, Windows 2000 operating systems, 17" driving display, 15" operator's display, modular steering unit with speed-sensitive steering feel provided by a computer controlled torque motor through a full-size steering wheel, modular accelerator and brake pedal unit, audio speakers, electronic Software User's Manual (HTML files) and 10 hours of phone/fax/email support. Price includes on-site installation, testing and training (one day).

Model 500W - Wide Field-of-View System with Comprehensive Vehicle Dynamics Model and Active Steering …… **US $ 64,500**

(Interactive driving simulator with three driving displays and 135 degree driver field-of-view, robust full-size driving controls with high-resolution digital sensors and speed-sensitive steering feel, and **STISIM *Drive*** simulation software with the **VDANL *Drive***™ comprehensive non-linear vehicle and tire dynamics model)

Includes: Pentium computers[1] and interface cards (sound/game, graphics, and digital control interface cards) with simulation software, Windows 2000 operating systems, Three 17" driving displays, 15" operator's display, modular steering unit with speed-sensitive steering feel provided by a computer controlled torque motor through a full-size steering wheel, modular accelerator and brake pedal unit, audio speakers, electronic Software User's Manual (HTML files) and 10 hours of phone/fax/email support. Price includes on-site installation, testing and training (one day).

Systems Technology, Inc.
www.systemstech.com
(310) 679-2281

Options

The following options are available with all **STISIM *Drive*** Models unless otherwise stated.

STISIM *Drive* Open Module ………………………………. **US $ 12,500**

The **STISIM *Drive*** Open Module allows the user to incorporate custom software modules in the simulation. Example applications include: incorporation of user-developed events in the scenario definition language (SDL), custom displays and audio cues for warning devices, specialized data measurement and recording functions, and interfaces with external hardware. This option permits the user to write and compile source code using Visual Basic 6.0 that can interact with **STISIM *Drive*** through the Windows Command Object Model (COM) interface. Example Open Module routines are provided.

VDANL Open Module ……………………………………… **US $ 9,995**
(Available with Model 500 and 500W only)

The VDANL Open Module allows the user to incorporate custom software modules in the advanced vehicle dynamics model, **VDANL *Drive***, provided with the Model 500 and 500W. Example applications include: the incorporation of user-developed driver and automatic steering control laws, and control strategies for traction control, active suspensions, and other advanced vehicle control systems including hardware-in-the-loop systems. This option permits the user to write and compile source code using Visual Basic 6.0 that can interact with **VDANL *Drive*** through the Windows **Command Object Model (COM) interface. Example Open Module routines are** provided.

Simulated Car Cab Unit ……………………………………… **US $9,500**
Replaces the modular steering, brake, and throttle units provided with **STISIM *Drive*** systems with an integrated simulated car cab unit and seat with standard full-size driving controls.
A manual transmission or automatic transmission selector could also be incorporated in this unit at additional cost.

Manual Transmission …………………………………………. **US $4,500**
(available with Models 300, 400, 500, and 500W only)

Includes a clutch pedal incorporated in the modular pedal unit and a six - speed manual transmission (5 Forward + Reverse) in a separate modular unit. Additional parameter files are provided for adjusting transmission parameters.

Additional Input-Output Interface Card ………………………… **US $1,050**

Provides additional digital and analog output channels and digital input channels for interfacing the simulation with other devices and equipment. Allows analog and digital communication between the simulation and external equipment through specific **STISIM *Drive*** scenario definition language (SDL) events. All models except for the Model 100 include some digital input-output capability -- this additional card could be used to enhance or add this capability in all **STISIM *Drive*** Models.

Other Options Include:

- Projection systems and larger monitors for the driving displays
- Printer
- Special driving control interfaces
- Customized driving scenario development
- Interface with other PC-based cognitive and psychomotor tests
- Consulting services on driver behavior assessment and measurement

Please call Bimal Aponso at (310) 679-2281 Ext. 61 (email: bimal@systemstech.com) for pricing information on these options.

Systems Technology, Inc.
www.systernstech. corn
(310) 679-2281

Responses from

University of Central Florida

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

1) How many types of simulator do you have at your site / build 2.
(If the respondent has more than one simulator, go to Question 2).

2) Could you describe the simulator/ **(if more than one, complete separate forms:** Could you describe each of these simulators (Up to three))?

Simulator #1: Fixed base simulator. Home built system. The Image Generator is an SGI multi processor. A 140-degree wrap around screen. 3 Channels. Home developed smart traffic and scenario generation. Visual database created with Multigen.

Simulator #2: Built by GE Capitol I-Sim. Motion base 6 DF with five channels. Interchangeable cab with a truck and passenger car. PC base IG system. Flat panel front screens. Pre-developed scenario generation system developed by GE Capitol I-Sim

(If more than one simulator, give information about each in turn)

3) What is the estimated price of this simulator?

Simulator #1 is home built and has been upgraded over a 12 year period. Hard to give a price range especially that hardware has gotten cheaper over the years. Simulator #2 cost $400,000.

a) Below $5,000 **b)** between $5,000-$10,000 **c)** between $10,000-$15,000 **d)** between $15,000-$20,000 **e)** between $20,000-$25,000 **f)** between $25,000-$30,000 **g)** between $30,000-$35,000 **h)** between $35,000-$40,000 **i)** between $40,000-$45,000 **j)** between $45,000-$50,000 **k)** between $50,000-$55,000 **l)** between $55,000-$60,000 **m)** between $60,000-$65,000 **n)** between $65,000-$70,000 **o)** between $70,000-$75,000

4) Would you classify the simulator as a:
a) Low-end_____ b) Mid-range_____ c) High-end __X__

5) Would you describe the simulator as:
a) Part-task driving simulator___ b) Interactive driving simulator _X__
c) Other (Describe) ____

6) (Check all that apply) Is the simulator mostly used as: **a) engineering simulator, b) research simulator, c) training simulator**

7) Is your simulator:
   a) Fixed-base simulator__**#1**__ b) motion base simulator__**#2**__

8) How are scenarios generated/programmed on your simulator?
   a) Fixed universe (no potential for modification)
   b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination
   c) Open architecture: capability for representing any road environment/geometry in #1. Scenario editor used for #2.
   d) Other: ____

9) How are scenarios displayed on your simulator?
   a) PC Monitors ______ (How many? ____)
   b) Forward projection screen __**X**___
   c) Back projection _____

10) If your simulator uses video display technology, what is the resolution of the display?
    1024 By 768 (#1) and 800 By 600 for #2

11) How wide is the field of view provided by the display?
    _**140 for #1 and 220 for #2**______ degrees

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?

Simulator #1 uses a model that was obtained from FHWA, developed for them by Systems Technology, Inc. It can be configured for different classes of passenger vehicles. We also use Clarus Drive from Prosolvia which is no longer in business.

Simulator #2 has a built in vehicle dynamics model that can simulate trucks pulling trailers (automatic and stick shift), passenger cars, buses (transit, school), emergence vehicles,...etc.

13) Can you use this simulator to model and evaluate specific road designs/geometrics?

Yes___**X**___ No______

14) What types of road designs/geometrics can you model and evaluate?

Two-lane roads, signalized streets, freeways, and urban/suburban streets.

15) What are the limitations of this simulator in modeling specific road geometrics?

IG polygon rendering, Multigen Road Tools cannot be used for intersections. (Visibility of traffic control devices)???

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?

Yes___X___ No______

17) What types of traffic control devices can be modeled on this simulator?

Signs, markings, traffic signals, and work zones

18) What are the limitations of this simulator in modeling specific traffic control devices?

Resolution of traffic signs and being able to read that in advance

19)What characteristics of this simulator do you like best?

Testing different stimulus on drivers' reaction in a systematic way including weather changes, light and dark, and different road surfaces.

20)What characteristics of this simulator do you like least?

The ability to show objects in high resolution from a distance

21) What percentage of people tested on this simulator experience simulator sickness? ___**Not Available**______

22) Could you list some publications on your work with this simulator?
Visit CATSS website at www.catss.ucf.edu and get names of projects and reports listed then contact the PIs

23)Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

Thank you, very much for your time.

Responses from

University of Michigan Transportation Research Institute

Questionnaire for Assessing the Capability of Simulation in Assessing Specific Improvements

Characteristics of Simulator

6) How many types of simulator do you have at your site / build _2______. (If the respondent has more than one simulator, go to Question 2).

7) Could you describe the simulator/ (if more than one, complete separate forms: Could you describe each of these simulators (Up to three))?
______KQ Corp (formerly Hyperion) Vection driving simulator______now bing installed____

(If more than one simulator, give information about each in turn)

8) What is the estimated price of this simulator?

a) Below $5,000 b) between $5,000-$10,000 c) between $10,000-$15,000 d) between $15,000-$20,000 e) between $20,000-$25,000 f) between $25,000-$30,000 g) between $30,000-$35,000 h) between $35,000-$40,000 i) between $40,000-$45,000 j) between $45,000-$50,000 k) between $50,000-$55,000 l) between $55,000-$60,000 m) between $60,000-$65,000 n) between $65,000-$70,000 o) between $70,000-$75,000

$130K approx for hardware and software, much more for building mods, ext
9) Would you classify the simulator as a:
a) Low-end_____ b) Mid-range__x___ c) High-end_____

10) Would you describe the simulator as:
a) Part-task driving simulator______ b) Interactive driving simulator___x__
c) Other (Describe) ____

6) (Check all that apply) Is the simulator mostly used as: a) engineering simulator, b) research simulator, c) training simulator (b)

7) Is your simulator:
d) Fixed-base simulator___x_ b) motion base simulator____

10) How are scenarios generated/programmed on your simulator?
a) Fixed universe (no potential for modification)
b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination
c) Open architecture: capability for representing any road environment/geometry
d) Other: ____
_________c____

11) How are scenarios displayed on your simulator?
a) PC Monitors ______ (How many? ____)
e) Forward projection screen __3___
f) Back projection ___1__

a) Part-task driving simulator______ b) Interactive driving simulator__x___
c) Other (Describe) ____

6) (Check all that apply) Is the simulator mostly used as: a) engineering simulator, b) research simulator, c) training simulator (b)

7) Is your simulator:
a) Fixed-base simulator____x b) motion base simulator____

8) How are scenarios generated/programmed on your simulator?
a) Fixed universe (no potential for modification)
b) Specific modules (e.g., buildings, vehicles, road sections, traffic control devices) with great range for combination
c) Open architecture: capability for representing any road environment/geometry
d) Other: ____
_______some b, some c, we can only simulate 2 lane curving roads, but we can have any types of buildings or traffic (which is scriptable)____

9) How are scenarios displayed on your simulator?
a) PC Monitors ______ (How many? ____)
b) Forward projection screen __x___
c) Back projection _____

10) If your simulator uses video display technology, what is the resolution of the display?
_640____ By _480_____

11) How wide is the field of view provided by the display?
___30____ degrees

12) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?
____________________________________our own creation, we mostly do cars____________________________________

13) Can you use this simulator to model and evaluate specific road designs/geometrics?
Yes____x__ No______

14) What types of road designs/geometrics can you model and evaluate?
_______yes, just curves and lane widthh____________________________________

15) What are the limitations of this simulator in modeling specific road geometrics?
_______only 2 lane cruving roads____________________________________

16) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?
Yes______ No__x____

17) What types of traffic control devices can be modeled on this simulator?
____

10) If your simulator uses video display technology, what is the resolution of the display?
_1024____ By ______

13) How wide is the field of view provided by the display?
___120____ degrees

14) What vehicle dynamics model is used in this simulator (What are the different types of vehicles that can be modeled by the simulator)?
______________________________vendor created for cars______________________________

13) Can you use this simulator to model and evaluate specific road designs/geometrics?
Yes____x__ No______

19) What types of road designs/geometrics can you model and evaluate?
______________________________expressways, 2 lane roads, 4 lane roads, wide range of intersection types and expressway entrances/exits______________________________

20) What are the limitations of this simulator in modeling specific road geometrics?
______________________________cannot specify curve radius except from list______________________________

21) Can you use this simulator to model specific types of Traffic control devices (e.g., lane markings, road signs, font, etc)?
Yes____x__ No______

22) What types of traffic control devices can be modeled on this simulator?
_____signs, lights of all types______________________________

23) What are the limitations of this simulator in modeling specific traffic control devices?
_______no changeable message signs yet______________________________

19) What characteristics of this simulator do you like best?
______________________________wide range of road tiles, scriptable traffic______________________________

20) What characteristics of this simulator do you like least?
______________________________cost, cannot fully specify road geometry______________________________

21) What percentage of people tested on this simulator experience simulator sickness? _________no subject run yet

22) Could you list some publications on your work with this simulator?
_____________none yet______________________________

18) What are the limitations of this simulator in modeling specific traffic control devices?

____

19) What characteristics of this simulator do you like best? _______ease of use, reliability, flexibility____

20) What characteristics of this simulator do you like least? ______limited road types____

21) What percentage of people tested on this simulator experience simulator sickness? ___<5%______

22) Could you list some publications on your work with this simulator? _there are probably 20 or more, here are a few

Lai, J., Cheng, K., Green, P. and Tsimhoni, O. (2001). On the Road and on the Web: Comprehension of Synthetic and Human Speech While Driving. CHI 2001 Conference Proceedings, New York, N.Y.: Association for Computing Machinery.

Tsimhoni, O., Green, P., and Watanabe, H. (2001). Detecting and Reading Text on HUDS: Effects of Driving Workload and Message Location. Paper presented at the 11th Annual ITS America Meeting, Miami, FL, CD-ROM

Nowakowski, C., Friedman, D., and Green, P. (2001). Cell Phone Ring Suppression and HUD Caller ID: Effectiveness in Reducing Momentary Driver Distraction Under Varying Workload Levels (Technical Report 2001-29). Ann Arbor, MI, The University of Michigan Transportation Research Institute. (Details Available in April 2002.)

Wooldridge, M., Bauer, K., Green, P., and Fitzpatrick, K. (2000). Comparison of Workload Values Obtained from Test Track, Simulator, and On-Road Experiments. Paper presented at the Transportation Research Board Annual Meeting, Washington, D.C.

Tsimhoni, O. and Green, P. (1999). Visual Demand of Driving Curves Determined by Visual Occlusion. Paper presented at the Vision in Vehicles 8 Conference, Boston, MA.

Watanabe, H., Yoo, H., Tsimhoni, O, and Green, P. (1999). The Effect of HUD Warning Location on Driver Responses. Paper presented at the 6th Annual ITS World Congress, Toronto, Ontario, Canada. Washington D.C.: ITS America.

Tsimhoni, O., Yoo, H., and Green, P. (1999). Effects of Workload and Task Complexity on Driving and Task Performance for In-Vehicle Displays As Assessed by Visual Occlusion (UMTRI-99-37). Ann Arbor, MI, The University of Michigan Transportation Research Institute.

____

23) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

____

simulator 2

24) Would you like to add any information about the simulator that is relevant to its capabilities to help in the evaluation of road designs or traffic control devices?

Thank you, very much for your time.

Human Factors Division • Driver Interface Group

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Simulator

The UMTRI Driver Interface Research Simulator is a low-cost, moderate performance, fixed-base simulator used for studies of new in-vehicle devices (e.g., cellular phones, traffic information systems, menu systems), driver workload and driver eye fixations, and driver medical conditions (due to alcohol, disease, etc.). The simulator is based on a network of Macintosh computers. The forward road scene has a 30 degree field of view, showing 2-lane roads with scriptable traffic and road signs. Roads and the vehicle dynamics are programmable. The simulator provides multichannel sound, torque feedback on the steering wheel, and vertical vibration.

For more information see:

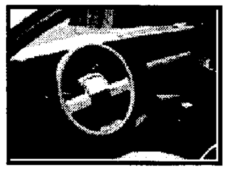
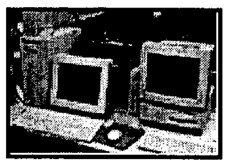
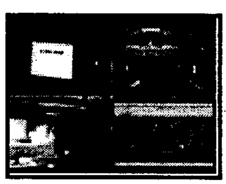
MacAdam, C.C., Green, P.A., and Reed, M.P. (1993). An Overview of Current UMTRI Driving Simulators, UMTRI Research Review, July-August, 24(1), 1-8.

Olson, A. and Green, P. (1997). A Description of the UMTRI Driving Simulator Architecture and Alternatives (Technical report UMTRI-97-15), Ann Arbor, MI: The University of Michigan Transportation Research Institute.

Green, P. and Olson, A. (1997). A Technical Description of the UMTRI Driving Simulator Family-1996 Implementation (Technical Report UMTRI 97-12), Ann Arbor, MI: University of Michigan Transportation Research Institute.

Green, P. and Olson, A. (1996). Practical Aspects of Prototyping Instrument Clusters, (SAE paper 960532), Warrendale, PA: Society of Automotive Engineers.

	160 K	A standard road scene from the simulator. The geometry, presence of objects and cars, colors, and sky image are all configurable.
	160 K	An example of alternate road colors and backgrounds. This scene simulates a course at the Texas A&M airport.

	128 K	This is a picture from behind the buck. The projection system is also visible. We use a LCD panel with an overhead projector. This allows easy repair, aiming, and replacement. The "screen" is retro-reflective highway sign material donated by 3M.
	96 K	Inside the buck. The instrument panel is back-projected with an LCD projector mounted unter the hood. Our touchscreen is visible in the center console. It can be masked off for reduced interface area or covered with a white panel for slide projection.
	128 K	These Macs generate the images the driver sees. The one on the left houses the main engine and handles graphics, auto dynamics, and torque motor control. The right-hand computer generates the instrument panel scene.
	128 K	These are the Macs that coordinate sound and traffic in the simulated environment. Also visible is the sound rack that houses the controls for the audio system. This includes the amplifier and control for the Aura Bass Shakers that provide z-axis vibration.
	96 K	We have the ability to record experiments on video. This quad image has the console, road scene, driver's face, and instrument panel selected. Videotapes provide additional insight beyond the driving and interface data collected by the computers.

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Who To Contact

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Note: Ms. Brock is the head of the group concerned with projects funded by private industry. The actual project monitor will be someone in her group. Projects for the Department of Transportation are administered by Doreen Graden (1-734-764-7246).

Purchase Orders (for small projects)

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