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DIGITAL BILLBOARD ZONE TEXT CHANGE

APPLICATION AND PRESENTATION MATERIALS

APPLICATION

CURSEADEN & MOORE, LLC
PROPERTY LAW FIRM
3 Lafayette Street • PO Box 31 • Milford, CT 06460
Phone: 203.874.9500 • FAX: 203.882.7247 • cmctlaw.com

KEVIN J. CURSEADEN
JOY TOPAZIAN MOORE

February 14, 2020

Via email: Dsulkis@Milfordct.gov and Hand-Delivery

Mr. David Sulkis, City Planner
City of Milford, Planning and Zoning
70 West River Street
Milford, CT 06460

SUBJECT: Digital Billboard Zoning Regulation Text Change

Dear David:

Enclosed please find our application for a zone text change to permit electronic digital billboards under certain conditions.

We request to be on the agenda for March 16, 2020.

Regards,

Kevin J. Curseaden

Enc.

MILFORD PLANNING & ZONING BOARD
PETITION FOR CHANGE OF ZONING REGULATIONS

I (WE) Dominick DeMartino

HEREBY PETITION FOR A CHANGE IN THE ZONING REGULATIONS OF THE CITY OF MILFORD AS FOLLOWS:

ARTICLE V + XI SECTION 5.2.1; 5.2.5; 5.3.6.A; 5.3.6.B

TEXT OF CHANGE SEE ATTACHED

REASON FOR REQUESTING CHANGE IN REGULATIONS:

To allow modernization of existing conforming and legal non conforming billboards abutting the I-95 corridor, and conversion to Electronic Digital Billboard signs.

HAS ANY PREVIOUS PETITION FOR SUBSTANTIALLY THE SAME CHANGE IN THE REGULATIONS BEEN FILED?

YES X NO ____ IF YES DATE OF HEARING 11/19/19 & 12/17/19

PETITIONER'S SIGNATURE [signature] as Attorney for Applicant

Kevin J. Curseaden

MAILING ADDRESS Curseaden & Moore LLC PHONE # 203-874-9500

3 Lafayette Street, Milford, CT 06460

IF APPEARING BY ATTORNEY OR AGENT: NAME Kevin J. Curseaden, Esq.

ADDRESS 3 Lafayette Street, Milford, CT 06460

For Office Use Only **NOTE : COPIES OF THIS APPLICATION WILL NOT BE ACCEPTED**

FEE – SEE SCHEDULE OF ZONING FEES

RECEIVED OF ____ DATE ____

RECEIVED BY ____ AMOUNT ____ RECEIPT NO. ____

SENT TO:

Regional Council of Governments ____
Greater Bridgeport Regional Council ____
Coastal Area Management Program ____

City of Milford, Connecticut

Founded 1639
70 West River Street ◆ Milford, Connecticut ◆ 06460-3317
www.ci.milford.ct.us

Department of Permitting and Land Use

David B. Sulkis,
City Planner

Zoning Regulation Amendment #20-5

TO:
- [X] South Central Regional Council of Governments
- [X] Greater Bridgeport Regional Planning Council
- [X] City Attorney, City of Milford
- [X] State of CT DEEP
- [X] City of West Haven, City Clerk
- [X] Town of Stratford, City Clerk
- [X] Town of Orange, City Clerk

RECEIVED
FEB 26 2020
Milford City Clerk

FROM: David B. Sulkis, City Planner/DBS

DATE: February 25, 2020

RE: **Proposed Changes to the City of Milford Zoning Regulations:**
Sections 5.2.1, 5.2.5, 5.3.6 and 11.2 Electronic Digital Billboard Signs

In accordance with Milford Zoning Regulations 10.3 and CT General Statute's 8-3b and 22a-104, the distribution of the following proposed regulation changes is submitted for your agency's review and comment. Please provide this office with acknowledgment of your receipt of this memorandum and provide your comments or approval within 35 days of the above date.

EXISTING TEXT:

5.2.1 **General Purpose:** This regulation of outdoor lighting applies to both permanently installed outdoor light fixtures and temporary installation of lighting for special events (i.e. carnivals, grand openings), and is necessary to prevent misdirected or excessive artificial light, caused by inappropriate or misarranged light fixtures that produce direct glare, light trespass, and also that such regulation is necessary to improve or maintain nighttime public safety, utility and security.

PROPOSED TEXT: (Changes indicated in BOLD italicized text)

5.2.1 **General Purpose**: This regulation of outdoor lighting applies to both permanently installed outdoor light fixtures and temporary installation of lighting for special events (i.e. carnivals, grand openings), and is necessary to prevent misdirected or excessive artificial light, caused by inappropriate or misarranged light fixtures that produce direct glare, light trespass, and also that such regulation is necessary to improve or maintain nighttime public safety, utility and

Milford Department of Permitting and Land Use

Building: 203-783-3234
Planning and Zoning: 203-783-3245
Wetlands: 203-783-3256

Fax (Building): 203-783-3690
Fax (Planning and Zoning/Wetlands): 203-783-3303
Director: 203-783-3374

security. ***Electronic Digital Billboard Signs shall be exempt from the provisions of this section 5.2., except as provided in Section 5.2.5.***

<u>(NEW) ***5.2.5***</u> ***– Electronic Digital Billboard Signs shall conform to the following standards in lieu of providing a Lighting Plan as set forth in section 5.2.4:***

1. ***Illumination produced by an Electronic Digital Billboard Sign with a face size of 14' x 48' shall not exceed 0.3 foot-candles of illumination over ambient light levels as measured by a foot-candle meter from a distance of 250 feet perpendicular to the Sign face as certified by a licensed architect or engineer.***

2. ***Measurements shall be taken as close to perpendicular to the face of the Electronic Digital Billboard Sign face as practical.***

3. ***If site conditions will not allow measurements from 250', or in the event it is found not to be practical to measure the foot-candle level of a Digital Billboard Sign at the 250' distance prescribed above, a measurer may opt to measure the Sign at any of the alternative measuring distances described in the table set forth below. In the even the sign measurer chooses to measure the Sign using an alternative measuring distance, the prescribed foot-candle level above ambient light shall not exceed the prescribed levels, as certified by a licensed architect or engineer, based on the alternative measuring distances set forth in the following table:***

Alternative Measuring Distance	***Prescribed Foot-Candle Level***
100	***1.88***
125	***1.2***
150	***0.83***
200	***0.47***
250	***0.3***
275	***0.25***
300	***0.21***
325	***0.18***
350	***0.15***
400	***0.12***

<u>(NEW) ***5.3.6(A) – Electronic Digital Billboard Signs.***</u>

5.3.6(A) – Electronic Digital Billboard Signs in LI, CDD-1 and ID Zoning Districts:

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Subject to all other provisions and limitations of these Regulations, Electronic Digital Billboard Signs shall be allowed in LI, CDD-1 and ID Zoning Districts, subject to a zoning permit and the following additional conditions and safeguards. Electronic Digital Billboard Signs shall:

1. *Be limited to the conversion from conforming and legal non-conforming Commercial Advertising Signs existing as of the effective date of this Regulation to an Electronic Digital Billboard Sign provided that there is no increase in the non-conformity including but not limited to height, distance, size and location requirements.*

2. *Be erected as a ground sign and located on real property in the LI, CDD-1 and ID Zoning Districts, which abuts the non-access highway line of the I-95 road system or an access ramp or Right of Way with respect thereto (hereinafter collectively the "I-95 Corridor").*

3. *Comply with the provisions of section 5.2.5.*

4. *Have the illuminated display facing the I-95 Corridor at an angle of 90 degrees or less at the point nearest the sign structure.*

5. *Have the illuminated display located no more than a distance of 200 feet from the I-95 Corridor.*

6. *Except as specifically set forth in this subsection, the restrictions in Sections 5.3.7.9 and 5.3.7.16 shall continue in full force and effect. Electronic Digital Billboard Signs shall not be considered "flashing signs or advertising devices" or "Electronic message signs" for the purposes of these Regulations.*

7. *Subject to the requirements of this section, V-Type Commercial Advertising Signs and/or Back to Back Commercial Advertising Signs (where they currently exist on the effective date of this regulation) shall be allowed under the definition of Electronic Digital Billboard Signs, notwithstanding anything else in these regulations to the contrary.*

Article XI Definitions; Section 11.2 OTHER TERMS:

(NEW) *Signs, Electronic Digital Billboard. An Electronic Digital Billboard Sign is a billboard that displays digital images that are changed remotely. Electronic Digital Billboard Signs shall conform to the following:*

1. *Change content no more frequently than once every ten (10) seconds;*

2. *The static display shall not move, appear to move or change in intensity;*

3. ***Must automatically adjust the brightness not to exceed 0.3 foot-candles above ambient light conditions measured at a distance of 250', or must meet the foot-candle level prescribed for Alternative Measuring Distance, as prescribed in Section 5.2.5;***

4. ***Must have an ambient light sensing device installed on the sign structure that will adjust the brightness as ambient light conditions change;***

5. ***Must utilize dimming software; and***

6. ***Light produced by an Electronic Digital Billboard Sign with a face size of 14' x 48' shall not exceed 0.3 foot-candles over ambient light levels measured at a distance of 250', or must meet the foot-candle level prescribed for Alternative Measuring Distance, as prescribed in section 5.2.5.***

(NEW) ***Signs, LED Display.*** ***A flat panel display which uses an array of light-emitting diodes as pixels for a static visual display.***

(NEW) ***Signs, Commercial Advertising, V-Type.*** ***A structure with two (2) sign faces forming the shape of the letter "V" when viewed from above, with an angle between the two faces of not more than 60 degrees.***

(NEW) ***Signs, Commercial Advertising, Back to Back.*** ***A structure with two (2) parallel sign faces oriented in opposite directions.***

REASON FOR CHANGE:

To allow modernization and conversion of existing conforming and legal non-conforming billboards abutting the I-95 Corridor to Electronic Digital Billboard Signs.

A petition for substantially the same change in regulations has previously been filed:
Yes X No ___ If yes, date of hearing: 11/19/2019 & 12/17/2019

This regulation change is proposed by:
Petitioner: Mr. Dominick DeMartino through his agent Kevin J. Curseaden, Esq.

Cc: James Quish, Chairman, P & Z
Joseph D. Griffith, Director,
DPLU

ATTORNEY PRESENTATION

May 5, 2020

PLANNING & ZONING BOARD
MILFORD, CT

TEXT AMENDMENT
ZONING REGULATIONS

CURSEADEN & MOORE, LLC
PROPERTY LAW FIRM

PROPOSED ZONING REGULATION TEXT REVISION

ARTICLES V & XI

Sections

5.2.1; 5.2.5; 5.3.6. & 11.2

EXISTING BILLBOARD LOCATIONS ALONG I-95 CORRIDOR

	Property Owner	Location	M B L	Zone	Adjacent Zones within 200′	Billboard Size	Style	Facing	Closest I-95 Exits
1	Car Wash Realty, LLC	45 Banner Drive	090 810 8 B	LI	ID	Approx. 14′ x 48′	Double Face	N	40 N
2	State of CT DOT ROW	Adjacent to 270 Rowe Avenue	024 340 13	ROW/ LI	R7-5	Approx. 14′ x 48′	Double Face	N & S	34 N & S
3	Damato Investments, LLC	58-60 Research Drive	091 809 6-8	ID	ID	Approx. 14′ x 48′	Double Face	N & S	40 N & S
4	Damato Investments, LLC	84 Research Drive	091 809 6-1 1	ID	ID	Approx. 14′ x 48′	Double Face	N & S	40 N & S
5	Damato Investments, LLC	116 Research Drive	091 809 6-1-4	ID	ID	Approx. 14′ x 48′	Double Face	N & S	-
6	Gloria Complex (Multi Acct.)	Adjacent to 590 West Avenue	042 304 1A 003-0050	CDD-1	CDD-1	Approx. 14′ x 48′	Single Face	N	35 N

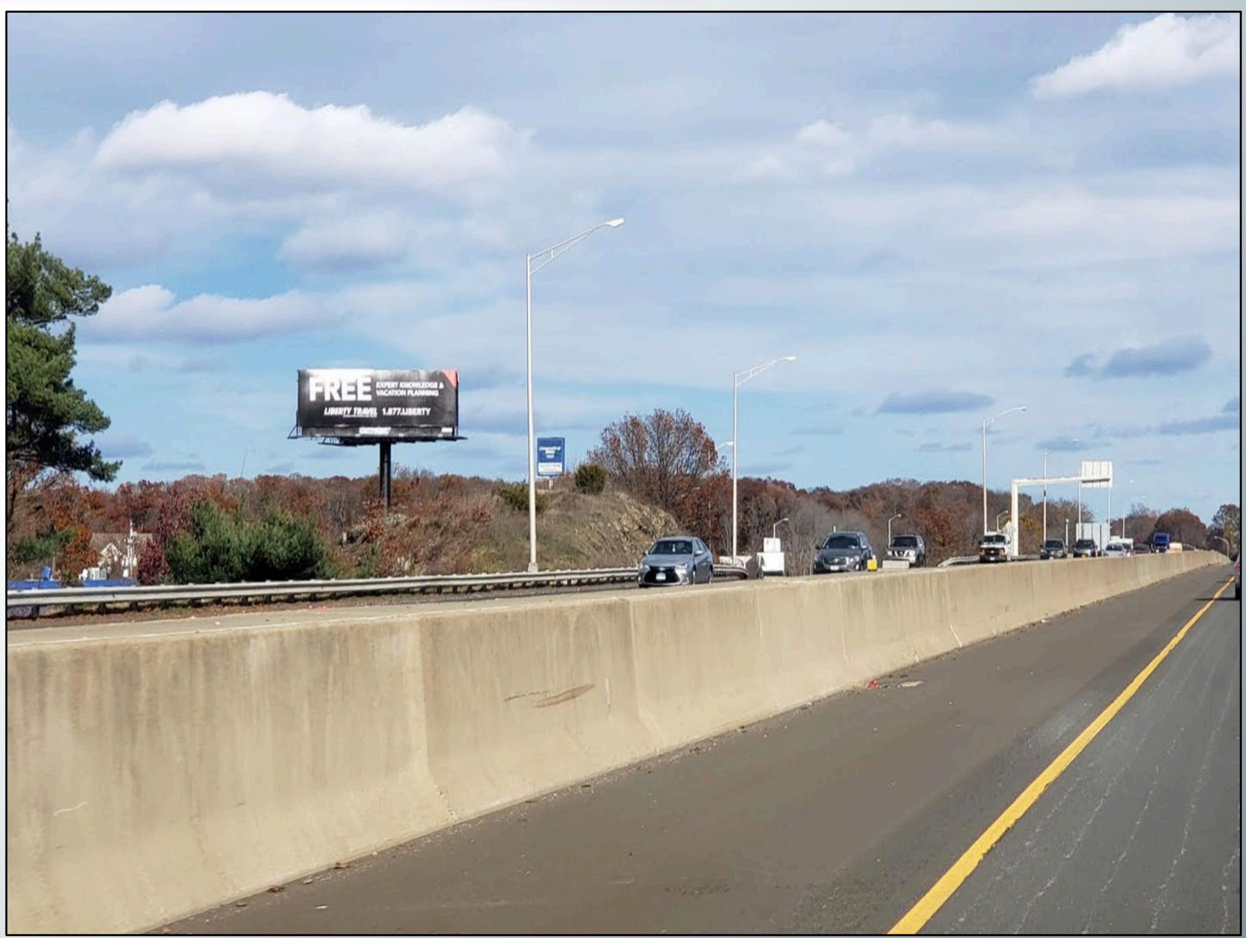
Aerial View of Parcels

Aerial View of Parcels

45 Banner Drive

1	Car Wash Realty, LLC	45 Banner Drive	090 810 8 B	ID	ID	Approx. 14′ x 48′	Double Face	N	40 N

Existing View from I-95
45 Banner Drive

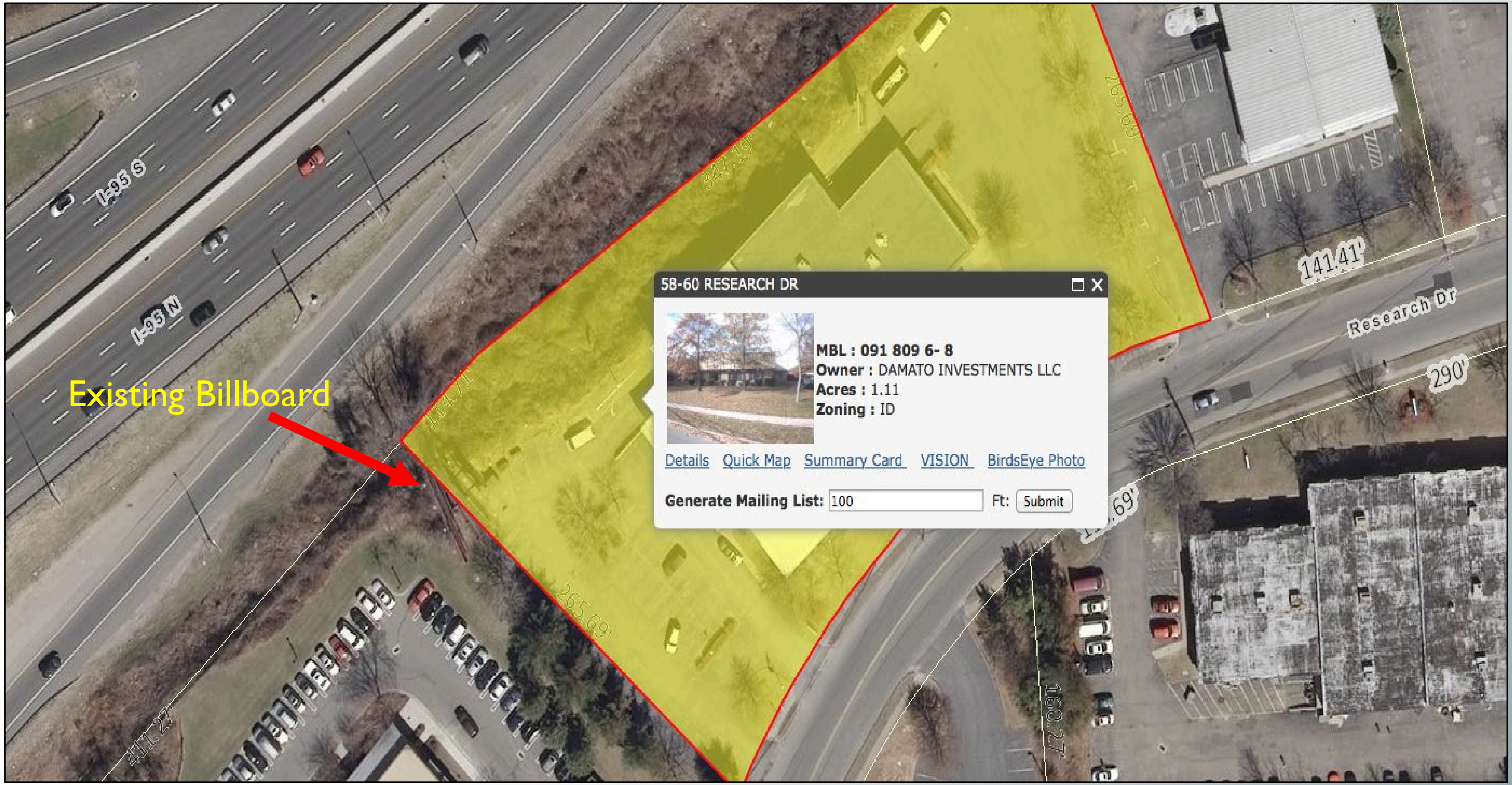


1	Car Wash Realty, LLC	45 Banner Drive	090 810 8 B	ID	ID	Approx. 14′ x 48′	Double Face	N	40 N

Existing View from of I-95 of
State of CT DOT ROW Adjacent to 270 Rowe Avenue

3	State of CT DOT ROW	Adjacent to 270 Rowe Avenue	024 340 13	ROW /LI	R7-5	Approx. 14′ x 48′	Double Face	N & S	34 N & S

58-60 Research Drive



4	Damato Investments, LLC	58-60 Research Drive	091 809 6-8	ID	ID	Approx. 14' x 48'	Double Face	N & S	40 N & S

Existing View from I-95
58-60 Research Drive

4	Damato Investments, LLC	58-60 Research Drive	091 809 6-8	ID	ID	Approx. 14′ x 48′	Double Face	N & S	40 N & S

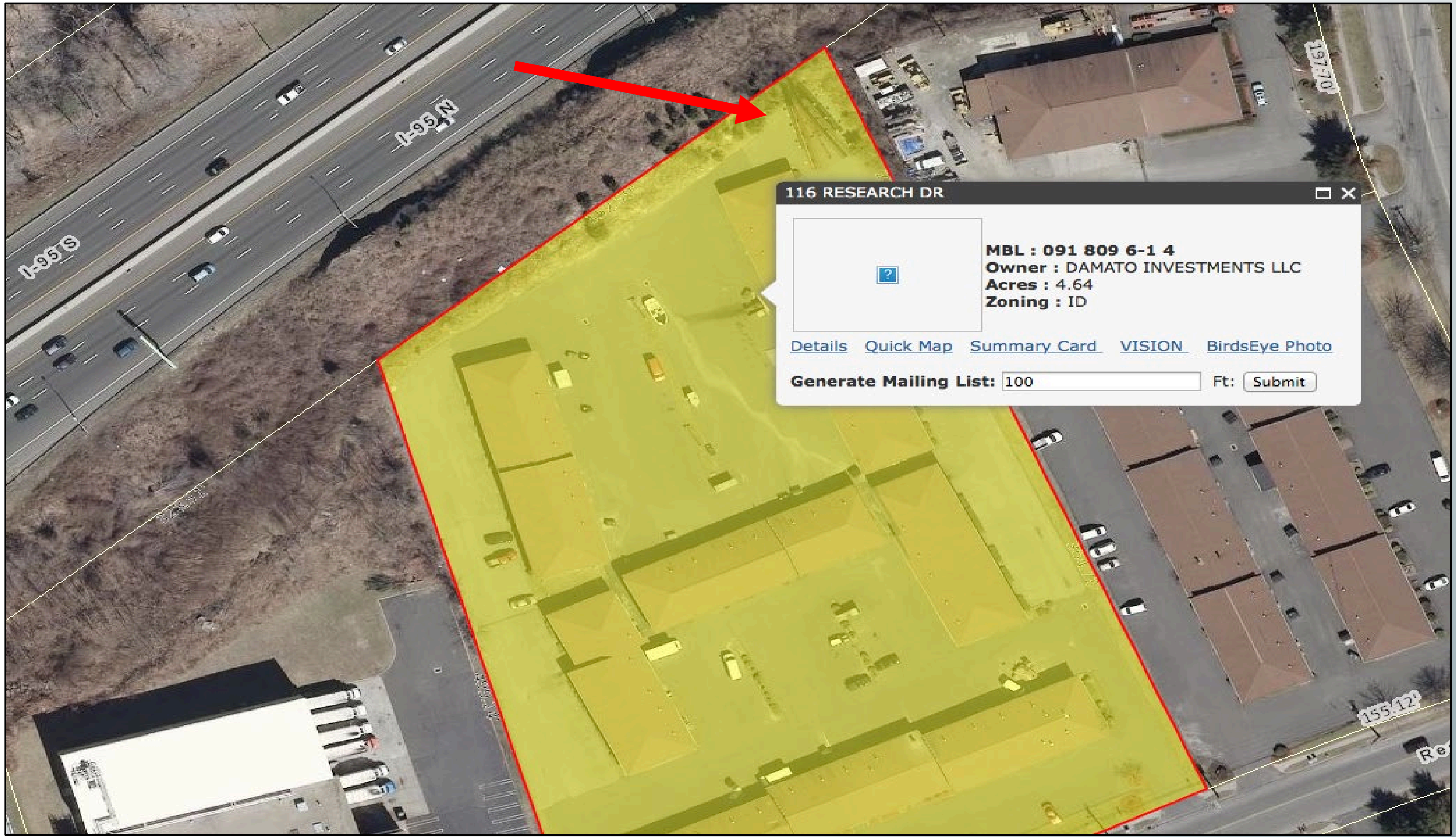
84 Research Drive

5	Damato Investments, LLC	84 Research Drive	091 809 6-1 1	ID	ID	Approx. 14′ x 48′	Double Face	N & S	40 N & S

Existing View from I-95
84 Research Drive

5	Damato Investments, LLC	84 Research Drive	091 809 6-1 1	ID	ID	Approx. 14′ x 48′	Double Face	N & S	40 N & S

116 Research Drive

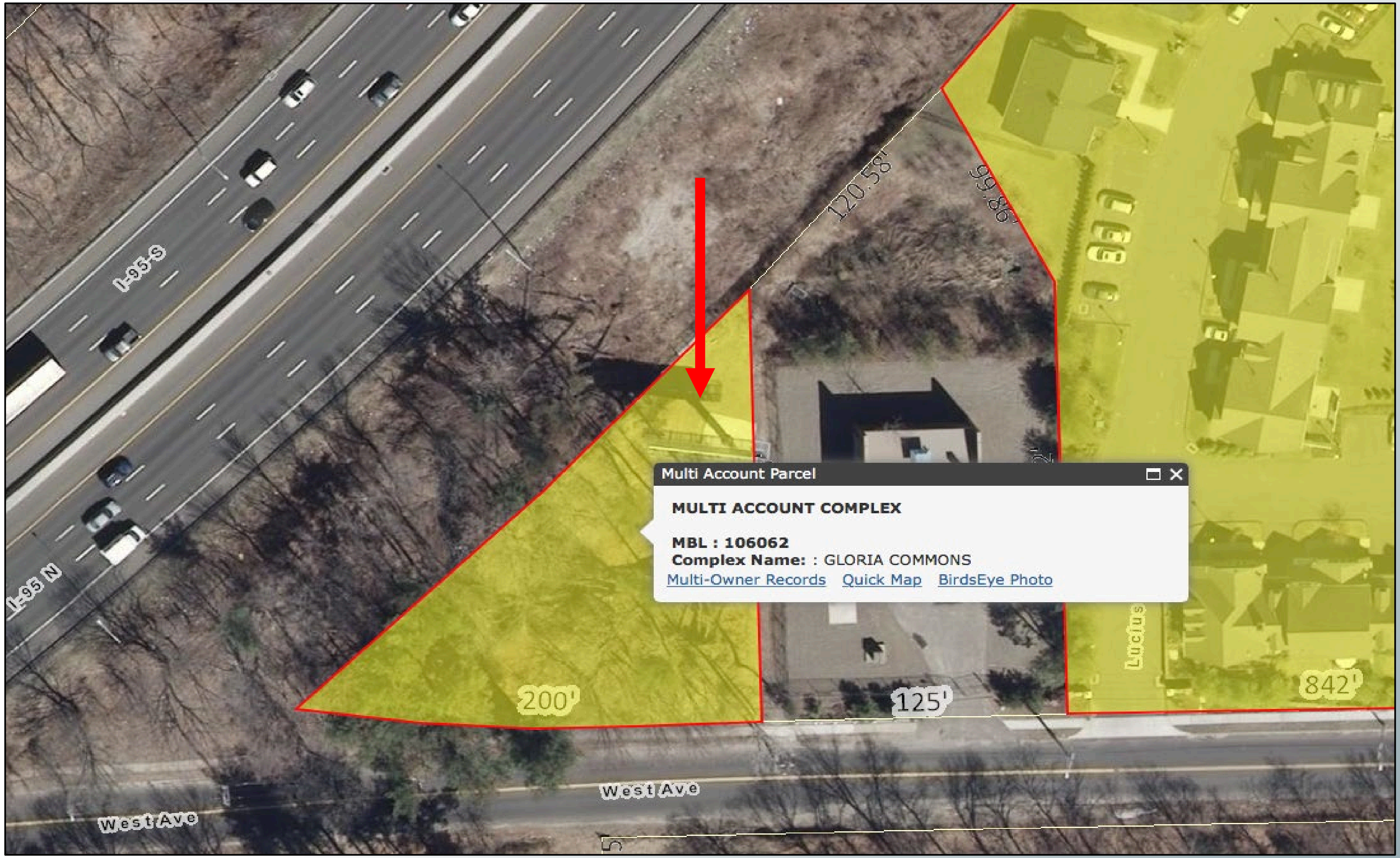


6	Damato Investments, LLC	116 Research Drive	091 809 6-1-4	ID	ID	Approx. 14′ x 48′	Double Face	N & S	-

Existing View from I-95
116 Research Drive

6	Damato Investments, LLC	116 Research Drive	091 809 6-1-4	ID	ID	Approx. 14′ x 48′	Double Face	N & S	-

Adjacent to 590 West Avenue



7	Gloria Complex (Multi Acct.)	Adjacent to 590 West Avenue	042 304 1A 003-0050	CDD-1	CDD-1	Approx. 14′ x 48′	Single Face	N	35 N

Existing View from I-95
Adjacent to 590 West Avenue

7	Gloria Complex (Multi Acct.)	Adjacent to 590 West Avenue	042 304 1A 003-0050	CDD-1	CDD-1	Approx. 14′ x 48′	Single Face	N	35 N

EXISTING DIGITAL BILLBOARD LOCATIONS ALONG I-95 CORRIDOR

Existing Digital Billboards	City or Town	Billboard Size	Style	Facing	Closest I-95 Exits
Digital Billboard	West Haven	Unknown	Double Faced	North & South	42 N
Digital Billboard	Stratford	Unknown	Double Faced	North & South	33 N
Digital Billboard	Bridgeport	Unknown	Double Faced	North & South	25 S
Digital Billboard	Bridgeport	16' x 50'	Double Faced V	North & South	27 S
Digital Billboard	Bridgeport	16' x 50'	Double Faced V	North & South	After 27 North

EXISTING DIGITAL BILLBOARD
I-95 CORRIDOR BRIDGEPORT, CT
WEBSTER ARENA

High-definition digital billboard, double sided, V-Shaped billboard overlooking I-95 and viewed by an estimated two million vehicles a week.

The billboard was designed by media firm Independent Outdoor of Stamford to be the first in Connecticut to use an angled support pole. Ultra-Lum Services in Berlin, Conn., installed the billboard. South Dakota's Daktronics built the digital screens. Each side of the billboard is 50 feet wide by 16 feet high (800 square feet) vs. 14' x 48' (672 square feet) for most conventional billboards.

This one rises 95 feet high and weighs 121,000 pounds, Harbor Yard Sports said. Ultra-Lum drilled through 30 feet of soil and five feet of bedrock to anchor the support pole.

Article & Photo Credit: www.Hartfordbusiness.com

QUESTIONS?

CURSEADEN & MOORE, LLC
PROPERTY LAW FIRM

PLANNING AND ZONING BOARD MINUTES FOR MEETING HELD TUESDAY 19 NOVEMBER 2019, 7:30 PM, CITY HALL AUDITORIUM, 110 RIVER STREET

The meeting of the Planning and Zoning Board came to order at 7:30 p.m.

A. PLEDGE OF ALLEGIANCE AND MOMENT OF SILENCE

B. ROLL CALL

Members Present: Nancy Austin, John Grant, Jim Kader, Brian Kaligian, Peggy Kearney, Scott Marlow, Carl S. Moore, Tom Panzella, Jim Quish, Robert Satti

Not Present:

Staff: David Sulkis, City Planner; Meg Greene, Rec. Sec'y

C. OLD BUSINESS: None

D. NEW BUSINESS VOTE BY DECEMBER 19, 2019

1. **528 Wheelers Farms Rd** (Zone DO-25) Petition of John Wicko for an amendment to a Special Permit with Site Plan Review for redevelopment of vocational education building on Map 104, Block 915, Parcel 13 of which Boys and Girls Village, Inc. is the owner.

Mr. Wicko, AIA, 58 Prospect Street, addressed the board. He noted the presence of the Boys and Girls Village (BGV) Director of Facilities. He displayed a rendering of the proposed new building and reviewed the site plan featuring the overall layout of the school. He asked the board to establish that the work would be deemed a minor amendment to the existing Special Permit, indicating a review under New Business rather than via a Public Hearing. **Chairman Quish** asked **Mr. Sulkis** to share his opinion; Mr. Sulkis agreed that it should be considered a minor amendment. **Chairman Quish** asked the board for a motion, reviewing the noticing requirements if the board deemed the project to require a public hearing.

Mr. Marlow moved to ***find the changes to use consistent with the original Site Plan and therefore accept as a Minor Amendment only*** the Petition of John Wicko for an amendment to a Special Permit with Site Plan Review for redevelopment of vocational education building on Map 104, Block 915, Parcel 13 of which Boys and Girls Village, Inc. is the owner.
Ms. Austin seconded.
There was no discussion
The motion carried unanimously.

Mr. Wicko thanked the board and referred to a Statement of Purpose document on the mission of the vocational school unit, saying it was an offshoot of the high school. He provided more detail on the project plan, saying it incorporated some functional features of the temporary building, noting that the permanent building will be slightly bigger. He described driveway access for automotive programs and deliveries. He noted walkways that tie into existing traffic areas of the campus. He noted storm water management features and the approval of the City Engineer as well as the Health Department. He reviewed other departmental approvals. He provided detail on the building and classrooms it will house. He described the floor plan and displayed elevations. He said the façade's progressive, high tech nature was meant to reflect the activities being taught within.

Mr. Sulkis said the board originally approved the temporary classroom building with the expectation that permanent plans would be forthcoming and had been provided with this application.

Mr. Satti asked Mr. Wicko to quantify how much bigger the permanent building would be: approximately 500 sf bigger.

Motion: Mr. Satti *moved to approve as presented* the Petition of John Wicko for an amendment to a Special Permit with Site Plan Review for redevelopment of vocational education building on Map 104, Block 915, Parcel 13 of which Boys and Girls Village, Inc. is the owner.
Second: **Ms. Austin** seconded.
Discussion: None.
Vote: Motion carried unanimously.

Public Public Hearing CLOSE BY DECEMBER 24, 2019; VOTE BY FEBRUARY 27, 2019

E. Proposed Change to City of Milford Zoning Regulations: Petition by Kevin Curseaden, for changes to Article 5, Sections 5.2.1, 5.2.5, 5.3.6 and 11.2 to allow for Electronic Digital Billboard Signs.

Attorney Curseaden, 3 Lafayette, handed out hard copy of his presentation and addressed the board. He introduced experts. He said the application had been under discussion for about a year and a half and included conversations with staff. He said the proposed revision would require changes to language of the regulations as well as definition changes, and by statute such proposals must be filed with the City Clerk; this had been done. He identified regulations that would be affected by the proposed changes. He displayed a list of 7 locations of current billboards in the City that abut I-95, noting that only one was in a zone included residential use. He showed aerial views of the parcels where the billboards were located, and how the billboard appear from major roadways. He provided a list of digital billboards in neighboring towns. He said the application included a light engineering report. He said a portion of the billboard display cycle could be used for public service messages. He said the billboards would meet the light trespass restriction for residential property. He said preexisting nonconforming billboards would be allowed to continue. He compared the evolution of digital billboard displays with previous evolution from using painted billboards to vinyl.

Mr. Sulkis questioned whether 2 of the 7 sites, if the proposal is approved, could be converted as they did not abut I-95 due to the railroad right of way. He also said that even if acceptable lighting levels could be met for residential uses, commercial requirements could not be met. **Attorney Curseaden** said the latter would be unlikely to cause problems given that most are located in commercial or industrial zones, minimizing the problem of light trespass.

Cheng Qian, MASC, Chief Product Architect, Media Resources, Inc, Ontario, Canada, provided an expert presentation on light pollution, providing definitions and units of measurement for glare and light trespass. He discussed ways of discouraging and containing light trespass. He reviewed different types of illuminated sign, saying digital billboards are fundamentally different from other types of illuminated billboards in that backlit LED billboards have no directional light or hot spots. He said dimming technology for nighttime display is similar to limits used for smartphones and that no glare would be produced. He said the billboards would comply with residential limits for light trespass.

Mr. Marlow described his understanding of the definition of ambient light at a given time of day or night, which Mr. Qian confirmed. **Mr. Marlow** also confirmed that the technique for measuring the strength of the light would be an average of several readings. He asked if the billboard's built-in self-metering would be affected by reflected light from nearby structures. **Mr. Qian** said nearby reflected light was generally not enough to affect a billboard's ambient light detection technology. **Mr. Sulkis** asked if, given the proposed industry-standard cycle of message changes every 10 seconds, the changes in displayed illumination, based on the changing message, would be distracting. He added a concern about attention-getting flashing in messages. **Mr. Qian** said such changes would be of limited magnitude. **Mr. Satti** asked how current billboard hot spots at the 7 sites compared to digital lighting emissions. **Mr. Qian** said the existing lighting has not been measured for all sites but provided the industry standard measurement for up-facing lights.

Chairman Quish invited public comment.

<u>OPPOSED</u>
Deanna Jacobs, 14 Darina Pl, said she became aware of the issue from the newspaper and was concerned that there was not sufficient awareness for the general public. She said she found were inconsistencies in the online regulation numbering and found the many zone acronyms confusing. She asked if old billboards would be replaced.

Chairman Quish replied that clarification could be provided. **Ms. Jacobs** asked if the display would be continuous; and was told that it would be. She asked what size the billboards would be and if sound would be associated with them. She read aloud the preamble to the regulations highlighting the section on promotion of the health, safety, and general welfare of citizens, consistent with Plan of Conservation and Development (POCD). She asked who would benefit from allowing digital billboards.

Chairman Quish said the benefit of billboards is both to the seller and potential buyers. He asked Mr. Sulkis to comment on the questions.

Mr. Sulkis said nothing in the proposed regulations involved content-related sound. He said Mr. Qian could probably comment on whether the LEDs emit any functional noise. He said the proposal is to take existing billboards and convert them to the electronic format of a standardized size limit of 14' x 48'.

Jeanne Cervin, 3 Central Avenue, said she was a long-term former Planning and Zoning board member and thought a similar application had been denied in years past. She expressed concern that CDD mixed use zones contain residential areas that could be affected by light trespass and also expressed concern about potential taxation issues. She said she thought the City might have as many as 60 existing billboards and feared such conversions could be applied to all of them. She listed states that prohibit digital billboards and noted that other nearby cities have also prohibited them. She said they can be hacking targets and asked about security provisions--whether control panels exist on site, how messages are monitored, and whether the City might want oversight. She said there were too many unknowns in the proposed regulation as written for approval and action should be forestalled until the next update to the POCD.

Bryan Anderson, 49 Ingersoll Rd, thanked PZ members whose terms were completed for their service: Messrs. Marlow, Grant, and Panzella. He said this proposal for digital billboards was coming before the board for a third time and was concerned about unintended consequences. He said converting to digital billboards would expand the carbon footprint of the billboards and recalled discussions aimed at making streetlight levels more environmentally friendly. He expressed concern for current billboard workers' livelihoods, about privacy, and the potential for a billboard to interact with smartphones. He was concerned about various board heights and driving visibility.

Jane Platt, 132 Platt Lane, said she shared previous speakers' concerns and that she viewed opposed the proposal as a quality of life issue. She said a recent trip to Vermont was calming due to absence of such billboards.

Dominick Cotton 60 Corona Drive, said he works with people who have brain injuries and he was concerned about human safety and distractibility, with drivers potentially taking attention off the road, particularly since Milford has more exits (7) than other communities.

Richard Platt, 132 Platt Lane, echoed the "who benefits?" question. He said society has enough information overload and agreed that such billboards are distracting with potential safety impacts.

Mary Oake, 30 Darina Pl, said the billboards are ugly marketing devices. She noted that the demographics are shifting toward an aging population that will have more difficulty ignoring distraction. She also worried about overuse of natural resources energy.

Ann Berman, 77 Pelham Street, said the current New Haven Avenue billboards are an eyesore and others are scattered throughout the city. She expressed concern for how flashing lights could trigger epilepsy and recalled historic use of subliminal messages in advertising—how such messages might be used. She noted an instance of a digital billboard being hacked by pornography. She said they may emit enough light pollution to affect both humans and animals. She wanted to know how much electricity would be used.

Donna Dutko, 236 Buckingham Ave, handed out a section of the state statute regarding uniform zoning regulations. She argued that the city would have to allow such billboards throughout all zones included in the list of 7 billboards abutting I-95. She was concerned about the issue of free speech. She said drivers sometimes will hold focus on the billboard for recurrence of an ad that's of interest, increasing danger. She asked how the light restrictions would be enforced and what the cost would be. She was concerned that the commercial light restriction could not be restricted within mixed use zones. She asked if a Gulf Street billboard would also be converted.

Chairman Quish asked if the Gulf Street billboard would be affected by the change; **Mr. Sulkis** said the proposed regulation restricts them to lots adjacent to I95. **Ms. Dutko** pressed the point about being allowed anywhere in an approved zone.

Nancy Iddings, 136 Housatonic Dr, agreed that the signs are distracting. She said Milford should be quaint, not like Las Vegas.

Dora Kubek, 33 Liberty St, said I95 is one of the busiest, most dangerous highways in the country. She compared digital billboards to the distraction of texting. She said she saw no benefit to the City and was concerned by possibility of hacking.

Sandy Griefzu, 39 Orland St, said the billboard would diminish the beauty of the city. She said information is readily available without billboards and asked if there were studies about safety impacts.

Mr. Sulkis noted emails received in opposition from:

Sarah Bromley, 27 Norway St, who said such billboards are distracting, unattractive, and harm the City's current charm.

Alana Fagan, 73 Housatonic Dr, said ordinary billboards are distracting and unattractive enough.

There was an email in opposition from speaker **Nancy Iddings** as well.

Chairman Quish invited anyone speaking in favor to address the board; seeing none, he invited Attorney Curseaden to rebut.

REBUTTAL

Attorney Curseaden read a synopsis by a third party of a Federal Highway Administration study on billboards into the record:

The U.S. Department of Transportation Federal Highway Administration has released a landmark study declaring that digital billboards do not pose a safety risk to passing motorists. For those within the industry, the results of this study come as no surprise. Numerous traffic studies and analyses performed in the last coup le of decades have come to a similar conclusion .

The report, actually divided into two studies, is officially titled "Driver Visual Behavior In The Presence of Commercial Electronic Variable Message Signs." For the purposes of the studies, the FHA refers to digital billboards as Commercial Electronic Variable Message Signs. The studies sought to address three specific questions:

1. *Do CEVMS attract drivers' attention away from the forward roadway and other driving-relevant stimuli?*
2. *Do glances to CEVMS occur that would suggest a decrease in safety?*
3. *Do drivers look at CEVMS more than at standard billboards?*

To conduct the study, the FHA tracked participant's eye movements with an eye-tracking camera device mounted in the vehicle. This device was able to track the driver's eyeball movement and determine if the driver was looking ahead at the roadway or off to the side of the roadway at a static billboard or CEVMS.

Drivers in Richmond, Va., and Reading, Pa., participated in the study, and the research concluded that drivers do indeed look at digital billboards longer than they do at static billboards. Glance duration toward digital billboards averaged 0.379 seconds, while glances at static billboards were at 0.335 seconds at both test sites. Both of these measurements fall far below the two-second benchmark, which would constitute a hazard, according to the National Highway Traffic Safety Administration.

In conclusion, the study states, "The results did not provide evidence indicating that CEVMS, as deployed and tested in the two selected cities, were associated with unacceptably long glances away from the road. When dwell times longerthan the currently accepted threshold of 2,000 ms [milliseconds] occurred, the road ahead was still in the driver's field of view. This was the case for both CEVMS and standard billboards."

This peer-reviewed study should help put to rest concerns that digital billboards, and other outdoor digital signs, pose a hazard to passing motorists. The study will also help pave the way for communities to bring this powerful outdoor advertising medium to their communities, benefiting not just local operators and advertisers but the entire local economy as well.

Attorney Curseaden continued saying local business could benefit from using the billboards. He said the statutory uniformity of regulation requirement doesn't mean all zones can do the same activities throughout the zone, rather it means that the regulations must be applied uniformly as legislated by the board, therefore the board has the power to enact this regulation. He said he perceived concern about a slippery slope for spreading the billboards into the heart of the community, but he said the regulation was limited to the 7 locations proposed. He said enforcement would be through the ZEO with the use of light measurement devices. He said there are also Department of Transportation regulations that must be met that regulate the devices. He said all notification requirements were met, and said information about the regulation is on file to be examined in the zoning offices. He stressed that care was taken to limit the regulation change to the 7 proposed sites.

Mr. Qian answered the question on sound, saying ventilation fans were used but the rest of the billboard is solid state. Regarding privacy concerns, he noted that data analytics software can track phones and movement anywhere without billboards. He said the internal diagnostics of signs are tracked by a network monitoring system that will shut down a sign if it malfunctions. He described power consumption as being similar to a commercial HVAC installation. He said LEDs are environmentally efficient, acknowledging that these billboards do consume power, but he said an argument could be made that mitigation from disposal of the vinyl used on traditional billboards is more environmentally harmful. He recalled a discussion at an industry conference of the porn hacking referenced by one speaker, saying that security breach involved a physical break-in of a secured room. He said most manufacturers have system locking and alarms; that no one buys unsecured system.

Mr. Satti asked for copies of letters of agreement referred to by Attorney Curseaden in his presentation and confirmed with **David Gannon**, of **Outfront Media**, 955 Washington Street, North Haven, that 14' by 48' is an industry standard. **Mr. Gannon** said that the existing structures would be refaced rather than replaced wherever possible. **Mr. Satti** asked if the public service announcements follow some standard display interval or ratio, saying he would wait for an answer if necessary. He further asked how often surrounding towns take advantage of the public service displays. Mr. Satti expressed dissatisfaction with the HFA synopsis, calling it an advertisement and asked for the original study.

Mr. Moore was told that the 10-second interval could not be extended to 15 or some other value.

Mr. Marlow said he looked at FHA study online and found another link to an independent think tank called Enotran.org, which asserted that the data used and collected for the FHA study was flawed. Mr. Marlow posited that since the idea of a billboard is to get people to look at it, how can it fail to distract?

Mr. Sulkis asked for decibel level of the billboards and how much more power they use compared to conventional billboards. He also asked how the FHA study relates to Interstate highways in urban areas.

Mr. Qian agreed that the FHA study results should be evidence-based. He referenced a series of 8 studies analyzed by the University of Alabama in 2014 with a conclusion consistent with the handout provided.

Attorney Curseaden said he would provide copies of the FHA study, a draft sample letter of agreement which would require review by the City Attorney's Office.

Mr. Sulkis pressed for more information on sound levels. **Mr. Qian** quantified the decibel levels of noise created by billboard fans stating it stood to reason that it would be below the ambient noise of highway traffic.

Attorney Curseaden confirmed for **Mr. Moore** that ads are sold in 8-10 sec increments, but would research further any possibility for variation. He confirmed for **Mr. Sulkis** that 10 seconds is the interval used by neighboring communities.

Attorney Curseaden and **Mr. Gannon** confirmed for **Mr. Satti** that the 14' x48' size is an industry standard and that if structures had to be replaced; they would be replaced in kind.

PUBLIC REBUTTAL

Donna Dutko, 236 Buckingham Ave, expressed doubts about the federal study, comparing it to vaping and saying that nothing is deemed hazardous until someone is hurt.

Richard Platt, 132 Platt Lane, said that even public service announcements can be driving distractions.

Jeanne Cervin, 3 Central Avenue, said more questions needed to be clarified before the regulation could be changed. She wanted to know the cost to City versus the benefit to the developer, saying tax issues should be researched. She acknowledged that the 2012 POCD doesn't have billboard info, but said the topic should be added and examined.

Sandy Griefzu, 39 Orland St, said given the recent election, the board was about to change, and new members should be able to consider the decision.

With no further public comment, **Mr. Sulkis** read his administrative summary and suggested that the public hearing be left open.

Attorney Curseaden formally asked for the hearing to be held open.

Mr. Satti wanted more information about financial benefits of the billboards and wanted to know the total number of billboards in City. He and Chairman Quish asked for minutes regarding previous applications on the issue.

F. LIAISON REPORTS: None.

G. SUBCOMMITTEE REPORTS: None.

H. APPROVAL OF MINUTES – 11/6/2019 not present abstained.

I. CHAIR'S REPORT: None.

J. STAFF REPORT – *[NOTE: **Mr. Satti** said he viewed the discussion on MGAT and was eligible to vote the calendar item.]* **Chairman Quish** reintroduced the topic of the 2020 meeting schedule. He asked **DPLU Director Joe Griffith** to provide an overview of the two choices discussed at the last meeting, which Mr. Griffith did. **Chairman Quish** said he favored changing the schedule to 1 meeting per month for public hearings and allowing the other meeting to focus on subcommittee work. He said he anticipated more effort going forward on the 2022 POCD and wanted to open more time for that. **Mr. Moore** asked if any 8-30g applications were still in the pipeline from prior to the City's moratorium. **Mr. Sulkis** said there was only one. Mr. Sulkis said the board had done a similar schedule 12 years ago and wanted the board members to be aware that the full board won't be able to participate in second meetings because it creates a full meeting which hasn't been properly noticed. He speculated on how new members might regard the change and whether 3 meetings might be needed regardless. **Chairman Quish** said a 2nd meeting can be added, if needed, by calling a Special Meeting. **Mr. Kader** asked for clarification on the second meeting agenda. **Mr. Grant** said subcommittees are for volunteers; but members represent their districts and should adequately accommodate applicants. **Chairman Quish** asked for an average period from application to hearing. **Mr. Sulkis** said simple CAM applications may take 2-3 weeks unless a Special Permit creates an advertising requirement**. Mr. Satti** asked for details about notification.

Motion: Chairman Quish moved to hold regular meetings on the 1st Tuesday of the month and subcommittee meetings on the 3rd Tuesday of the month unless a Special Meeting is required; which will be scheduled for the 3rd Tuesday. The motion was amended to have all meetings start at 7:00PM.
Second: **Mr. Kaligian** seconded.
Discussion: None.
Vote: Motion carried with an abstention from Mr. Grant.

K. ADJOURNMENT was at 10:31

Attest:

M.E. Greene

New Business, not on the Agenda, may be brought up by a 2/3's vote of those Members present and voting.

ANY INDIVIDUAL WITH A DISABILITY WHO NEEDS SPECIAL ASSISTANCE TO PARTICIPATE IN THE MEETING SHOULD CONTACT THE DIRECTOR OF COMMUNITY DEVELOPMENT, (203) 783-3230, FIVE DAYS PRIOR TO THE MEETING, IF POSSIBLE.

PLANNING AND ZONING BOARD MINUTES FOR MEETING HELD TUESDAY 17 DECEMBER 2019, 7:30 PM, CITY HALL AUDITORIUM, 110 RIVER STREET

The meeting of the Planning and Zoning Board came to order at 7:30 p.m.

A. PLEDGE OF ALLEGIANCE AND MOMENT OF SILENCE

B. ROLL CALL

Members Present: Nancy Austin, John Grant, Jim Kader, Brian Kaligian, Scott Marlow, Carl S. Moore, Tom Panzella, Jim Quish, Robert Satti

Not Present: Peggy Kearney

Staff: David Sulkis, City Planner; Meg Greene, Rec. Sec'y

Chairman Quish opened the meeting.

C. OLD BUSINESS: VOTE BY FEBRUARY 6, 2020

1) **Proposed Change to City of Milford Zoning Regulations**: Petition by Kevin Curseaden, for changes to Article 5, Sections 5.2.1, 5.2.5, 5.3.6 and 11.2 to allow for Electronic Digital Billboard Signs.

Chairman Quish reviewed the status of the hearing and asked the board for comment. He stated that he viewed the meeting on MGAT for the meeting he was unable to attend. He said that he considered the signs safe as located along the I-95 corridor.

Mr. Panzella stated that he was also in support of the billboards, which he said can be made aesthetically pleasing and provide public information. He said he considered it a win for the city.

Mr. Grant said when considering a change to the regulations, he reviews Article 1 of the zoning regulations to remind himself of the criteria to be used. He said he could not find how the proposed regulation benefits the public per the guidance reflected in that article. He said he didn't see a direct benefit to the community as is the intention of the regulations and that he personally considered them a traffic hazard. He said the regulation is not currently requesting billboards in three zones and suggested barring them in those zones in the future. He additionally suggested that a Special Permit be required.

Mr. Satti said he agreed with Mr. Grant, and that the burden is on the applicant to prove safety. He noted the amount of pushback to the billboards proposal during public comment. He said the property tax does not provide a significant benefit to the City. He said he agreed fully with the regulatory comments Mr. Grant made, and he preferred that 8-second displays be used, not 10.

Mr. Marlow said he agreed with Messrs Grant and Satti. He asked if this is where the City should be headed. He said he dislikes billboards in general, but he said at night when they change constantly, it's still a distraction.

Mr. Kader said he was initially in support, but was moved by the public comments. He noted his own experience of driving by a billboard of interest, resulting in an increase in his level of distraction. He said he also feared their encroachment into areas other than along the interstate.

Mr. Moore said he was not convinced the billboards represent a safety hazard and felt the City was not keeping up with the digital environment we now live in. He said maintaining safety while driving is incumbent upon the driver.

Chairman Quish said he agreed with Mr. Moore that we live in a digital world. He reemphasized the potential for beneficial public safety alerts and general advertising for City events. He felt it would be a boon to economic development and business-friendly.

Mr. Panzella said it was only a matter of time before everything went digital. He said drivers become acclimated to roadside sights and drivers' phones are a far more dangerous distraction.

Ms. Austin said she works in advertising and disagreed that billboards flash like Las Vegas style displays. She said most people will be past the billboard well before it changes. She said she works with small businesses and this is a very appealing opportunity for such businesses.

Chairman Quish asked for a motion.

Motion: Mr. Satti moved to shift this item for review by the Regulations Subcommittee. The motion did not receive a second.

Mr. Panzella to approve as presented (or) [I move to approve with the following conditions] the Petition: Petition by Kevin Curseaden, for changes to Article 5, Sections 5.2.1, 5.2.5, 5.3.6 and 11.2 to allow for Electronic Digital Billboard Signs. Effective Date: January 13th, 2020.
Mr. Grant asked to add an amendment to the motion, which Mr. Panzella allowed: that Zones CDD-3, CDD5, and IDG be deleted from the proposal and the word Special be reinserted into "subject to a permit".
Second: **Mr. Moore** seconded.
Mr. Satti made an additional amendment to limit the billboard display cycles to 8 seconds, which Mr. Panzella also allowed, as did Mr. Moore.
Discussion: None.
Vote: Motion failed because 6 votes are required for a regulation change.
Votes were as follows:
WITH THE MOTION: N. Austin, B. Kaligian, C.S. Moore, T. Panzella, J. Quish
AGAINST THE MOTION: J. Grant, J. Kader, S. Marlow, R. Satti

NEW BUSINESS **VOTE BY FEBRUARY 20, 2020**

1. **5 Year Capital Improvement Plan** Referral pursuant to CGS Section 8-24, to approve the 5 Year Capital Improvement Plan for 2020-2024.

Mr. Sulkis described the process for Capital Improvement Plan approval.

Chairman Quish introduced Mayor's Chief of Staff Justin Rosen, who was there to answer questions; none were raised.

Motion: Mr. Satti ***moved to approve as presented***, pursuant to CGS Section 8-24, the 5 Year Capital Improvement Plan for 2020-2024, submitted by Mayor Benjamin G. Blake.
Second: **Mr. Grant** seconded.
Discussion: None.
Vote: Motion carried unanimously.

F. LIAISON REPORTS– None.
G. SUBCOMMITTEE REPORTS– None.
H. APPROVAL OF MINUTES – 12/03/2019: Approved unanimously.
I. CHAIR'S REPORT – **Chairman Quish** handed out Certificates of Appreciation to Messrs Grant, Marlow, and Panzella.
J. STAFF REPORT – **Mr. Sulkis** also expressed his appreciation for the service of board members whose terms were complete.
K. ADJOURNMENT was at 8:20.

Attest:

M.E. Greene

New Business, not on the Agenda, may be brought up by a 2/3's vote of those Members present and voting.
ANY INDIVIDUAL WITH A DISABILITY WHO NEEDS SPECIAL ASSISTANCE TO PARTICIPATE IN THE MEETING SHOULD CONTACT THE DIRECTOR OF COMMUNITY DEVELOPMENT, (203) 783-3230, FIVE DAYS PRIOR TO THE MEETING, IF POSSIBLE.

SCROG & DEEP

Susan LaFond

From: Eugene Livshits <elivshits@scrcog.org>
Sent: Thursday, February 27, 2020 10:27 AM
To: Susan LaFond
Subject: City of Milford: Referrals

Good morning,

Thank you for submitting the proposed zoning regulations amendments (#11-18; #13-18; #15-18; #20-18; #65-18). The referrals were received on Tuesday, February 25th and the next Regional Planning Commission meeting is scheduled for Thursday, March 12th.

Best,

Eugene

Eugene Livshits
Senior Regional Planner
South Central Regional Council of Governments
127 Washington Avenue, 4th Floor West
North Haven, CT 06473
(203) 466-8626

Connecticut Department of
ENERGY &
ENVIRONMENTAL
PROTECTION

79 Elm Street • Hartford, CT 06106-5127 www.ct.gov/deep Affirmative Action/Equal Opportunity Employer

March 3, 2020

Planning and Zoning Commission
c/o David Sulkis, City Planner
City of Milford
City Hall
70 West River Street
Milford, Connecticut 06460-3317

RECEIVED
MAR 06 2020
PLANNING & ZONING

Re: Proposed Zoning Regulation Text Amendments for Sections 5.2.1, 5.2.5, 5.3.6, and 11.2, Electronic Billboard Signs; Article 5, Section 5.8, Flood Hazard and Flood Damage Prevention Regulations; Article 7, Section 7.2, Special Permit Approval; Article 2, Section 2.6, Effect of Zoning Changes on Subdivisions; and, Article 5, Section 5.8.12.1, Anchoring of Manufactured Homes in A and AE Zones

Dear Commissioners:

Thank you for notifying this office of the proposed zoning regulation amendments noted above. Acting as the Commissioner's staff, our office has reviewed the amendments for consistency with the policies and standards of the Connecticut Coastal Management Act (CCMA), and we find them to be consistent with the CCMA.

Please be advised that this consistency determination was based on coastal management considerations only, and does not necessarily reflect other municipal planning and zoning considerations that may apply. These comments are made in response to the review requirement contained in Section 22a-104(e) of the Connecticut General Statutes, which requires that notification be sent to the Commissioner of Energy and Environmental Protection at least 35 days prior to the commencement of the public hearing. Once notified, our office is responsible for reviewing the proposal's consistency with the policies of Section 22a-92 and the criteria of Section 22a-102(b) of the CCMA.

Should you have any questions regarding this letter, please feel free to contact me at (860) 424-3779 or by email at karen.michaels@ct.gov.

Sincerely,

Karen A. Michaels

Karen A. Michaels
Environmental Analyst III
Land and Water Resources Division

KAM/kam

cc: K. Michaels, DEEP
Milford Coastal File

EXPERTS & THEIR PRESENTATION MATERIALS

SUMMARY OF LIGHTING CONSIDERATIONS FOR DIGITAL BILLBOARDS

PREPARED BY: CHENG QIAN, MASC,

CHIEF PRODUCT ARCHITECT,

MEDIA RESOURCES INC.

WHAT IS LIGHT POLLUTION?

Elements of light pollution

1. Glare
2. Light trespass

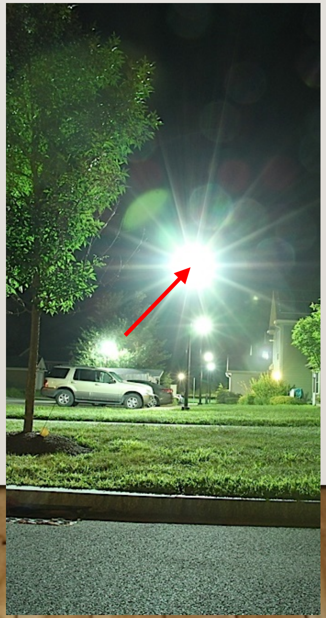
UNITS OF MEASUREMENT FOR EACH TYPE OF LIGHT POLLUTION

1. Glare – Luminance (NITS)

   "Surface density of a light emitting surface"

2. Light trespass – Illuminance (foot-candle, or fc)

   "Amount of light passing through an area". 1 foot-candle is light from 1 candle experienced from 1 foot away.

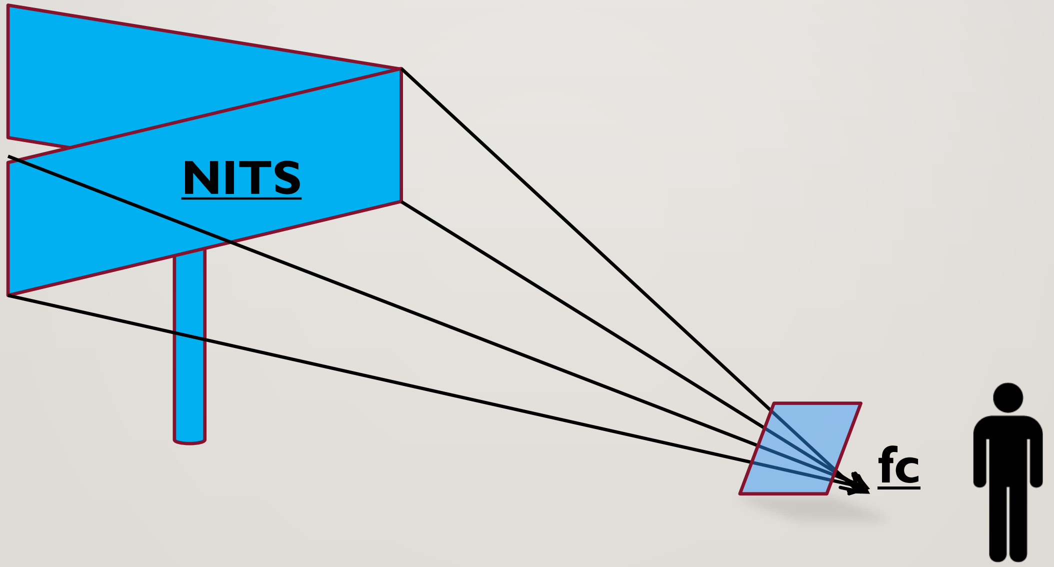


LUMINANCE VS. ILLUMINANCE

Surface brightness (Luminance)
Limited by DOTs to 300 NITS for night time to avoid glare.

Pros: Easy to measure with proper but expensive instrumentation

Cons: Does not fully capture lighting impact to any individual point of view



Local light passing through a surface (Illuminance)
OAAA guidelines set a limit of 0.3 fc at 250’ away for a 14’x48’ display.

Pros: Perceptually relevant for light trespass, especially when considered at a particular viewpoint.

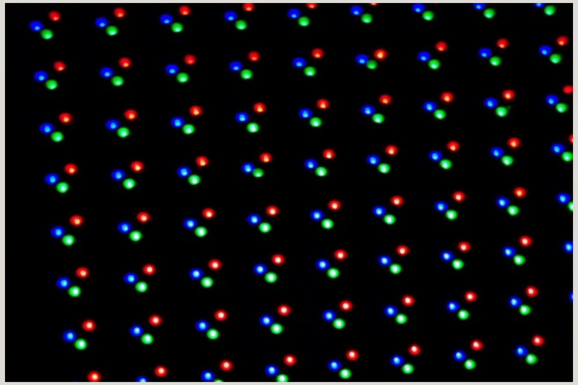
Cons: Can be challenging to measure depending on access to specific areas

ILLUMINATED SIGNAGE TYPES

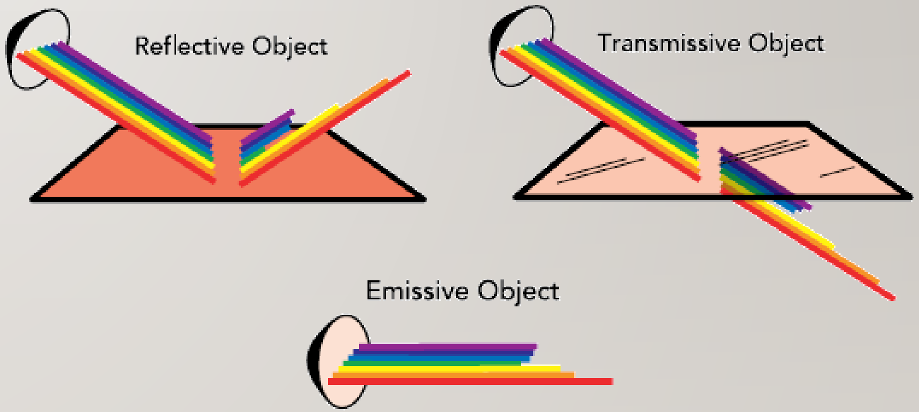
Uplit static (reflective)

Backlit "Internally Lighted"[1] (transreflective)

Downlit static (reflective)



LED digital (emissive)



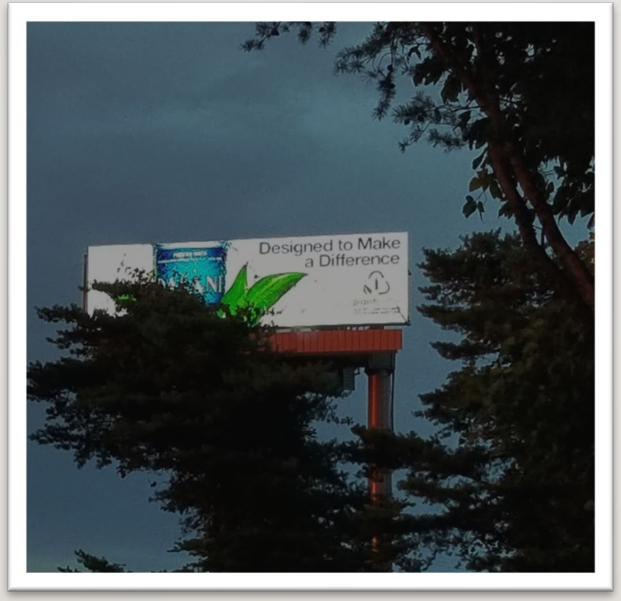
From lighting perspective, emissive LED digitals are most similar to Backlit signs:

- There are no glare-inducing hotspots (small areas of very high luminance/NITS)
- No directional projection of light

[1] §5.2.2.2 - "internally lighted" signs are acceptable

LUMINAIRES AND DIGITAL BILLBOARDS ARE DIFFERENT

Small area but high luminance (2000-10000 NITS), causes glare and unwanted illumination if not shielded properly



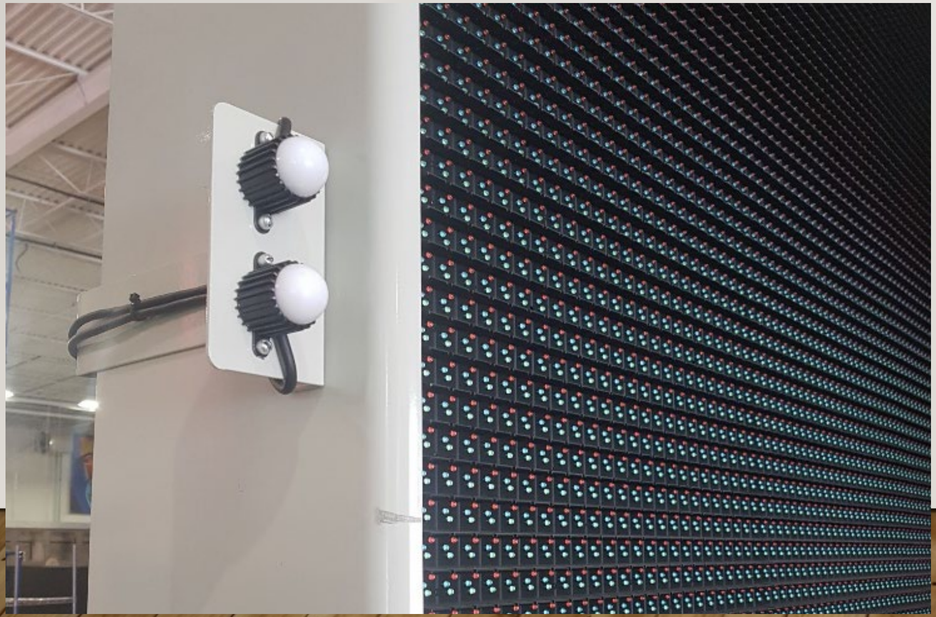
Large area but low luminance (<300 NITS), does not cause glare but capable of unwanted illumination

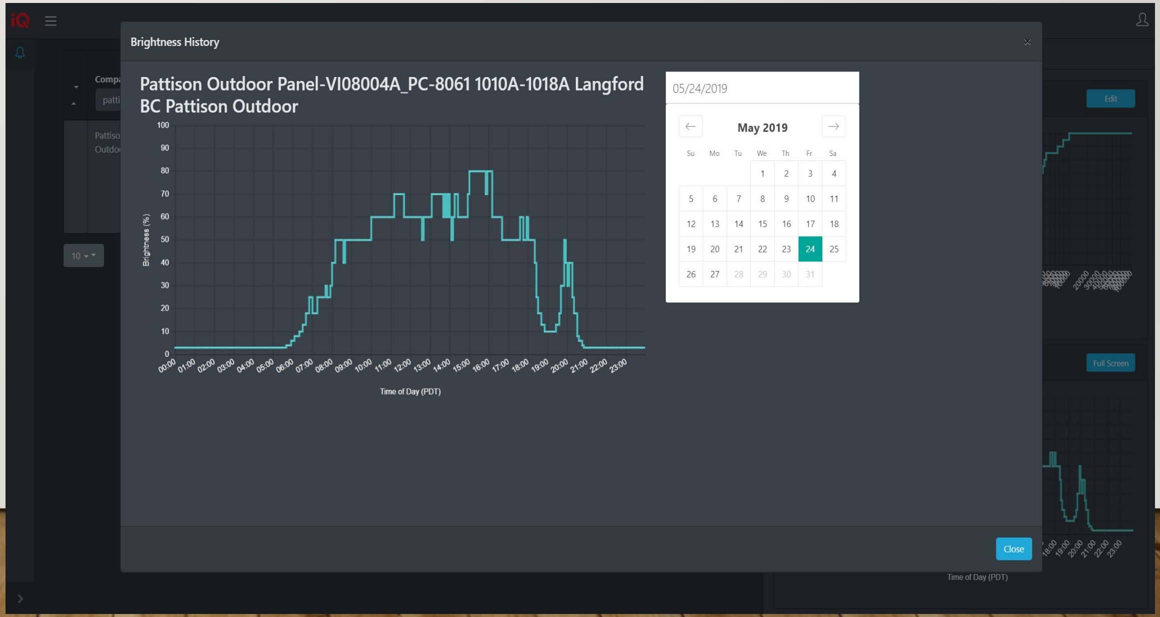
Because of these significant qualitative difference between light fixtures and digital billboards, specific rules around light fixtures are not always valid. **However, unwanted illumination needs be considered and limited.**

LED DIGITAL DISPLAYS – IMPORTANT FEATURES FOR LIGHT MANAGEMENT

Ambient sensitive brightness control with redundant backups ensure accurate sunset time dimming.

Monitoring / Logging – Modern Digital Billboards will maintain a record of the historical brightness output to reduce inadvertent non-compliance.





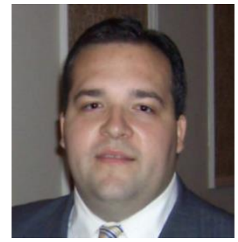
SUMMARY

1. Digital Billboards, at the required 300 NITS (or 0.3 fc at 250') level, does not produce glare in the same way that light fixtures do.
2. All the sites of the proposal shall be limited to 0.1 fc residential property impact, abiding by the current regulation on lighting impact to residential.

Highlights of **Michael W. Tantala, P.E.**

- **Licensed Professional Engineer**; licensed in **10 states**; NCEES Model Law Engineer (MLE)
- **Principal** of Tantala Associates, LLC, Engineers and Architects; Michael has 15 years in practice with Tantala Associates, which has been in business for over 50 years.
- Engineering degrees from the **University of Pennsylvania** and **Princeton University**
- International Code Council member and Chair of one of ICC code development committees; member of numerous professional organizations
- 15 years professional experience in design and engineering-inspection of buildings for life-safety and code-compliance issues
- Currently also an **Adjunct Professor** at City College of New York; also lectured at Princeton University, University of Pennsylvania, and Harvard University
- His **research** areas include design and engineering of structures, code compliance, risk assessment for earthquake, wind and flood hazards, traffic safety, GIS/geospatial modeling of urban infrastructure systems and their interactions
- **Awarded Mayoral Commendation** by the City of New York for engineer response and recovery work during 9/11 attacks; specifically, he inspected buildings prior to fire fighters entering to ensure their safety during 1st-response
- Authored **30 technical papers and publications** in safety research; Performed funded research: for FEMA concerning fire following earthquakes and essential facility performance; for NSF and State EMOs (Emergency Management Office); for The Rockefeller Foundation and the United States Army Corps of Engineers concerning infrastructure, water, and resiliency; for United States Sign Council (USSC) and Foundation for Outdoor Advertising Research and Education (FOARE) concerning signage and safety, *inter alia*
- Conducted **traffic research** examining the statistical relationship between signage and traffic safety in Pennsylvania, Ohio, Virginia, Minnesota and New Mexico; also published work with the Transportation Research Board (TRB) of the National Academies and the Institute of Transportation Engineers (ITE)
- Numerous **professional awards** from AIA, ASCE, *inter alia*
- **Site Safety Qualifications** include: OSHA 30, NYC/DOB Site Safety Manager (SSM) Training, City of Philadelphia Special Inspector, FEMA EMI and numerous safety certifications (NYC MTA, Amtrak, Conrail, LIRR, Metro-North, NJ Transit, Septa, etc); successfully completed numerous site-safety work plans to varied authorities
- Completed numerous **continuing education** programs; including coursework by the National Fire academy; he also presented the Building Safety Week Seminar for the City of Philadelphia, L&I and for the Delaware Valley Regional Planning Commission (DVRPC) as part of their continuing education programs

MICHAEL WALTER TANTALA, P.E.



TANTALA ASSOCIATES, LLC
Engineers & Architects
6200 Frankford Avenue, Philadelphia, PA 19135-3400
T 215.289.4600, F 215.289.4601, MTANTALA@TANTALA.com

PERSONAL

Professional Engineer in private practice providing site/civil, transportation, building/structural, geotechnical, risk assessment, environmental, design/project coordination and development planning services, geospatial analyses, design, consulting and research

Born on March 11, 1976 in Philadelphia, PA; Married on November 16, 2002 to Nicole Carlucci in Saint Thomas Aquinas Catholic Church, Philadelphia, PA; Father to Marisa Jean, born on August 21, 2014

Travel: Canada, Japan, Germany, Switzerland, Poland, Ukraine, Czech Republic, Italy, Vatican, England, Scotland, Greece, Ecuador (Galápagos) and China

EDUCATION

Princeton University	**M.S.E.**, Master of Science in Engineering, Civil Engineering, 2001
Princeton University	**M.A.**, Master of Arts, Civil Engineering, 2000
University of Pennsylvania	**B.S.E.**, Bachelor of Science in Engineering, Civil Engineering Systems, 1998

PROFESSIONAL LICENSURE AND AFFILIATIONS

Registered **Professional Engineer**, Commonwealth of Pennsylvania, License PE071443
Registered **Professional Engineer**, State of New Jersey, License 24GE04914100
Registered **Professional Engineer**, State of New York, License 096307
Registered **Professional Engineer**, State of Connecticut, License PEN.0032620
Registered **Professional Engineer**, State of Delaware, License 16560
Registered **Professional Engineer**, State of Maryland, License 43291
Registered **Professional Engineer**, Commonwealth of Massachusetts, License 50906
Registered **Professional Engineer**, State of Michigan, License 6201067971
Registered **Professional Engineer**, State of Ohio, License PE72050
Registered **Professional Engineer**, State of Florida, License 86350
Registered **Model Law Engineer (MLE)**, The National Council of Examiners for Engineering and Surveying (NCEES), a license designee for reciprocities in other states, Record 29313

Member, American Society of Civil Engineers (ASCE)
Member, Transportation and Development Institute (TDI)
Member, Structural Engineering Institute (SEI)

Member, National Society of Professional Engineers (NSPE)

Member, Pennsylvania Society of Professional Engineers (PSPE)

Member, Institute of Transportation Engineers (ITE)
Member, Transportation Safety Council (TSC)

Member, Association of Transportation Safety Information Professionals (ATSIP)

Member and Vice-Chair, International Code Council (ICC) Consensus Committee on Bleacher Safety (IS-BLE) which develops the American National Standard for Bleachers, Folding & Telescopic Seating, & Grandstands

Member, International Association of Bridge and Structural Engineers (IABSE)

Member, Engineer's Club of Philadelphia (ECP)

Member, American Society of Landscape Architects (ASLA), Affiliate Member

Member, Alumni Association of Princeton University

Member, Alumni Association of the University of Pennsylvania

Member, Board of Trustees, Saint Basil Academy (Girls Catholic College-Preparatory High School), Jenkintown, Pennsylvania, 2006 to date

Member, Holy Family University, Scholarship Ball Committee, 2007 to date

HONORS AND AWARDS

The Latrobe Prize, The American Institute of Architects (AIA), international prize awarded once every two years to advance the art & science of architectural practice, awarded with Guy Nordenson, Stan Allen & others, 2007

Honorable Mention, Outstanding Engineering Project, Delaware Valley Engineers Week Award, 2005

Siedliska Award (as part of Tantala Associates), Holy Family University, 2004

Mayoral Commendation for Engineering Assistance during the 9/11 Tragedy, The City of New York, Office of the Mayor and the NYC Department of Design and Construction, 2002

Graduate Travel Grant, National Science Foundation and Earthquake Engineering Research Institute, 2002

University Research Board (URB) Tuition Award, Princeton University, 2000 and 2001

Recognition Award for "Teaching to Making a Difference" Program, Princeton University, 2000

Graduate Tuition Award, Princeton University, 1998 to 2001

Sloan Foundation / ASCE National, Selected to represent the American Society of Civil Engineers (ASCE) and the Civil Engineering Profession in *Cornerstones of Engineering* on Video, CD-ROM and website, 1998

Tau Beta Pi Award, University of Pennsylvania, 1998

E. Stuart Eichert, Jr. Memorial Prize for Civil and Systems Engineering, University of Pennsylvania, 1997

Humphry Scholarship, American Society of Civil Engineers (ASCE), Philadelphia Chapter, 1997

Jury Prize Award, Pennsylvania Environmental Council, Transportation Ideas Competition, 1997

Daniel W. Mead Award, American Society of Civil Engineers (ASCE, Zone I), 1997

Mulford-Neal-Payne Award and Scholarship, Engineers Club of Philadelphia, 1997

National Engineer's Week Outstanding Research Award, Pennsylvania Society of Professional Engineers, 1996

The Shimizu Prize (National Award including honorarium and all-expenses trip to Japan), American Society of Civil Engineers (ASCE National) and Shimizu Corporation of Japan, 1995

SAFETY CERTIFICATIONS

OSHA 30 Certification

Rail Safety Certifications – NYC MTA, Amtrak, Conrail, LIRR, Metro-North, NJ Transit, Septa, TWIC

NYC, Department of Buildings, Site Safety Manager (SSM) Training, 2019

City of Philadelphia, Department of Licenses and Inspections, Certified Special Inspector

City of Philadelphia, Department of Licenses and Inspections, Building Safety Speaker, Structural Safety and Soundness

FEMA, United States Emergency Management Institute (EMI), Hazards Training (HAZUS), Emmitsburg, MD

WORK EXPERIENCE

TANTALA ASSOCIATES, *LLC*, *Engineers & Architects, Philadelphia, PA, 2002 to date*
Principal, Professional Engineer

Professional Engineer in private practice providing site/civil, transportation, building/structural, geotechnical, risk assessment, environmental, design/project coordination and development planning services, site safety site-specific work plans

Key Projects include: numerous public, residential, commercial and institutional developments in Pennsylvania; *Holy Family University*, Phila and Newtown Campuses (Education & Technology Center, Garden Residence Hall, Athletic Fields Development); *Sunoco, Inc* (Multiple Facility-wide Projects); *CSFN* Delaney Hall, Religious Residence, Phila; *Transcor* Distribution Center, Phila; *Nazareth* Academy Performing Arts Center, Phila; *RGO* Leadership Learning Center, Charter School, Phila; *Washington Savings Bank* Headquarters, Phila; Traffic impact analysis of *PennDOT* project interchange redesign near Commodore Barry Bridge. Chester, PA*;* the *Foundation for Outdoor Advertising Research and Education (FOARE)* and the *United States Sign Council (USSC)* Traffic Safety Research Projects, Lighting and Visibility studies, Office of Emergency Management, Infrastructure Risk Assessments from Earthquakes, Various Counties in NJ; *City of Philadelphia*, Office of Risk Management, Site-Specific Work Plan Submissions to Transit Authorities (FEMA, EMOs, Federal Aviation Administration, Conrail, Septa, Amtrak, Conrail, CSX, NJT,LIRR, Metro-North, LA Metro), Various Locations; *inter alia;*

THE UNIVERSITY OF PENNSYLVANIA, STUART WEITZMAN SCHOOL OF DESIGN, Philadelphia, PA, 2017 to date

Lecturer, School of Design, Graduate Teaching and Research activities, 2019 to date
Visiting Scholar, School of Design, Research activities, 2017-2019

THE CITY COLLEGE OF NEW YORK (CCNY) OF **THE CITY UNIVERSITY OF NEW YORK *(CUNY)***, *New York, NY, 2013 to date*

Adjunct Professor, The Bernard and Anne Spitzer School of Architecture, Graduate Teaching and Research activities

PRINCETON UNIVERSITY*, School of Architecture, Princeton, NJ, 2005 to 2017*

Visiting Fellow, SoA, research with (1) the AIA Latrobe Prize research award for the Planning and Sustainability of the New Jersey and New York Upper Bay project, (2) the Palisades Bay Research Project, (3) the Princeton Lighting Impact and Sustainability Research Project, (4) the La Biennale di Venezia Research Project, (5) the Princeton Environmental Atlas (PEA) Master Plan project, and (6) the Structures of Coastal Resilience (SCR) / Rockefeller Foundation-funded project for developing resilient and adaptive coastal design strategies addressing climate change and sea level rise.

Visiting Lecturer, SoA course arc408: Infrastructure and Society (Spring 2006 and Spring 2008) and SoA course arc IWS: junior architectural studio (Spring 2010).

GUY NORDENSON & ASSOCIATES*, Structural Engineers, LLP, New York, NY, Fall 2001*

Volunteer for response effort for World Trade Center disaster. Assisted with comprehensive structural damage and impact study of 400 building site, inspection of WTC Bankers Trust Building and loss estimates for FEMA. Awarded a Mayoral Commendation for Engineering Assistance during the 9/11 Recovery Effort from The City of New York, Office of the Mayor and the NYC Department of Design and Construction.

UNITED STATES NAVY, *Naval Surface Warfare Center, Facilities & Turbines Division, Philadelphia, PA, 1993-1994*

Designed, researched, evaluated submarine antenna test sites & power systems for United States Naval Destroyer Class Ships

CONSULTING

Princeton University, School of Architecture, Research in Regional Planning, Sustainability and Hazards Research

University of Pennsylvania, School of Design, Research in Sustainability

University of Pennsylvania, Department of Systems Engineering, Recoverable Materials Research

The Rockefeller Foundation, Structures of Coastal Resilience (SCR) Research

The City College of New York, various research grants

Holy Family University for University Environmental Compliance Audit and Certification with the Environmental Protection Agency (EPA) and the Pennsylvania Department of Environmental Protection

Foundation for Outdoor Advertising Research and Education (FOARE), Traffic Safety Research

United States Sign Council (USSC), Traffic Safety Research

American Museum of Natural History (AMNH), Program for Risk Assessment of Collections

Federal Emergency Management Agency (FEMA) Region II, Multi-hazard Research

Multidisciplinary Center for Earthquake Engineering (MCEER), Multi-hazard Research

National Science Foundation (NSF), Materials Research

New York State Emergency Management Office (NYSEMO), Multi-hazard Research

New York City-Area Consortium for Earthquake Loss Mitigation (NYCEM), Multi-hazard Research

New Jersey State Police Emergency Management Office (NJSP-EMO), Multi-hazard Research

New York City Office of Emergency Management (NYCOEM), Multi-hazard Research

TEACHING EXPERIENCE

Adjunct Professor, The City College of New York, The Bernard and Anne Spitzer School of Architecture, Graduate Architecture Courses, 2010 to date

Guest lecturer, University of Pennsylvania, School of Design, 2016 and 2019

Guest lecturer, Harvard University, Graduate School of Design, 2014

Visiting lecturer, Princeton University School of Architecture, 2006 to 2011

Taught and helped develop the Princeton University "Teaching to Make a Difference" Program and Workshop, a campus-wide initiative for improving undergraduate education

Supervised four Princeton University undergraduates for their senior theses and several undergraduate students on their independent studies

Assistant-in-Instruction, Princeton University and University of Pennsylvania Courses: Mechanics of Solids, Analysis and Design of Reinforced Concrete Structures, Structures and the Urban Environment, Structural Analysis, Structural Dynamics, Risk Assessment and Management, Civil Engineering Materials Laboratory

SELECT RESEARCH AND SPECIAL PROJECTS

Structures of Coastal Resilience Project, Rockefeller Foundation-funded grant collaborating closely with the United States Army Corps of Engineers and research teams from Princeton University, City College of New York, University of Pennsylvania and Harvard University, in developing resilient and adaptive coastal design strategies addressing climate change and sea level rise, 2013-2015.

Dredged Materials Pilot Project: Red Hook, Research collaborating with engineers Guy Nordenson and Associates, Langan, and Arcadis US and the Port Authority of New York and New Jersey on the design of a coastal storm protection pilot project utilizing dredged materials at the Red Hook waterfront, New York, 2013-2014.

Finalist Team Entry Future Ground, team proposal for Van Alen Institute's Competition, 2014.

Premiated proposal for Reinventing Dharavi Competition, Dharavi Deep Streets, 2014.

Yangtze River Estuary: Adaptation for the Pudong Delta, City College of New York and Princeton University, 2013.

Exhibition at the 12th International Architecture in the United States Pavilion at La Biennale di Venezia, Venice, Italy. Open on 29 August to 21 November 2010.

Exhibition "Rising Currents: Projects for New York's Waterfront", The Museum of Modern Art (MoMA) in New York, Select work addresses some of the most urgent challenges of sea-level rise resulting from global climate change in New York City. Open on 24 March to 11 October 2010.

Princeton Lighting Impact and Sustainability Study, for Princeton University, High Meadows Grant Research, 2010.

The Latrobe Prize Research, for the American Institute of Architects (AIA), with Princeton University, "On the Water: A Model for the Future: A Study of New York and New Jersey Upper Bay" on Regional Planning and Sustainability, 2007 to date.

The Foundation for Outdoor Advertising Research and Education (FOARE), on a study of the relationship between digital billboards and traffic safety, 2007 to date.

Princeton Environmental Atlas (PEA), for Princeton University, School of Architecture. Master planning activities and research for campus development, 2005 to 2007

American Museum of Natural History, Consultant, Comprehensive Risk Assessment Program of Collections, 2005.

Earthquake Loss Estimation Study for the New York City Area, for the Federal Emergency Management Agency (FEMA) & Multidisciplinary Center for Earthquake Engineering Research (MCEER). Multi-year, 1999 to 2005.

Signage and Traffic Safety: Research, Perspectives and Correlations for the United States Sign Council (USSC), Multi-year research, 2003 to 2004.

Risk Assessments for New Jersey State (including Bergen, Essex, Hudson, Union and Somerset Counties), for the New Jersey State Police, Office of Emergency Management (NJSP-OEM). Multi-year research, 2001 to date.

World Trade Center Disaster, Professional Consultant with Recovery Effort, Structural Evaluations and Financial Estimates, and related work, for the Federal Emergency Management Agency, September-November 2001.

Earthquake Loss Estimation Study for Selected Blocks in the City of Patras, Greece, prepared for Technical Chamber of Greece, Working Group No. I.2, Estimation of Seismic Vulnerability of Buildings, 2001 and 2005.

Stochastic Methods in Finite Elements Study. Comparison of the computational efficiency of the stochastic finite element method (SFEM) versus the stochastic boundary element method (SBEM), Princeton University, 2000.

Particulate Rubber Included Concrete Compositions for the National Science Foundation (NSF), Grant Number CMS94-23749 (P.I. John A. Lepore, Ph.D., P.E. at University of Pennsylvania), 1996 to 1998.

SELECT PUBLICATIONS AND TECHNICAL REPORTS

[1] Chapman, J., M. Tantala, N. Lin, C. Little, M. Oppenheimer, et al., “Structures of Coastal Resilience: Probabilistic Coastal Flood Hazard Mapping for Dynamic Performance Based Design”, American Water Resources Association (AWRA), Specialty Conference on Climate Change Adaptation, June 2015.

[2] Nordenson, G., M. Tantala, SCR Team (Princeton, CCNY, Penn, Harvard), *et al.* “Structures of Coastal Resilience (SCR), Phase 2: Detailed Design”, Sections of the Technical Report, June 2014.

[3] Nordenson, G., M. Tantala, SCR Team (Princeton, CCNY, Penn, Harvard), *et al.* “Structures of Coastal Resilience (SCR), Phase 1: Context, Site, and Vulnerability Analysis”, Sections of the Technical Report, February 2014.

[4] Tantala, M., A. Tantala, “An Examination of the Relationship between Digital Billboards and Traffic Safety in Reading, Pennsylvania Using Empirical Bayes Analyses”, Technical Paper, Institute of Transportation Engineers (ITE), 2011 Technical Conference, April 2011, paper accepted for proceedings and presentation.

[5] Nordenson, G., *et al*. <u>Patterns and Structure</u>. Section on Earthquake Loss Estimation. Lars Muller Publishers, 2010.

[6] Tantala, M., C. Seavitt, *et al.*, “Soft Infrastructure in the Urban Estuary / Palisade Bay”, Technical Paper, International Association for Bridge and Structural Engineering (IABSE), 34th Conference and Symposium in Venice, Italy, September 2010, paper accepted for proceedings and presentation.

[7] Tantala, M., A. Tantala, “A Study of the Relationship between Digital Billboards and Traffic Safety in Henrico County and Richmond, Virginia”, Technical Reports submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), 2010.

[8] Tantala, M., A. Tantala, “A Study of the Relationship between Digital Billboards and Traffic Safety in the Greater Reading Area, Berks County, Pennsylvania”, Technical Report submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), 2010.

[9] Tantala, M., A. Tantala, “An Update of a Study of the Relationship between Digital Billboards and Traffic Safety in Cuyahoga County, Ohio”, Technical Report submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), 2009.

[10] Tantala. M., G. J. P. Nordenson, *et al.*, <u>On the Water: the Palisades Bay</u>. Lulu Book Publishing, 2009.

[11] Tantala, M., P. Lewis, *et al.*, “Princeton’s Exterior Pathways: Lighting Analysis + Sustainable Prototypes”, Technical Report submitted to the Princeton Sustainability Committee, Princeton University, 2009.

[12] Tantala, M., A. Tantala, “An Update of a Study of the Relationship between Digital Billboards and Traffic Safety in Cuyahoga County, Ohio”, Technical Report submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), 2009.

[13] Tantala, M., A. Tantala, “A Study of the Relationship between Digital Billboards and Traffic Safety in Rochester, MN”, Technical Report submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), 2009.

[14] Tantala. M., G. J. P. Nordenson, *et al.*, “Envisioning Radical Futures on the Water”, Journal article in Places: Forum of Design for the Public Realm, Volume 20, Number 2, 2008.

[15] Tantala. M., G. Deodatis, G. J. P. Nordenson, K. Jacob, “Earthquake Loss Estimation for the New York City Metropolitan Region”, Journal of Soil Dynamics and Earthquake Engineering, Volume 28, Numbers 10-11, Oct/Nov 2008.

[16] Tantala. M., G. J. P. Nordenson, *et al.*, "On the Water: A Model for the Future: A Study of New York and New Jersey Upper Bay", Princeton University, School of Architecture Technical Report for the American Institute of Architects (AIA), 2007.

[17] Tantala, M., A. Tantala, "A Study of the Relationship between Digital Billboards and Traffic Safety in Cuyahoga County, OH", Technical Report submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), 2007.

[18] Tantala. M., G. J. P. Nordenson, *et al.*, "Princeton Environmental Atlas", Princeton University, School of Architecture, Technical Report, 2006.

[19] Tantala. M., New Jersey State Police, Office of Emergency Management, Technical Reports of Earthquake Loss Estimation for Various Counties, 2006, 2005, 2004, 2003 and 2001.

[20] Tantala. M., G. Nordenson, *et al.*, "NYCEM : Earthquake Risks and Mitigation in the New York | New Jersey | Connecticut Region", Multidisciplinary Center for Earthquake Engineering (MCEER) Technical Report MCEER-03-SP02, 2005.

[21] Tantala, M., P. Tantala, "An Examination of the Relationship between Advertising Signs and Traffic Safety", 84th Transportation Research Board (TRB) Annual Conference Proceedings, Washington, D.C., 2005.

[22] Tantala, M., A. Tantala, P. Tantala "Traffic Safety Study: Research, Perspectives and Correlations" United States Sign Council (USSC) Technical Report, Bristol, PA, November 2003.

[23] Tantala, M., G. Deodatis. "Development of Seismic Fragility Curves for Tall Buildings", American Society of Civil Engineers (ASCE) 15th Engineering Mechanics Conference, Columbia University, New York, June 2002.

[24] Tantala, M., G. Deodatis. "Essential Facilities Performance Study for Seismic Scenarios in Manhattan", Urban Hazards Forum, John Jay College of Criminal Justice of the City University of New York, New York, January 2002.

[25] Tantala, M. W., A. Dargush, G. Deodatis, K. Jacob, G. J. P. Nordenson, D. O'Brien, B. Swiren. "Earthquake Loss Estimation for the New York City Area", 7th National Conference on Earthquake Engineering (7NCEE), Earthquake Engineering Research Institute (EERI), Boston, MA, July 2002.

[26] Tantala. M., G. J. P. Nordenson, *et al.*, "Estimating Earthquake Losses for the Greater New York City Area", Multidisciplinary Center for Earthquake Engineering (MCEER) Research Progress and Accomplishments, Technical Publication MCEER-01-SP01, May 2001.

[27] Tantala, M., G. Deodatis, "Earthquake Loss Estimation Study for Selected Blocks in the City of Patras, Greece", prepared for Technical Chamber of Greece, Working Group No. I.2, Estimation of Seismic Vulnerability of Buildings, April 2001.

[28] Nordenson, G. J. P., G. Deodatis, K. H. Jacob, M. W. Tantala. "Earthquake Loss Estimation for the New York City Area", 12th World Conference on Earthquake Engineering, New Zealand, 2000.

[29] Lepore, J.A. and M.W. Tantala. "Behavior and Feasibility of Rubber Included Concrete (RIC)", CONCRETE 97 International Conference, Adelaide, South Australia, May 11-14, 1997.

[30] Zandi, I., J.A. Lepore and M.W. Tantala. "Quasi-Elastic Behavior of Rubber Included Concrete (RIC) Using Waste Rubber Tires", Proceedings, International Conference on Solid Waste Management and Technology, November, 1996.

[31] Lepore, J.A. and M.W. Tantala. "Particulate Rubber Included Concrete Compositions", National Science Foundation (NSF) Report, Grant, Number CMS94-23749, December, 1996.

SELECT FEATURES AND CONFERENCE PRESENTATIONS

Exhibition, “Structures of Coastal Resilience: Designing for Climate Change”, Collaboration with the SCR Research Group, The Center for Architecture of The American Institute of Architects (AIA) New York Chapter, 2016.

Conference Presentation, 2015 American Water Resources Association (AWRA) Special Conference on Climate Change Adaptation, Session on Extreme Events, “Structures of Coastal Resilience: Probabilistic Coastal Flood Hazard Mapping for Dynamic Performance Based Design” with J. Chapman, G. Nordenson, N. Lin, C. Little, T. Mayo, and M. Oppenheimer, 2015

Seminar Presentation “Structural Safety and Soundness”, City of Philadelphia, Department of Licenses and Inspections, Building Safety Week, 2013

Conference Presentation, Institute of Transportation Engineers (ITE), 2011 Technical Conference in Lake Buena Vista, Florida, April 2011.

Workshop Seminar, Geospatial Modeling, American Society of Landscape Architects (ASLA) Chapter of The City College of New York (CCNY), 2011

Conference Presentation, 34th International Association for Bridge and Structural Engineering Symposium on Large Structures and Infrastructures for Environmentally Constrained and Urbanized Areas, in Venice, Italy, September 2010.

Exhibition at the 12th International Architecture in the United States Pavilion at La Biennale di Venezia, Venice, Italy. Open on 29 August to 21 November 2010.

Exhibition “Rising Currents: Projects for New York’s Waterfront”, The Museum of Modern Art (MoMA) in New York, Select work addresses some of the most urgent challenges of sea-level rise resulting from global climate change in New York City. Open on 24 March to 11 October 2010.

Technical Presentations to the National Alliance of Highway Beautification Agencies (NAHBA):
12th Annual Education Conference on the Control of Outdoor Advertising in Branson, Missouri, 2009
10th Annual Education Conference on the Control of Outdoor Advertising in Jackson, Mississippi, 2007

Conference Presentation, Transportation Research Board, Annual Conference in Washington, D.C., January, 2008

Research Featured on the History Channel Special Series and DVD *Mega Disasters: New York Earthquake*, 2007

Traffic Safety Interview and Research Feature on the DVD “Digital out-of-home advertising: the latest info on digital billboard regulations and safety” distributed the Outdoor Advertising Association of America, 2007

Conference Presentation, Transportation Research Board, Annual Conference in Washington, D.C., 2005

Conference Presentation, American Society of Civil Engineers, 15th Engineering Mechanics Conference, Columbia University, New York, June 2002

Conference Presentation, 7th National Conference on Earthquake Engineering, Boston, MA, July 2002

Conference Presentation, Urban Hazards Forum, John Jay College of Criminal Justice of the City University of New York, January 2002

Keynote Speaker, Princeton University Geographic Information Systems (GIS) Day, 2000

Guest Speaker, NYC Geospatial Information Systems and Mapping Organization (GISMO), 2000

Guest Speaker, Graduate Course Lecture, Multidisciplinary Center for Earthquake Engineering (MCEER), University at Buffalo, The State University of New York, 1999

Sloan Foundation / ASCE National, selected to represent the American Society of Civil Engineers (ASCE) and the Civil Engineering Profession in *Cornerstones of Engineering* on Video, CD-ROM and website, 1998

Conference Presentation, International Conference on Solid Waste Management and Technology, 1996

Invited Speaker, American Society of Civil Engineers / Shimizu Corporation Award Receptions, New York and Tokyo, 1995

TANTALA ASSOCIATES, LLC
ENGINEERS & ARCHITECTS

3 December 2019
Phila.

City of Milford Planning and Zoning Board
c/o Chairman Jim Quish
70 West River Street
Milford, CT 06460

Re: ***Digital Billboard Zoning Regulation Text Change***
concerning the modernization of existing billboards along Interstate 95
in the City of Milford, Connecticut

Chairman Quish:

During the past decade, I conducted **traffic research** examining the relationship between digital billboards and traffic safety in the United States. The digital billboards which I studied are comparable to those proposed for digital conversion in the City of Milford; they display static messages with no animation, have strictly controlled brightness and dwell time, and will be professionally designed to comply with industry standards.

1. Proposed Conversions and Analysis. I understand that a proposed zoning regulation text change would potentially allow for the conversion of several existing billboards in industrial zones along the Interstate 95 corridor in the City of Milford. The proposed digital billboard conversion locations are within 200 feet of the I-95 corridor with face sizes of 14'x48', restricted brightness over ambient lighting, and a dwell time limited to 10 seconds. I observed the existing locations and analyzed engineering parameters including lines-of-sight, viewing angles and key travel times and distances.

2. Traffic Safety. The issue of traffic safety and digital billboards was studied extensively over the last decade by government agencies, the academic community, and others; these studies include both theoretical (science-based) and empirical (real-world) data. Concerning the proposed digital conversions and traffic safety, I offer the following.

- The 2012 peer-reviewed research study by *FHWA* collectively studied digital billboards with dwell times of 8 to 10 seconds and used human factors analysis to conclude that drivers are not distracted by digital billboards along roads in two States. The study found that the "data suggest that the drivers in this study directed the majority of their visual attention to areas of the roadway that were relevant to the task at hand (e.g., the driving task)." The researchers also opined that "the results did not provide evidence indicating that [digital technology of this type], as deployed and tested in [the] two selected cities, were associated with unacceptably long glances away from the road", adding that "the demands of the driving task tend to affect the driver's self-regulation of gaze behavior" (Reference A.).

- The 2007 *United States Federal Highway Administration* (*FHWA*) guidance memorandum also established acceptable criteria for this technology and recommends that the "duration of each display is generally between 4 and 10 seconds – 8 seconds is recommended" (Reference B.). The proposed 10-second duration for these locations will comply.

- My 2011 paper published by the *Institute of Transportation Engineers* (*ITE*) examined accident statistics for billboards with 6-, 8-, and 10-second dwell times in Reading, Pennsylvania, and found consistent results among dwell times. My research used quantitative data and accident reports near digital billboards for periods of comparison in excess of eight years by examining temporal (when and how frequent) and spatial (where and how far) comparisons under a variety of factors (size, display time, day/night conditions, etc.). The data show that these types of controlled digital billboards are safety neutral and are statistically not linked to traffic accidents (Reference C.).

- In 2007, a study was also completed by the Virginia Tech Transportation Institute (VTTI) of the human factors in two different cities and found similar conclusions. VTTI's research showed that "several driving performance measures in the presence of digital billboards are on par with those associated with everyday driving, such as the on-premises signs located at businesses" and that "these performance measures included eyeglance performance, speed maintenance, and lane keeping." (Reference D.).

- The use of digital billboards has and continues to be safely and regularly permitted throughout the United States by numerous federal, state and local units of government [including the Connecticut Department of Transportation] and is positively supported by Federal (FHWA) research and others. Studies, reports, and examples from the academic community, U.S. federal, state, and local governmental agencies, law enforcement officials, the engineering profession, and the advertising industries amplify these findings.

3. Professional Opinion. It is my professional opinion, within a reasonable degree of engineering certainty, and based on the design, location, configuration, size, height, and lighting, that the proposed, digital-sign conversions

A. will not present a physical or visual obstruction to vehicles travelling on Interstate 95,

B. will not detract or interfere with the effectiveness of official traffic-control devices,

C. is appropriate based on industry standards, traffic safety, visibility, *inter alia*, and

D. will comply with professional design and industry standards to include design, lighting, etc.

Based on my best knowledge, information, and belief. Captions used in this report are for convenience of reference only and shall not affect the meaning or construction of any of its provisions. I reserve the right to supplement our report if any additional information is provided to us.

As an addendum to this letter, I enclose my *Curriculum Vitae* and copies of several of the studies which I reference. Thank you for your consideration. Please feel free to contact me if you have any questions.

Sincerely,

TANTALA ASSOCIATES, LLC

Michael W. Tantala, P.E.
CT License PEN.0032620

MWT:ows
Enc.
cc (w/Enc.): K Curseaden / *Curseaden & Moore, LLC*

Annex A

REFERENCES

A. Report No. FHWA-HRT concerning “Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)” dated Sep12, *U.S. Department of Transportation, Federal Highway Administration*, 70 sheets.

B. Memorandum concerning “Guidance on Off-Premise Changeable Message Signs” dated 25Sep07, *U.S. Department of Transportation, Federal Highway Administration*, four sheets.

C. Technical Paper titled “An Examination of the Relationship between Digital Billboards and Traffic Safety in Reading, Pennsylvania Using Empirical Bayes Analyses”, by Michael W. Tantala, P.E. and Albert M. Tantala. Sr., P.E., Proceedings of the *Institute of Transportation Engineers* (*ITE*), Technical Conference, Apr11, 19 sheets.

D. Final Report titled “Digital Performance and Digital Billboards” prepared by the *Virginia Tech Transportation Institute* for the *Foundation for Outdoor Advertising Research and Education* by S. Lee, M. McElheny and R. Gibbons, 22Mar07, 90 pages.

2012 Federal Traffic Study and Related Materials

DRIVER VISUAL BEHAVIOR IN THE PRESENCE OF COMMERCIAL ELECTRONIC VARIABLE MESSAGE SIGNS (CEVMS)

SEPTEMBER 2012

U.S. Department of Transportation
Federal Highway Administration

FHWA-HEP-

FOREWORD

The advent of electronic billboard technologies, in particular the digital Light-Emitting Diode (LED) billboard, has necessitated a reevaluation of current legislation and regulation for controlling outdoor advertising. In this case, one of the concerns is possible driver distraction. In the context of the present report, outdoor advertising signs employing this new advertising technology are referred to as Commercial Electronic Variable Message Signs (CEVMS). They are also commonly referred to as Digital Billboards and Electronic Billboards.

The present report documents the results of a study conducted to investigate the effects of CEVMS used for outdoor advertising on driver visual behavior in a roadway driving environment. The report consists of a brief review of the relevant published literature related to billboards and visual distraction, the rationale for the Federal Highway Administration research study, the methods by which the study was conducted, and the results of the study, which used an eye tracking system to measure driver glances while driving on roadways in the presence of CEVMS, standard billboards, and other roadside elements. The report should be of interest to highway engineers, traffic engineers, highway safety specialists, the outdoor advertising industry, environmental advocates, Federal policymakers, and State and local regulators of outdoor advertising.

Monique R. Evans
Director, Office of Safety Research and Development

Nelson Castellanos
Director, Office of Real Estate Services

TECHNICAL DOCUMENTATION PAGE

1. Report No. FHWA-HRT-	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)	5. Report Date 6. Performing Organization Code
7. Author(s) William A. Perez, Mary Anne Bertola, Jason F. Kennedy, and John A. Molino	8. Performing Organization Report No.
9. Performing Organization Name and Address SAIC 6300 Georgetown Pike McLean, VA 22101	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Real Estate Services Federal Highway Administration 1200 New Jersey Avenue SE Washington, DC 20590	13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes
The Contracting Officer's Technical Representatives (COTR) were Christopher Monk and Thomas Granda.

16. Abstract
This study was conducted to investigate the effect of CEVMS on driver visual behavior in a roadway driving environment. An instrumented vehicle with an eye tracking system was used. Roads containing CEVMS, standard billboards, and control areas with no off-premise advertising were selected. Data were collected on arterials and freeways in the day and nighttime. Field studies were conducted in two cities where the same methodology was used but there were differences in the roadway visual environment. The gazes to the road ahead were high across the conditions; however, the CEVMS and billboard conditions resulted in a lower probability of gazes as compared to the control conditions (roadways not containing off-premise advertising) with the exception of arterials in Richmond where none of the conditions differed from each other. Examination of where drivers gazed in the CEVMS and standard billboard conditions showed that gazes away from the road ahead were not primarily to the billboards. Average and maximum fixations to CEVMS and standard billboards were similar across all conditions. However, four long dwell times were found (sequential and multiple fixations) that were greater than 2,000 ms. One was to a CEVMS on a freeway in the day time, two were to the same standard billboard on a freeway once in the day and once at night; and one was to a standard billboard on an arterial at night. In Richmond, the results showed that drivers gazed more at CEVMS than at standard billboards at night; however, in Reading the drivers were equally likely to gaze towards CEVMS or standard billboards in day and night. The results of the study are consistent with research and theory on the control of gaze behavior in natural environments. The demands of the driving task tend to affect the driver's self-regulation of gaze behavior.

17. Key Words Driver visual behavior, visual environment, billboards, eye tracking system, commercial electronic variable message signs, CEVMS, visual complexity	18. Distribution Statement No restrictions.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

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SI* (MODERN METRIC) CONVERSION FACTORS

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 yard	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
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		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	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ACRONYMS AND SYMBOLS

CEVMS	Commercial Electronic Variable Message Sign
EB	Empirical Bayes
DCZ	Data Collection Zone
ROI	Region of Interest
LED	Light-Emitting Diode
IR	Infra-Red
CCD	Charge-Coupled Device
MAPPS	Multiple-Analysis of Psychophysical and Performance Signals
GEE	Generalized Estimating Equations
FHWA	Federal Highway Administration
DOT	Department of Transportation

EXECUTIVE SUMMARY

This study examines where drivers look when driving past commercial electronic variable message signs (CEVMS), standard billboards, or no off-premise advertising. The results and conclusions are presented in response to the three research questions listed below:

1. Do CEVMS attract drivers' attention away from the forward roadway and other driving-relevant stimuli?

2. Do glances to CEVMS occur that would suggest a decrease in safety?

3. Do drivers look at CEVMS more than at standard billboards?

This study follows a Federal Highway Administration (FHWA) review of the literature on the possible distracting and safety effects of off-premise advertising and CEVMS in particular. The review considered laboratory studies, driving simulator studies, field research vehicle studies, and crash studies. The published literature indicated that there was no consistent evidence showing a safety or distraction effect due to off-premise advertising. However, the review also enumerated potential limitations in the previous research that may have resulted in the finding of no distraction effects for off-premise advertising. The study team recommended that additional research be conducted using instrumented vehicle research methods with eye tracking technology.

The eyes are constantly moving and they fixate (focus on a specific object or area), perform saccades (eye movements to change the point of fixation), and engage in pursuit movements (track moving objects). It is during fixations that we take in detailed information about the environment. Eye tracking allows one to determine to what degree off-premise advertising may divert attention away from the forward roadway. A finding that areas containing CEVMS result in significantly more gazes to the billboards at a cost of not gazing toward the forward roadway would suggest a potential safety risk. In addition to measuring the degree to which CEVMS may distract from the forward roadway, an eye tracking device would allow an examination of the duration of fixations and dwell times (multiple sequential fixations) to CEVMS and standard billboards. Previous research conducted by the National Highway Traffic Safety Administration (NHTSA) led to the conclusion that taking your eyes off the road for 2 seconds or more presents a safety risk. Measuring fixations and dwell times to CEVMS and standard billboards would also allow a determination as to the degree to which these advertising signs lead to potentially unsafe gaze behavior.

Most of the literature concerning eye gaze behavior in dynamic environments suggests that task demands tend to override visual salience (an object that stands out because of its physical properties) in determining attention allocation. When extended to driving, it would be expected that visual attention will be directed toward task-relevant areas and objects (e.g., the roadway, other vehicles, speed limit signs) and that other salient objects, such as billboards, would not necessarily capture attention. However, driving is a somewhat automatic process and conditions generally do not require constant, undivided attention. As a result, salient stimuli, such as CEVMS, might capture driver attention and produce an unwanted increase in driver distraction. The present study addresses this concern.

This study used an instrumented vehicle with an eye tracking system to measure where drivers were looking when driving past CEVMS and standard billboards. The CEVMS and standard billboards were measured with respect to luminance, location, size, and other relevant variables to characterize these visual stimuli extensively. Unlike previous studies on digital billboards, the present study examined CEVMS as deployed in two United States cities. These billboards did not contain dynamic video or other dynamic elements, but changed content approximately every 8 to 10 seconds. The eye tracking system had nearly a 2-degree level of resolution that provided significantly more accuracy in determining what objects the drivers were looking at compared to an earlier naturalistic driving study. This study assessed two data collection efforts that employed the same methodology in two cities.

In each city, the study examined eye glance behavior to four CEVMS, two on arterials and two on freeways. There were an equal number of signs on the left and right side of the road for arterials and freeways. The standard billboards were selected for comparison with CEVMS such that one standard billboard environment matched as closely as possible that of each of the CEVMS. Two control locations were selected that did not contain off-premise advertising, one on an arterial and the other on a freeway. This resulted in 10 data collection zones in each city that were approximately 1,000 feet in length (the distance from the start of the data collection zone to the point that the CEVMS or standard billboard disappeared from the data collection video).

In Reading, Pennsylvania, 14 participants drove at night and 17 drove during the day. In Richmond, Virginia, 10 participants drove at night and 14 drove during the day. Calibration of the eye tracking system, practice drive, and the data collection drive took approximately 2 hours per participant to accomplish.

The following is a summary of the study results and conclusions presented in reference to the three research questions the study aimed to address.

Do CEVMS attract drivers' attention away from the forward roadway and other driving relevant stimuli?

- On average, the drivers in this study devoted between 73 and 85 percent of their visual attention to the road ahead for both CEVMS and standard billboards. This range is consistent with earlier field research studies. In the present study, the presence of CEVMS did not appear to be related to a decrease in looking toward the road ahead.

Do glances to CEVMS occur that would suggest a decrease in safety?

- The average fixation duration to CEVMS was 379 ms and to standard billboards it was 335 ms across the two cities. The average fixation durations to CEVMS and standard billboards were similar to the average fixation duration to the road ahead.

- The longest fixation to a CEVMS was 1,335 ms and to a standard billboard it was 1,284 ms. The current widely accepted threshold for durations of glances away from the road ahead that result in higher crash risk is 2,000 ms. This value comes from a NHTSA naturalistic driving study that showed a significant increase in crash odds when glances away from the road ahead were 2,000 ms or longer.

- Four dwell times (aggregate of consecutive fixations to the same object) greater than 2,000 ms were observed across the two studies. Three were to standard billboards and one was to a CEVMS. The long dwell time to the CEVMS occurred in the daytime to a billboard viewable from a freeway. Review of the video data for these four long dwell times showed that the signs were not far from the forward view while participant's gaze dwelled on them. Therefore, the drivers still had access to information about what was in front of them through peripheral vision.

- The results did not provide evidence indicating that CEVMS, as deployed and tested in the two selected cities, were associated with unacceptably long glances away from the road. When dwell times longer than the currently accepted threshold of 2,000 ms occurred, the road ahead was still in the driver's field of view. This was the case for both CEVMS and standard billboards.

Do drivers look at CEVMS more than at standard billboards?

- When comparing the probability of a gaze at a CEVMS versus a standard billboard, the drivers in this study were generally more likely to gaze at CEVMS than at standard billboards. However, some variability occurred between the two locations and between the types of roadway (arterial or freeway).

- In Reading, when considering the proportion of time spent looking at billboards, the participants looked more often at CEVMS than at standard billboards when on arterials (63 percent to CEVMS and 37 percent to a standard billboard), whereas they looked more often at standard billboards when on freeways (33 percent to CEVMS and 67 percent to a standard billboard). In Richmond, the drivers looked at CEVMS more than standard billboards no matter the type of road they were on, but as in Reading, the preference for gazing at CEVMS was greater on arterials (68 percent to CEVMS and 32 percent to standard billboards) than on freeways (55 percent to CEVMS and 45 percent to standard billboards). When a gaze was to an off-premise advertising sign, the drivers were generally more likely to gaze at a CEVMS than at a standard billboard.

- In Richmond, the drivers showed a preference for gazing at CEVMS versus standard billboards at night, but in Reading the time of day did not affect gaze behavior. In Richmond, drivers gazed at CEVMS 71 percent and at standard billboards 29 percent at night. On the other hand, in the day the drivers gazed at CEVMS 52 percent and at standard billboards 48 percent.

- In Reading, the average gaze dwell time for CEVMS was 981 ms and for standard billboards it was 1,386 ms. The difference in these average dwell times was not statistically significant. In contrast, the average dwell times to CEVMS and standard billboards were significantly different in Richmond (1,096 ms and 674 ms, respectively).

The present data suggest that the drivers in this study directed the majority of their visual attention to areas of the roadway that were relevant to the task at hand (e.g., the driving task). Furthermore, it is possible, and likely, that in the time that the drivers looked away from the forward roadway, they may have elected to glance at other objects in the surrounding environment (in the absence of billboards) that were not relevant to the driving task. When billboards were present, the drivers in this study sometimes looked at them, but not such that overall attention to the forward roadway decreased.

It also should be noted that, like other studies in the available literature, this study adds to the knowledge base on the issues examined, but does not present definitive answers to the research questions investigated.

INTRODUCTION

"The primary responsibility of the driver is to operate a motor vehicle safely. The task of driving requires full attention and focus. Drivers should resist engaging in any activity that takes their eyes and attention off of the road for more than a couple of seconds. In some circumstances even a second or two can make all the difference in a driver being able to avoid a crash." – US Department of Transportation[(1)]

The advent of electronic billboard technologies, in particular the digital Light-Emitting Diode (LED) billboard, has prompted a reevaluation of regulations for controlling outdoor advertising. An attractive quality of these LED billboards, which are hereafter referred to as Commercial Electronic Variable Message Signs (CEVMS), is that advertisements can change almost instantly. Furthermore, outdoor advertising companies can make these changes from a central remote office. Of concern is whether or not CEVMS may attract drivers' attention away from the primary task (driving) in a way that compromises safety.

The current Federal Highway Administration (FHWA) guidance recommends that CEVMS should not change content more frequently than once every 8 seconds.[(2)] However, according to Scenic America, the basis of the safety concern is that the "…distinguishing trait…" of a CEVMS "… is that it can vary while a driver watches it, in a setting in which that variation is likely to attract the drivers' attention away from the roadway."[(3)]This study was conducted to provide the FHWA with data to determine if CEVMS capture visual attention differently than standard off-premise advertising billboards.

BACKGROUND

A 2009 review of the literature by Molino et al. for the FHWA failed to find convincing empirical evidence that CEVMS, as currently implemented, constitutes a safety risk greater than that of conventional vinyl billboards.[(4)] A great deal of work has been focused in this area, but the findings of these studies have been mixed.[(4,5)] A summary of the key past findings is presented here, but the reader is referred to Molino et al. for a comprehensive review of studies prior to 2008.[(4)]

Post-Hoc Crash Studies

Post-hoc crash studies use reviews of police traffic collision reports or statistical summaries of such reports in an effort to understand the causes of crashes that have taken place in the vicinity of some change to the roadside environment. In the present case, the change of concern is the introduction of CEVMS to the roadside or the replacement of conventional billboards with CEVMS.

The literature review conducted by Molino et al. did not find compelling evidence for a distraction effect attributable to CEVMS.[(4)] The authors concluded that all post-hoc crash studies are subject to certain weaknesses, most of which are difficult to overcome. For example, the vast majority of crashes are never reported to police; thus, such studies are likely to underreport crashes. Also, when crashes are caused by factors such as driver distraction or inattention, the involved driver may be unwilling or unable to report these factors to a police investigator.

Another weakness is that police, under time pressure, are rarely able to investigate the true root causes of crashes unless they involve serious injury, death, or extensive property damage. Furthermore, to have confidence in the results, such studies need to collect comparable data before and after the change, and, in the after phase, at equivalent but unaffected roadway sections. Since crashes are infrequent events, data collection needs to span extended periods of time both before and after introduction of the change. Few studies are able to obtain such extensive data.

Two recent studies by Tantala and Tantala examined the relationship between the presence of CEVMS and crash statistics in Richmond, Virginia, and Reading, Pennsylvania.(6,7) For the Richmond area, 7 years of crash data at 10 locations with CEVMS were included in the analyses. The study used a before-after methodology where most sites originally contained vinyl billboards (before) that were converted to CEVMS (after). The quantity of crash data was not the same for all locations and ranged from 1 year before/after to 3 years before/after. The study employed the Empirical Bayes (EB) method to analyze the data.(8) The results indicated that the total number of crashes observed was consistent with what would be statistically expected with or without the introduction of CEVMS. The analysis approach for Reading locations was much the same as for Richmond other than there were 20 rather than 10 CEVMS and 8 years of crash statistics. The EB method showed results for Reading that were very similar to those of Richmond.

The studies by Tantala and Tantala appear to address many of the concerns from Molino et al. regarding the weaknesses and issues associated with crash studies.(4,6,7) For example, they include crash comparisons for locations within multiple distances of each CEVMS to address concerns about the visual range used in previous analyses. They used EB analysis techniques to correct for regression-to-mean bias. Also, the EB method would better reflect crash rate changes due to changes in average daily traffic and the interactions of these with the roadway features that were coded in the model. The studies followed approaches that are commonly used in post-hoc crash studies, though the results would have been strengthened by including before-after results for non-CEVMS locations as a control group.

Field Investigations

Field investigations include unobtrusive observation, naturalistic driving studies, on-road instrumented vehicle investigations, test track experiments, driver interviews, surveys, and questionnaires. The following focuses on relevant studies that employed naturalistic driving and on-road instrumented vehicle research methods.

Lee, McElheny, and Gibbons undertook an on-road instrumented vehicle study on Interstate and local roads near Cleveland, Ohio.(9) The study looked at driver glance behavior in the vicinity of digital billboards, conventional billboards, comparison sites (sites with buildings and other signs, including digital signs), and control sites (those without similar signage). The results showed that there were no differences in the overall glance patterns (percent eyes-on-road and overall number of glances) between the different sites. Drivers also did not glance more frequently in the direction of digital billboards than in the direction of other event types (conventional billboards, comparison events, and baseline events) but drivers did take longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites. However, the mean glance length toward the digital billboards was less than

1,000 ms. It is important to note that this study employed a video-based approach for examining drivers' visual behavior, which has an accuracy of no better than 20 degrees.[10] While this technique is likely to be effective in assessing gross eye movements and looks that are away from the road ahead, it may not have sufficient resolution to discriminate what specific object the driver is looking at outside of the vehicle.

Beijer, Smiley, and Eizenman evaluated driver glances toward four different types of roadside advertising signs on roads in the Toronto, Canada, area.[11] The four types of signs were: (a) billboard signs with static advertisements; (b) billboard advertisements placed on vertical rollers that could rotate to show one of three advertisements in succession; (c) scrolling text signs with a minor active component, which usually consisted of a small strip of lights that formed words scrolling across the screen or, in some cases, a larger area capable of displaying text but not video; and (d) signs with video images that had a color screen capable of displaying both moving text and moving images. The study employed an on-road instrumented vehicle with a head-mounted eye tracking device. The researchers found no significant differences in average glance duration or the maximum glance duration for the various sign types; however, the number of glances was significantly lower for billboard signs than for the roller bar, scrolling text, and video signs.

Smiley, Smahel, and Eizenman conducted a field driving study that employed an eye tracking system that recorded drivers' eye movements as participants drove past video signs located at three downtown intersections and along an urban expressway.[12] The study route included static billboards and video advertising. The results of the study showed that on average 76 percent of glances were to the road ahead. Glances at advertising, including static billboards and video signs, constituted 1.2 percent of total glances. The mean glance durations for advertising signs were between 500 ms and 750 ms, although there were a few glances of about 1,400 ms in duration. Video signs were not more likely than static commercial signs to be looked at when headways were short; in fact, the reverse was the case. Furthermore, the number of glances per individual video sign was small, and statistically significant differences in looking behavior were not found.

Kettwich, Kartsen, Klinger, and Lemmer conducted a field study where drivers' gaze behavior was measured with an eye tracking system.[13] Sixteen participants drove an 11.5 mile (18.5 km) route comprised of highways, arterial roads, main roads, and one-way streets in Karlsruhe, Germany. The route contained advertising pillars, event posters, company logos, and video screens. Mean gaze duration for the four types of advertising was computed for periods when the vehicle was in motion and when it was stopped. Gaze duration while driving for all types of advertisements was under 1,000 ms. On the other hand, while the vehicle was stopped, the mean gaze duration for video screen advertisements was 2,750 ms. The study showed a significant difference between gaze duration while driving and while stationary: gaze duration was affected by the task at hand. That is, drivers tended to gaze longer while the car was stopped and there were few driving task demands.

The previously mentioned studies estimated the duration of glances to advertising and computed mean values of less than 1,000 ms. Klauer et al., in his analysis of the 100-Car Naturalistic Driving Study, concluded that glances away from the roadway for any purpose lasting more than 2,000 ms increase near-crash/crash risk by at least two times that of normal, baseline driving.[14]

Klauer et al. also indicated that short, brief glances away from the forward roadway for the purpose of scanning the driving environment are safe and actually decrease near-crash/crash risk.[14] Using devices in a vehicle that draw visual attention away from the forward roadway for more than 2,000 ms (e.g., texting) is incompatible with safe driving. However, for external stimuli, especially those near the roadway, the evaluation of eye glances with respect to safety is less clear since peripheral vision would allow the driver to still have visual access to the forward roadway.

Laboratory Studies

Laboratory investigations related to roadway safety can be classified into several categories: driving simulations, non-driving-simulator laboratory testing, and focus groups. The review of relevant laboratory studies by Molino et al. did not show conclusive evidence regarding the distracting effects of CEVMS.[4] Moreover, the authors concluded that present driving simulators do not have sufficient visual dynamic range, image resolution, and contrast ratio capability to produce the compelling visual effect of a bright, photo-realistic LED-based CEVMS against a natural background scene. The following is a discussion of a driving simulator study conducted after the publication of Molino et al.[4] The study focused on the effects of advertising on driver visual behavior.

Chattington, Reed, Basacik, Flint, and Parkes conducted a driving simulator study in the United Kingdom (UK) to evaluate the effects of static and video advertising on driver glance behavior.[15] The researchers examined the effects of advertisement position relative to the road (left, right, center on an overhead gantry, and in all three locations simultaneously), type of advertisement (static or video), and exposure duration of the advertisement. (The paper does not provide these durations in terms of time or distance. The exposure duration had to do with the amount of time or distance that the sign would be visible to the driver.) For the advertisements presented on the left side of the road (recall that drivers travel in the left lane in the UK), mean glance durations for static and video advertisements were significantly longer (approximately 650 to 750 ms) when drivers experienced long advertisement exposure as opposed to medium and short exposures. Drivers looked more at video advertisements (about 2 percent on average of the total duration recorded) than at static advertisements (about 0.75 percent on average). In addition, the location of the advertisements had an effect on glance behavior. When advertisements were located in the center of the road or in all three positions simultaneously, the glance durations were about 1,000 ms and were significantly longer than for signs placed on the right or left side of the road. For advertisements placed on the left side of the road, there was a significant difference in glance duration between static (about 400 ms) and video (about 800 ms). Advertisement position also had an effect on the proportion of time that a driver spent looking at an advertisement. The percentage of time looking at advertisements was greatest when signs were placed in all three locations, followed by center location signs, then the left location signs, and finally the right location signs. Drivers looked more at the video advertisements relative to the static advertisements when they were placed in all three locations, placed on the left, and placed on the right side of the road. The center placement did not show a significant difference in percent of time spent looking between static and video.

Summary

The results from these key studies offer some insight into whether CEVMS pose a visual distraction threat. However, these same studies also reveal some inconsistent findings and potential methodological issues that are addressed in the current study. The studies conducted by Smiley et al. showed drivers glanced forward at the roadway about 76 percent of the time in the presence of video and dynamic signs where a few long glances of approximately 1,400 ms were observed.(12) However, the video and dynamic signs used in these studies portray moving objects that are not present in CEVMS as deployed in the United States. In another field study employing eye tracking, Kettwich et al. found that gaze duration while driving for all types of advertisements that they evaluated was less than 1,000 ms; however, when the vehicle was stopped, mean gaze duration for advertising was as high as 2,750 ms.(16) Collectively, these studies did not demonstrate that the advertising signs detracted from drivers' glances forward at the roadway in a substantive manner while the vehicle was moving.

In contrast, the simulator study by Chattington et al. demonstrated that dynamic signs showing moving video or other dynamic elements may draw attention away from the roadway.(15) Furthermore, the location of the advertising sign on the road is an important factor in drawing drivers' visual attention. Advertisements with moving video placed in the center of the roadway on an overhead gantry or in all three positions (right, left, and in the center) simultaneously are very likely to draw glances from drivers.

Finally, in a study that examined CEVMS as deployed in the United States, Lee et al. did not show any significant effects of CEVMS on driver glance behavior.(9) However, the methodology that was used likely did not employ sufficient sensitivity to determine at what specific object in the environment a driver was looking.

None of these studies combined all necessary factors to address the current CEVMS situation in the United States. Those studies that used eye tracking on real roads had animated and video-based signs, which are not reflective of current off-premise CEVMS practice in the United States.

STUDY APPROACH

Based on an extensive review of the literature, Molino et al. concluded that the most effective method to use in an evaluation of the effects of CEVMS on driver visual behavior was the instrumented field vehicle method that incorporated an eye tracking system.(4) The present study employed such an instrumented field vehicle with an eye tracking system and examined the degree to which CEVMS attract drivers' attention away from the forward roadway.

The following presents a brief overview and discussion of studies using eye tracking methodology with complex visual stimuli, especially in natural environments (walking, driving, etc.). The review by Molino et al. recommended the use of this type of technology and method; however, a discussion laying out technical and theoretical issues underlying the use of eye tracking methods was not presented.(4) This background is important for the interpretation of the results of the studies conducted here.

Standard and digital billboards are often salient stimuli in the driving environment, which may make them conspicuous. Cole and Hughes define attention conspicuity as the extent to which a stimulus is sufficiently prominent in the driving environment to capture attention. Further, Cole and Hughes state that attention conspicuity is a function of size, color, brightness, contrast relative to surroundings, and dynamic components such as movement and change.(17) It is clear that under certain circumstances image salience or conspicuity can provide a good explanation of how humans orient their attention.

At any given moment a large number of stimuli reach our senses, but only a limited number of them are selected for further processing. In general, attention can be focused on a stimulus because it is important for achieving some goal, or because the properties of the stimulus can attract the attention of the observer independent of their intentions (e.g., a car horn may elicit an orienting response). When the focus of attention is goal directed, it is referred to as top-down. When the focus of attention is principally a function of stimulus attributes, it is referred to as bottom-up.(18)

In general, billboards (either standard or CEVMS) are not relevant to the driving task but are presumably designed to be salient stimuli in the environment where they may draw a driver's attention. The question is to what degree CEVMS draw a driver's attention away from driving-relevant stimuli (e.g., road ahead, mirrors, and speedometer) and is this different from a standard billboard? In his review of the literature Wachtel leads one to consider CEVMS as stimuli in the environment where attention to them would be drawn in a bottom-up manner; that is, the salience of the billboards would make them stand out relative to other stimuli in the environment and drivers would reflexively look at these signs.(19) Wachtel's conclusions were in reference to research by Theeuwees who employed simple letter stimulus arrays in a laboratory task.(20) Research using simple visual stimuli in a laboratory environment are very useful for testing different theories of perception, but often lack direct application to tasks such as driving. The following discusses research using complex visual stimuli and tasks that are more relevant to natural vision as experienced in the driving task.

A recent review of stimulus salience and eye guidance by Tatler et al. shows that most of the evidence for the capture of attention by the conspicuity of stimuli comes from research in which the stimulus is a simple visual search array or in which the target is uniquely defined by simple visual features.(21) In other words, these are laboratory studies that use letters, arrays of letters, or simple geometric patterns as the stimuli. Pure salience-based models are capable of predicting eye movement endpoint in simple displays, but are less successful for more complex scenes that contain task-relevant and task-irrelevant salient areas.(22,23)

Research by Henderson et al. using photographs of actual scenes showed that subjects looked at non-salient scene regions containing a search target and rarely looked at salient non-task-relevant regions of the scenes.(24) Salience of the stimulus alone was not a good predictor of where participants looked. Additional research by Henderson using photographs of real world scenes also showed that subjects fixated on regions of the pictures that provided task-relevant information rather than visually salient regions with no task-relevant information. However, Henderson acknowledges that static pictures have many shortcomings when used as surrogates for real environments.(25)

Land's review of eye movements in dynamic environments concluded that the eyes are proactive and typically seek out information required in the second before each new activity commences.[26] Specific tasks (e.g., driving) have characteristic but flexible patterns of eye movement that accompany them, and these patterns are similar between individuals. Land concluded that the eyes rarely visit objects that are irrelevant to the task, and the conspicuity of objects is less important than the objects' roles in the task. In a subsequent review of eye movement and natural behavior, Land concluded that in a task that requires fixation on a sequence of specific objects, the capture of gaze by irrelevant salient objects would, in general, be an obtrusive nuisance.[22]

The literature examining gaze control under natural behavior suggests that it is principally top-down driven, or intentional.[24,25,26,22,21,27] However, top-down processing does not explain all gaze control or eye movements. For example, imagine driving down a two-lane country road and a deer jumps into the road. It is most likely that you will attend and react to this deer. Unplanned or unexpected stimuli capture our attention as we engage in complex natural tasks. Research by Jovancevic-Misic and Hayhoe showed that human gaze patterns are sensitive to the probabilistic nature of the environment.[28] In this study, participants' eye movement behavior was observed while walking among other pedestrians. The other pedestrians were confederates and were either safe, risky, or rogue pedestrians. When the study began, the risky pedestrian took a collision course with the participant 50 percent of the time, and the rogue pedestrian always assumed a collision course as he approached the participant, whereas the safe pedestrian never took a collision course. Midway through the study the rogue and safe pedestrians exchanged roles but the risky pedestrian role remained the same. The participants were not informed about the behavior of the other pedestrians. Participants were asked to follow a circular path for several laps and to avoid other pedestrians. The study showed that the participants modified their gaze behavior in response to the change in the other pedestrians' behavior. Jovancevic-Misic concluded that participants learned new priorities for gaze allocation within a few encounters and looked both sooner and longer at potentially dangerous pedestrians.[28]

Gaze behavior in natural environments is affected by expectations that are derived through long-term learning. Using a virtual driving environment, Shinoda et al. asked participants to look for stop signs while driving an urban route.[29] Approximately 45 percent of the fixations fell in the general area of intersections during the simulated drive, and participants were more likely to detect stop signs placed near intersections than those placed in the middle of a block. Over time, drivers have learned that stop signs are more likely to appear near intersections and, as a result, drivers prioritize their allocation of gazes to these areas of the roadway.

The Tatler et al. review of the literature concludes that in natural vision, a consistent set of principles underlies eye guidance. These principles include relevance or reward potential, uncertainty about the state of the environment, and learned models of the environment.[21] Salience of environmental stimuli alone typically does not explain most eye gaze behavior in naturalistic environments.

In sum, most of the literature concerning eye gaze behavior in dynamic environments suggests that task demands tend to override visual salience in determining attention allocation. When extended to driving, it would be expected that visual attention will be directed toward task-relevant areas and objects (e.g., the roadway, other vehicles, speed limit signs, etc.) and other salient objects, such as billboards, will not necessarily capture attention. However, driving is a somewhat automatic process and conditions generally do not require constant undivided attention. As a result, salient stimuli, such as CEVMS, might capture driver attention and provide an unwarranted increase in driver distraction. The present study addresses this concern.

Research Questions

The present research evaluated the effects of CEVMS on driver visual behavior under actual roadway conditions in the daytime and at night. Roads containing CEVMS, standard billboards, and areas not containing off-premise advertising were selected. The CEVMS and standard billboards were measured with respect to luminance, location, size, and other relevant visual characteristics. The present study examined CEVMS as deployed in two United States cities. Unlike previous studies, the signs did not contain dynamic video or other dynamic elements. In addition, the eye tracking system used in this study has approximately a 2-degree level of resolution. This provided significantly more accuracy in determining what objects the drivers were looking at than in previous on-road studies examining looking behavior (recall that Lee et al. used video recordings of drivers' faces that, at best, examined gross eye movements).(9)

Two studies are reported. Each study was conducted in a different city. The two studies employed the same methodology. The studies' primary research questions were:

1. Do CEVMS attract drivers' attention away from the forward roadway and other driving relevant stimuli?

2. Do glances to CEVMS occur that would suggest a decrease in safety?

3. Do drivers look at CEVMS more than at standard billboards?

EXPERIMENTAL APPROACH

The study used a field research vehicle equipped with a non-intrusive eye tracking system. The vehicle was a 2007 Jeep® Grand Cherokee Sport Utility Vehicle. The eye tracking system used (SmartEye® vehicle-mounted infrared (IR) eye-movement measuring system) is shown in figure 1.[30] The system consists of two IR light sources and three face cameras mounted on the dashboard of the vehicle. The cameras and light sources are small in size, and are not attached to the driver in any manner. The face cameras are synchronized to the IR light sources and are used to determine the head position and gaze direction of the driver.

Figure 1. Eye tracking system camera placement.

As a part of this eye tracking system, the vehicle was outfitted with a three-camera panoramic scene monitoring system for capturing the forward driving scene. The scene cameras were mounted on the roof of the vehicle directly above the driver's head position. The three cameras together provided an 80-degree wide by 40-degree high field of forward view. The scene cameras captured the forward view area available to the driver through the left side of the windshield and a portion of the right side of the windshield. The area visible to the driver through the rightmost area of the windshield was not captured by the scene cameras.

The vehicle was also outfitted with equipment to record GPS position, vehicle speed, and vehicle acceleration. The equipment also recorded events entered by an experimenter and synchronized those events with the eye tracking and vehicle data. The research vehicle is pictured in figure 2.

Figure 2. FHWA's field research vehicle.

EXPERIMENTAL DESIGN OVERVIEW

The approach entailed the use of the instrumented vehicle in which drivers navigated routes in cities that presented CEVMS and standard billboards as well as areas without off-premise advertising. The participants were instructed to drive the routes as they normally would. The drivers were not informed that the study was about outdoor advertising, but rather that it was about examining drivers' glance behavior as they followed route guidance directions.

Site Selection

More than 40 cities were evaluated in the selection of the test sites. Locations with CEVMS displays were identified using a variety of resources that included State department of transportation contacts, advertising company Web sites, and a popular geographic information system. A matrix was developed that listed the number of CEVMS in each city. For each site, the number of CEVMS along limited access and arterial roadways was determined.

One criterion for site selection was whether the location had practical routes that pass by a number of CEVMS as well as standard off-premise billboards and could be driven in about 30 minutes. Other considerations included access to vehicle maintenance personnel/facilities, proximity to research facilities, and ease of participant recruitment. Two cities were selected: Reading, and Richmond.

Table 1 presents the 16 cities that were included on the final list of potential study sites.

Table 1. Distribution of CEVMS by roadway classification for various cities.

State	*Area*	*Limited Access*	*Arterial*	*Other [(1)]*	*Total*
VA	Richmond	4	7	0	11
PA	Reading	7	11	0	18
VA	Roanoke	0	11	0	11
PA	Pittsburgh	0	0	15	15
TX	San Antonio	7	2	6	15
WI	Milwaukee	14	2	0	16
AZ	Phoenix	10	6	0	16
MN	St. Paul/Minneapolis	8	5	3	16
TN	Nashville	7	10	0	17
FL	Tampa-St. Petersburg	7	11	0	18
NM	Albuquerque	0	19	1	20
PA	Scranton-Wilkes Barre	7	14	1	22
OH	Columbus	1	22	0	23
GA	Atlanta	13	11	0	24
IL	Chicago	22	2	1	25
CA	Los Angeles	3	71	4	78

(1) Other includes roadways classified as both limited access and arterial or instances where the road classification was unknown. *Source:* www.lamar.com and www.clearchannel.com

In both test cities, the following independent variables were evaluated:

- **The type of advertising.** This included CEVMS, standard billboards, and no off-premise advertising. (It should be noted that in areas with no off-premise advertising, it was still possible to encounter on-premise advertising; e.g., for gas stations, restaurants, and other miscellaneous stores and shops.)

- **Time of day.** This included driving in the daytime and at night.

- **The functional class of roadways in which off-premise advertising signs were located.** Roads were classified as either freeway or arterial. It was observed that the different road classes were correlated with the presence of other visual information that could affect the driver's glance behavior. For example, the visual environment on arterials may be more complex or cluttered than on freeways because of the close proximity of buildings, driveways, and on-premise advertising, etc.

READING

The first on-road study was conducted in Reading. This study examined the type of advertising (CEVMS, standard billboard, or no off-premise advertising), time of day (day or night) and road type (freeway or arterial) as independent variables. Eye tracking was used to assess where participants gazed and for how long while driving. The luminance and contrast of the advertising signs were measured to characterize the billboards in the current study.

METHOD

Selection of Data Collection Zone Limits

Data collection zones (DCZ) were defined on the routes that participants drove where detailed analyses of the eye tracking data were planned. The DCZ were identified that contained a CEVMS, a standard billboard, or no off-premise advertising.

The rationale for selecting the DCZ limits took into account the geometry of the roadway (e.g., road curvature or obstructions that blocked view of billboards) and the capabilities of the eye tracking system (2 degrees of resolution). At a distance of 960 ft (292.61 m), the average billboard in Reading was 12.8 ft (3.90 m) by 36.9 ft (11.25 m) and would subtend a horizontal visual angle of 2.20 degrees and a vertical visual angle of 0.76 degrees, and thus glances to the billboard would just be resolvable by an eye tracking system with 2 degrees of accuracy. Therefore 960 ft was chosen as the maximum distance from billboards at which a DCZ would begin. If the target billboard was not visible from 960 ft (292.61 m) due to roadway geometry or other visual obstructions, such as trees or an overpass, the DCZ was shortened to a distance that prevented these objects from interfering with the driver’s vision of the billboard. In DCZs with target off-premise billboards, the end of the DCZ was marked when the target billboard left the view of the scene camera. If the area contained no off-premise advertising, the end of the DCZ was defined by a physical landmark leaving the view of the eye tracking systems’ scene camera.

Table 2 shows the data collection zone limits used in this study.

Advertising Conditions

The type of advertising present in DCZs was examined as an independent variable. DCZs fell into one of the following categories, which are listed in the second column of table 2:

- **CEVMS**. These were DCZs that contained one target CEVMS. Two CEVMS DCZs were located on freeways and two were located on arterials. Figure 3 and figure 4 show examples of CEVMS DCZs with the CEVMS highlighted in the pictures.

- **Standard billboard**. These were DCZs that contained one target standard billboard. Two standard billboard DCZs were located on freeways and two were located on arterials. Figure 5 and figure 6 show examples of standard billboard DCZs; the standard billboards are highlighted in the pictures.

- **No off-premise advertising conditions**. These DCZs contained no off-premise advertising. One of these DCZs was on a freeway (see figure 7) and the other was on an arterial (see figure 8).

Table 2. Inventory of target billboards with relevant parameters.

DCZ	*Advertising Type*	*Copy Dimensions (ft)*	*Side of Road*	*Setback from Road (ft)*	*Other Standard Billboards*	*Approach Length (ft)*	*Type of Roadway*
1	CONTROL	N/A	N/A	N/A	N/A	786	Freeway
6	CONTROL	N/A	N/A	N/A	N/A	308	Arterial
3	CEVMS	10'6" x 22'9"	L	12	0	375	Arterial
5	CEVMS	14'0" x 48'0"	L	133	1	853	Freeway
9	CEVMS	10'6" x 22'9"	R	43	0	537	Arterial
10	CEVMS	14'0" x 48'0"	R	133	1	991	Freeway
2	Standard	14'0" x 48'0"	L	20	0	644	Arterial
7	Standard	14'0" x 48'0"	R	35	1	774	Freeway
8	Standard	10'6" x 22'9"	R	40	1	833	Arterial
4	Standard	14'0" x 48'0"	L	10	0	770	Freeway

**N/A indicates that there were no off-premise advertising in these areas and these values are undefined.*

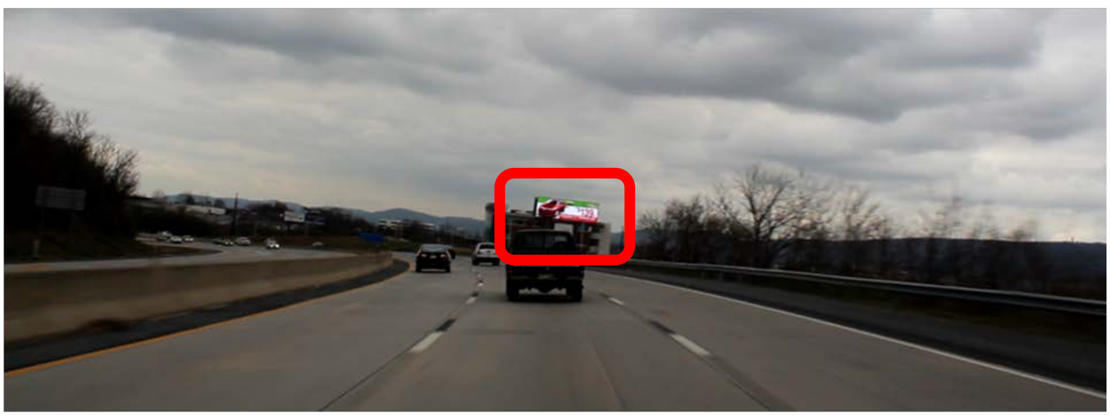

Figure 3. DCZ with a target CEVMS on a freeway.

Figure 4. DCZ with a target CEVMS on an arterial.

Figure 5. DCZ with a target standard billboard on a freeway.

Figure 6. DCZ with a target standard billboard on an arterial.

Figure 7. DCZ for the control condition on a freeway.

Figure 8. DCZ for the control condition on an arterial.

Photometric Measurement of Signs

Two primary metrics were used to describe the photometric characteristics of a sample of the CEVMS and standard billboards present at each location: luminance (cd/m^2) and contrast (Weber contrast ratio).

Photometric Equipment

Luminance was measured with a Radiant Imaging ProMetric 1600 Charge-Coupled Device (CCD) photometer with both a 50 mm and a 300 mm lenses. The CCD photometer provided a method of capturing the luminance of an entire scene at one time.

The photometric sensors were mounted in a vehicle of similar size to the eye tracking research vehicle. The photometer was located in the experimental vehicle as close to the driver's position as possible and was connected to a laptop computer that stored data as the images were acquired.

Measurement Methodology

Images of the billboards were acquired using the photometer manufacturer's software. The software provided the mean luminance of each billboard message. To prevent overexposure of images in daylight, neutral density filters were manually affixed to the photometer lens and the luminance values were scaled appropriately. Standard billboards were typically measured only once; however, for CEVMS multiple measures were taken to account for changing content.

Photometric measurements were taken during day and night. Measurements were taken by centering the billboard in the photometer's field of view with approximately the equivalent of the width of the billboard on each side and the equivalent of the billboard height above and below the sign. The areas outside of the billboards were included to enable contrast calculations.

Standard billboards were assessed at a mean distance of 284 ft (ranging from 570 ft to 43 ft). The CEVMS were assessed at a mean distance of 479 ft (ranging from 972 ft to 220 ft). To include the background regions of appropriate size, the close measurement distances required the use of the 50 mm lens whereas measurements made from longer distances required the 300 mm lens. A significant determinant of the measurement locations was the availability of accessible and safe places from which to measure.

The Weber contrast ratio was used because it characterizes a billboard as having negative or positive contrast when compared to its background area.(31) A negative contrast indicates the background areas have a higher mean luminance than the target billboard. A positive contrast indicates the target billboard has a higher mean luminance than the background. Overall, the absolute value of a contrast ratio simply indicates a difference in luminance between an item and its background. From a perceptual perspective luminance and contrast are directly related to the perception of brightness. For example, two signs with equal luminance may be perceived differently with respect to brightness because of differences in contrast.

Visual Complexity

Regan, Young, Lee and Gordon presented a taxonomic description of the various sources of driver distraction.(32) Potential sources of distraction were discussed in terms of: things brought into the vehicle; vehicle systems; vehicle occupants; moving objects or animals in the vehicle; internalized activity; and external objects, events, or activities. The external objects may include buildings, construction zones, billboards, road signs, vehicles, and so on. Focusing on the potential for information outside the vehicle to attract (or distract) the driver's attention, Horberry and Edquist developed a taxonomy for out-of-the-vehicle visual information. This suggested taxonomy includes four groupings of visual information: built roadway, situational entities, natural environment, and built environment.(33) These two taxonomies provide an organizational structure for conducting research; however, they do not currently provide a systematic or quantitative way of classifying the level of clutter or visual complexity present in a visual scene.

The method proposed by Rozenholtz, Li, and Nakano provides quantitative and perhaps reliable measures of visual clutter.(34) Their approach measures the feature congestion in a visual image. The implementation of the feature congestion measure involves four stages: (1) compute local feature covariance at multiple scales and compute the volume of the local covariance ellipsoid, (2) combine clutter across scale, (3) combine clutter across feature types, and (4) pool over space to get a single measure of clutter for each input image. The implementation that was used employed color, orientation and luminance contrast as features. Presumably, less cluttered images can be visually coded more efficiently than cluttered images. For example, visual clutter can cause decreased recognition performance and greater difficulty in performing visual search.[35]

Participants

In the present study participants were recruited at public libraries in the Reading area. A table was set up so that recruiters could discuss the requirements of the experiment with candidates. Individuals who expressed interest in participating were asked to complete a pre-screening form, a record of informed consent, and a department of motor vehicles form consenting to release of their driving record.

All participants were between 18 and 64 years of age and held a valid driver's license. The driving record for each volunteer was evaluated to eliminate drivers with excessive violations. The criteria for excluding drivers were as follows: (a) more than one violation in the preceding year; (b) more than three recorded violations; and (c) any driving while intoxicated violation.

Forty-three individuals were recruited to participate. Of these, five did not complete the drive because the eye tracker could not be calibrated to track their eye movements accurately. Data from an additional seven participants were excluded as the result of equipment failures (e.g., loose camera). In the end, usable data was collected from 31 participants (12 males, M = 46 years; 19 females, M = 47 years). Fourteen participants drove at night and 17 drove during the day.

Procedures

Data were collected from two participants per day (beginning at approximately 12:45 p.m. and 7:00 p.m.). Data collection began on September 18, 2009, and was completed on October 26, 2009.

Pre-Data Collection Activities

Participants were greeted by two researchers and asked to complete a fitness to drive questionnaire. This questionnaire focused on drivers' self-reports of alertness and use of substances that might impair driving (e.g., alcohol). All volunteers appeared fit.

Next, the participant and both researchers moved to the eye tracking calibration location and the test vehicle. The calibration procedure took approximately 20 minutes. Calibration of the eye tracking system entailed development of a profile for each participant. This was accomplished by taking multiple photographs of the participant's face as they slowly rotate their head from side to side. The saved photographs include points on the face for subsequent real-time head and eye tracking. Marked coordinates on the face photographs were edited by the experimenter as needed to improve the real-time face tracking. The procedure also included gaze calibration in which participants gazed at nine points on a wall. These points had been carefully plotted on the wall and correspond to the points in the eye tracking system's world model. Gaze calibration relates the individual participant's gaze vectors to known points in the real world. The eye tracking system uses two pulsating infrared sources mounted on the dashboard to create two corneal glints that are used to calculate gaze direction vectors. The glints were captured at 60 Hz. A second set of cameras (scene cameras), fixed on top of the car close to the driver's viewpoint, were used to produce a video scene of the area ahead. The scene cameras recorded at 25 Hz. A parallax correction algorithm compensated for the distance between the driver's viewpoint and the scene cameras so that later processing could use the gaze vectors to show where in the forward scene the driver was gazing.

If it was not possible to calibrate the eye tracking system to a participant, the participant was dismissed and paid for their time. Causes of calibration failure included reflections from eye glasses, participant height (which put their eyes outside the range of the system), and eyelids that obscure a portion of the pupil.

Practice

After eye-tracker calibration, a short practice drive was made. Participants were shown a map of the route and written turn-by-turn directions prior to beginning the practice drive. Throughout the drive, verbal directions were provided by a GPS device.

During the practice drive, a researcher in the rear seat of the vehicle monitored the accuracy of eye tracking. If the system was tracking poorly, additional calibration was performed. If the calibration could not be improved, the participant was paid for their time and dismissed.

Data Collection

Participants drove two test routes (referred to as route A and B). Each route required 25 to 30 minutes to complete and included both freeway and arterial segments. Route A was 13 miles long and contained 6 DCZs. Route B was 16 miles long and contained 4 DCZs. Combined, participants drove in a total of 10 DCZs. Similar to the practice drive, participants were shown a map of the route and written turn-by-turn directions. A GPS device provided turn-by-turn guidance during the drive. Roughly one half of the participants drove route A first and the remaining participants began with route B. A 5 minute break followed the completion of the first route.

During the drives, a researcher in the front passenger seat assisted the driver when additional route guidance was required. The researcher was also tasked with recording near misses and driver errors if these occurred. The researcher in the rear seat monitored the performance of the eye tracker. If the eye tracker performance became unacceptable (i.e., loss of calibration), then the researcher in the rear asked the participant to park in a safe location so that the eye tracker could be recalibrated. This recalibration typically took a minute or two to accomplish.

Debriefing

After driving both routes, the participants provided comments regarding their drives. The comments were in reference to the use of a navigation system. No questions were asked about billboards. The participants were given $120.00 in cash for their participation.

DATA REDUCTION

Eye Tracking Measures

The Multiple-Analysis of Psychophysical and Performance Signals (MAPPS™) software was used to reduce the eye tracking data.[36] The software integrates the video output from the scene cameras with the output from the eye tracking software (e.g., gaze vectors). The analysis software provides an interface in which the gaze vectors determined by the eye tracker can be related to areas or objects in the scene camera view of the world. Analysts can indicate regions of interest (ROIs) in the scene camera views and the analysis software then assigns gaze vectors to the ROIs.

Figure 9 shows a screen capture from the analysis software in which static ROIs have been identified. These static ROIs slice up the scene camera views into six areas. The software also allows for the construction of dynamic ROIs. These are ROIs that move in the video because of own-vehicle movement (e.g., a sign changes position on the display as it is approached by the driver) or because the object moves over time independent of own-vehicle movement (e.g., pedestrian walking along the road, vehicle entering or exiting the road).

Static ROIs need only be entered once for the scenario being analyzed whereas dynamic ROIs need to be entered several times for a given DCZ depending on how the object moves along the video scene; however, not every frame needs to be coded with a dynamic ROI since the software interpolates across frames using the 60-Hz data to compute eye movement statistics.

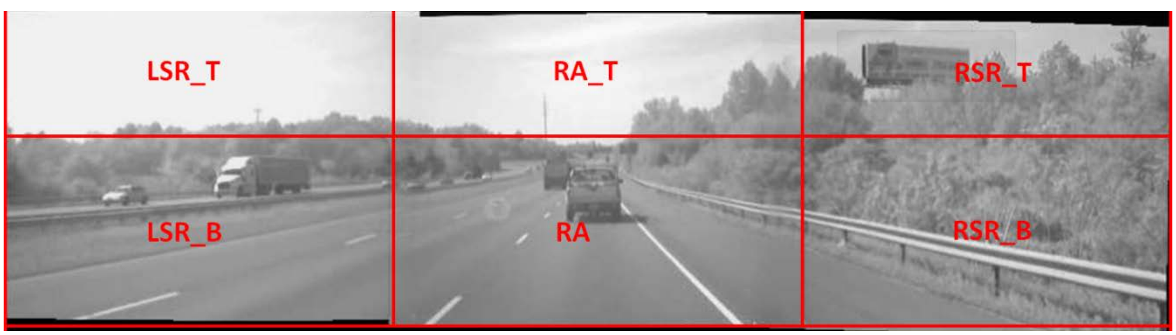

Figure 9. Screen capture showing static ROIs on a scene video output.

The following ROIs were defined with the analysis software:

Static ROIs

These ROIs were entered once into the software for each participant. The static ROIs for the windshield were divided into top and bottom to have more resolution during the coding process. The subsequent analyses in the report combines the top and bottom portion of these ROIs since it appeared that this additional level of resolution was not needed in order to address research questions:

- Road ahead: bottom portion (approximately 2/3) of the area of the forward roadway (center camera).

- Road ahead top: top portion (approximately 1/3) of the area of the forward roadway (center camera).

- Right side of road bottom: bottom portion (approximately 2/3) of the area to the right of the forward roadway (right camera).

- Right side of road top: top portion (approximately 1/3) of the area to the right of the forward roadway (right camera).

- Left side of road bottom (LSR_B): bottom portion (approximately 2/3) of the area to the left of the forward roadway (left camera).

- Left side of road bottom (LSR_T): top portion (approximately 1/3) of the area to the left of the forward roadway (left camera).

- Inside vehicle: below the panoramic video scene (outside of the view of the cameras, but eye tracking is still possible).

- Top: above the panoramic video scene (outside of the view of the cameras, but eye tracking is still possible).

Dynamic ROIs

These ROIs are created multiple times within a DCZ for stimuli that move relative to the driver:

- Driving-related safety risk: vehicle which posed a potential safety risk to the driver, defined as a car that is/may turn into the driver's direction of travel at a non-signalized or non-stop-controlled intersection (e.g., a car making a U-turn, a car waiting to turn right, or a car waiting to turn left). These vehicles were actively turning or entering the roadway or appeared to be in a position to enter the roadway.

- Target standard billboard: target standard billboard that defines the start and end of the DCZ.

- Other standard billboard: standard billboard(s) located in the DCZ, other than the target standard billboard or the target digital billboard.

- CEVMS: target digital billboard that defines the start and end of the DCZ.

The software determines the gaze intersection for each 60 Hz frame and assigns it to an ROI. In subsequent analyses and discussion, gaze intersections are referred to as gazes. Since ROIs may overlap, the software allows for the specification of priority for each ROI such that the ROI with the highest priority gets the gaze vector intersection assigned to it. For example, an ROI for a CEVMS may also be in the static ROI for the road ahead.

The 60 Hz temporal resolution of the eye tracking software does not provide sufficient information to make detailed analysis of saccade characteristics,[1] such as latency or speed. The analysis software uses three parameters in the determination of a fixation: a fixation radius, fixation duration, and a time out. The determination begins with a single-gaze vector intersection. Any subsequent intersection within a specified radius will be considered part of a fixation if the minimum fixation duration criterion is met. The radius parameter used in this study was 2 degrees and the minimum duration was 100 ms. The 2-degree selection was based on the estimated accuracy of the eye tracking system, as recommended by Recarte and Nunes.[(37)] The 100 ms minimum duration is consistent with many other published studies; however, some investigators use minimums of as little as 60 ms.[(37,38)] Because of mini-saccades and noise in the eye tracking system, it is possible to have brief excursions outside the 2 degree window for a fixation. In this study, an excursion time outside the 2-degree radius of less than 90 ms was ignored. Once the gaze intersection fell outside the 2-degree radius of a fixation for more than 90 ms, the process of identifying a fixation began anew.

Other Measures

Driving Behavior Measures

During data collection, the front-seat researcher observed the driver's behavior and the driving environment. The researcher used the following subjective categories in observing the participant's driving behavior:

- **Driver Error:** signified any error on behalf of the driver in which the researcher felt slightly uncomfortable, but not to a significant degree (e.g., driving on an exit ramp too quickly, turning too quickly).

- **Near Miss:** signified any event in which the researcher felt uncomfortable due to driver response to external sources (e.g., slamming on brakes, swerving). A near miss is the extreme case of a driver error.

- **Incident:** signified any event in the roadway which may have had a potential impact on the attention of the driver and/or the flow of traffic (e.g., crash, emergency vehicle, animal, construction, train).

These observations were entered into a notebook computer linked to the research vehicle data collection system.

Level of Service Estimates

For each participant and each DCZ the analyst estimated the level of service of the road as they reviewed the scene camera video. One location per DCZ was selected (approximately halfway through the DCZ) where the number of vehicles in front of the research vehicle was counted. The procedure entailed (1) counting the number of travel lanes visible in the video, (2) using the

[1] During visual scanning, the point of gaze alternates between brief pauses (ocular fixations) and rapid shifts (saccades).

skip lines on the road to estimate the approximate distance in front of the vehicle that constituted the analysis zone, and (3) counting the number of vehicles present within the analysis zone. Vehicle density was calculated with the formula:

> Vehicle Density = [(Number of Vehicles in Analysis Zone)/(Distance of Analysis Zone in ft/5280)]/Number of Lanes.

Vehicle density is the number of vehicles per mile per lane.

Vehicle Speed

The speed of the research vehicle was recorded with GPS and a distance measurement instrument. Vehicle speed was used principally to ensure that the eye tracking data was recorded while the vehicle was in motion.

RESULTS

Results are presented with respect to the photometric measures of signs, the visual complexity of the DCZs, and the eye tracking measures. Photometric measurements were taken and analyzed to characterize the billboards in the study based on their luminance and contrasts, which are related to how bright the signs are perceived to be by drivers.

Photometric Measurements

Luminance

The mean daytime luminance of both the standard billboards and CEVMS was greater than at night. Nighttime luminance measurements reflect the fact that CEVMS use illuminating LED components while standard billboards are often illuminated from below by metal halide lamps. At night, CEVMS have a greater average luminance than standard billboards. Table 3 presents summary statistics for luminance as a function of time of day for the CEVMS and standard billboards.

Contrast

The daytime and nighttime Weber contrast ratios for both types of billboards are shown in table 3. Both CEVMS and standard billboards had contrast ratios that were close to zero (the surroundings were about equal in brightness to the signs) during the daytime. On the other hand, at night the CEVMS and standard billboards had positive contrast ratios (the signs were brighter than the surrounding), with the CEVMS having higher contrast than the standard billboards.

Table 3. Summary of luminance (cd/m^2) and contrast (Weber ratio) measurements.

	Luminance (cd/m^2)		*Contrast*	
Day	*Mean*	*St. Dev.*	*Mean*	*St .Dev.*
CEVMS	2126	798.81	-0.10	0.54
Standard Billboard	2993	2787.22	-0.27	0.84
Night				
CEVMS	56.00	23.16	73.72	56.92
Standard Billboard	17.80	17.11	36.01	30.93

Visual Complexity

The DCZs were characterized by their overall visual complexity or clutter. For each DCZ, five pictures were taken from the driver's viewpoint at various locations within the DCZ. In Reading, the pictures were taken from 2:00 p.m. to 4:00 p.m. In Richmond, one route was photographed from 11:00 a.m. to noon and the other from 2:30 p.m. to 3:30 p.m. The pictures were taken at the start of the DCZ, quarter of the way through, half of the way through, three quarters of the way through, and at the end of the DCZ. The photographs were analyzed with MATLAB® routines that computed a measure of feature congestion for each image. Figure 10 shows the mean feature congestion measures for each of the DCZ environments. The arterial control condition was shown to have the highest level of clutter as measured by feature congestion. An analysis of variance was performed on the feature congestion measure to determine if the conditions differed significantly from each other. The four conditions with off-premise advertising did not differ significantly with respect to feature congestion; $F(3,36) = 1.25$, $p > 0.05$. Based on the feature congestion measure, the results indicate that the four conditions with off-premise advertising were equated with respect to the overall visual complexity of the driving scenes.

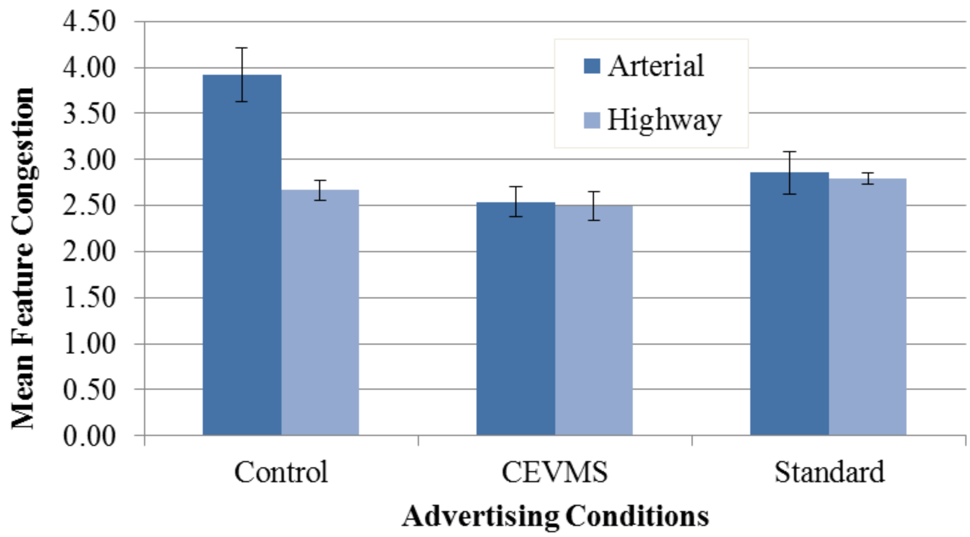

Figure 10. Mean feature congestion as a function of advertising condition and road type (standard errors for the mean are included in the graph).

Effects of Billboards on Gazes to the Road Ahead

For each 60 Hz frame, a determination was made as to the direction of the gaze vector. Previous research has shown that gazes do not need to be separated into saccades and fixations before calculating such measures as percent of time or the probability of looking to the road ahead.[39] This analysis examines the degree to which drivers gaze toward the road ahead across the different advertising conditions as a function of road type and time of day. Gazing toward the road ahead is critical for driving, and so the analysis examines the degree to which gazes toward this area are affected by the independent variables (advertising type, type of road, and time of day) and their interactions.

Generalized estimating equations (GEE) were used to analyze the probability of a participant gazing at driving-related information.[40,41] The data for these analyses were not normally distributed and included repeated measures. The GEE model is appropriate for these types of data and analyses. Note that for all results included in this report, Wald statistics were the chosen alternative to likelihood ratio statistics because GEE uses quasi-likelihood instead of maximum likelihood.[42] For this analysis, road ahead included the following ROIs (as previously described and displayed in figure 9): road ahead, road ahead top, and driving-related risks. A logistic regression model for repeated measures was generated by using a binomial response distribution and Logit (i.e., log odds) link function. Only two possible outcomes are allowed when selecting a binomial response distribution. Thus, a variable (RoadAhead) was created to classify a participant's gaze behavior. If the participant gazed toward the road ahead, road ahead top, or driving-related risks, then the value of RoadAhead was set to one. If the participant gazed at any other object in the panoramic scene, then the value of RoadAhead was set to zero. Logistic regression typically models the probability of a success. In the current analysis, a success would be a gaze to road ahead information (RoadAhead = 1) and a failure would be a gaze toward non-road ahead information (RoadAhead = 0). The resultant value was the probability of a participant gazing at road-ahead information.

Time of day (day or night), road type (freeway or arterial), advertising condition (CEVMS, standard billboard, or control), and all corresponding second-order interactions were explanatory variables in the logistic regression model. The interaction of advertising condition by road type was statistically significant, $\chi^2(2) = 6.3$, $p = 0.043$. Table 4 shows the corresponding probabilities for gazing at the road ahead as a function of advertising condition and road type.

Table 4. The probability of gazing at the road ahead as a function of advertising condition and road type.

Advertising Condition	*Arterial*	*Freeway*
Control	0.92	0.86
CEVMS	0.82	0.73
Standard	0.80	0.77

Follow-up analyses for the interaction used Tukey-Kramer adjustments with an alpha level of 0.05. The arterial control condition had the greatest probability of looking at the road ahead (M = 0.92). This probability differed significantly from the remaining five probabilities. On arterials, the probability of gazing at the road ahead did not differ between the CEVMS (M = 0.82) and the standard billboard (M = 0.80) DCZs. In contrast, there was a significant difference in this probability on freeways, where standard billboard DCZs yielded a higher probability (M = 0.77) than CEVMS DCZs (M = 0.73). The probability of gazing at the road ahead was also significantly higher in the freeway control DCZ (M = 0.86) than in either of the corresponding freeway off-premise advertising DCZs. The probability of gazing at road-ahead information in arterial CEVMS DCZs was not statistically different from the same probability in the freeway control DCZ.

Additional descriptive statistics were computed to determine the probability of gazing at the various ROIs that were defined in the panoramic scene. Some of the ROIs depicted in figure 9 were combined in the following fashion for ease of analysis:

- Road ahead, road ahead top, and driving-related risks combined to form *road ahead*.
- Left side of road bottom and left side of road top combined to form *left side of vehicle*.
- Right side of road bottom and right side of road top combined to form *right side of vehicle*.
- Inside vehicle and top combined to form *participant vehicle*.

Table 5 presents the probability of gazing at the different ROIs.

Table 5. Probability of gazing at ROIs for the three advertising conditions on arterials and freeways.

Road Type	***ROI***	***CEVMS***	***Standard Billboard***	***Control***
Arterial	*CEVMS*	0.07	N/A	N/A
	Left Side of Vehicle	0.06	0.06	0.02
	Road ahead	0.82	0.80	0.92
	Right Side of Vehicle	0.03	0.06	0.04
	Standard Billboard	N/A	0.03	N/A
	Participant Vehicle	0.03	0.05	0.02
Freeway	*CEVMS*	0.05	N/A	N/A
	Left Side of Vehicle	0.08	0.07	0.04
	Road ahead	0.73	0.77	0.86
	Right Side of Vehicle	0.09	0.02	0.05
	Standard Billboard	0.02*	0.09	N/A
	Participant Vehicle	0.04	0.05	0.05

* The CEVMS DCZs on freeways each contained one visible standard billboard.

The probability of gazing away from the forward roadway ranged from 0.08 to 0.27. In particular, the probability of gazing toward a CEVMS was greater on arterials (M = 0.07) than on freeways (M = 0.05). In contrast, the probability of gazing toward a target standard billboard was greater on freeways (M = 0.09) than on arterials (M = 0.03).

Fixations to CEVMS and Standard Billboards

About 2.4 percent of the fixations were to CEVMS. The mean fixation duration to a CEVMS was 388 ms and the maximum duration was 1,251 ms. Figure 11 shows the distribution of fixation durations to CEVMS during the day and night. In the daytime, the mean fixation duration to a CEVMS was 389 ms and at night it was 387 ms. Figure 12 shows the distribution of fixation durations to standard billboards. Approximately 2.4 percent of fixations were to standard billboards. The mean fixation duration to standard billboards was 341 ms during the daytime and 370 ms at night. The maximum fixation duration to standard billboards was 1,284 ms (which occurred at night). For comparison purposes, figure 13 shows the distribution of fixation durations to the road ahead (i.e., top and bottom road ahead ROIs) during the day and night. In the daytime, the mean fixation duration to the road ahead was 365 ms and at night it was 390 ms.

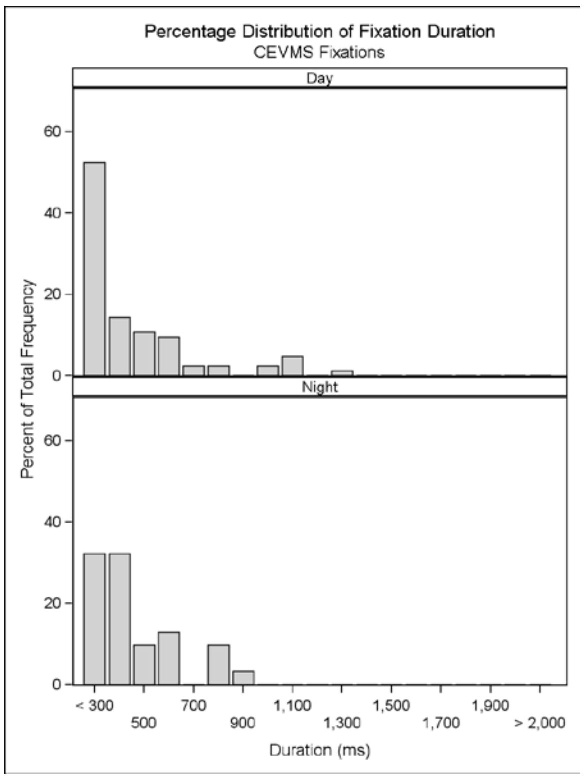

Figure 11. Distribution of fixation duration for CEVMS in the daytime and nighttime.

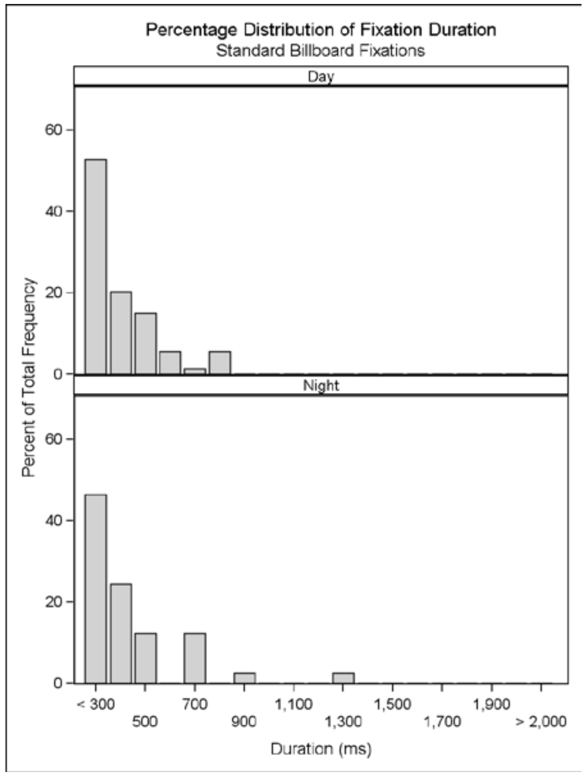

Figure 12. Distribution of fixation duration for standard billboards in the daytime and nighttime.

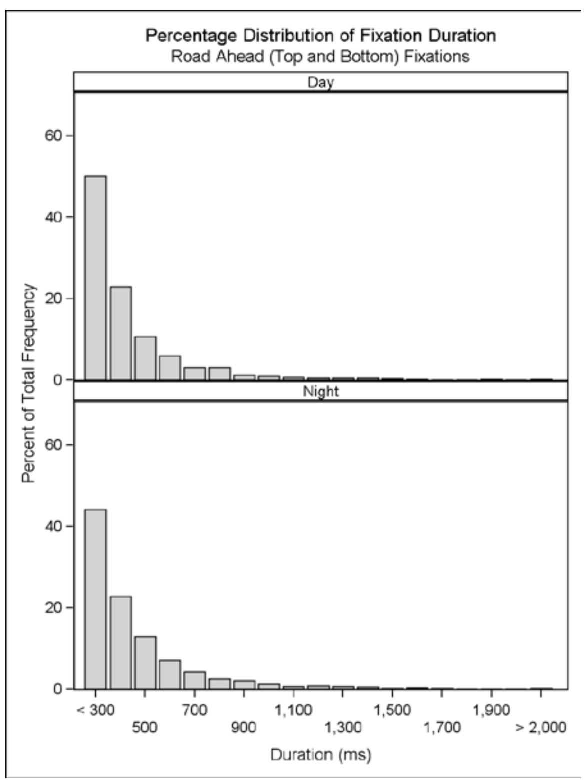

Figure 13. Distribution of fixation duration for road ahead (i.e., top and bottom road ahead ROIs) in the daytime and nighttime.

Dwell times on CEVMS and standard billboards were also examined. Dwell time is the duration of back-to-back fixations to the same ROI.[43,44] The dwell times represent the cumulative time for the back-to-back fixations. Whereas there may be no long, single fixation to a billboard, there might still be multiple fixations that yield long dwell times. There were a total of 25 separate instances of multiple fixations to CEVMS with a mean of 2.4 fixations (minimum of 2 and maximum of 5). The 25 dwell times came from 15 different participants distributed across four different CEVMS. The mean duration of these dwell times was 994 ms (minimum of 418 ms and maximum of 1,467 ms).

For standard billboards, there were a total of 17 separate dwell times with a mean of 3.47 sequential fixations (minimum of 2 fixations and maximum of 8 fixations). The 17 dwell times came from 11 different participants distributed across 4 different standard billboards. The mean duration of these multiple fixations was 1,172 ms (minimum of 418 ms and maximum of 3,319 ms). There were three dwell-time durations that were greater than 2,000 ms. These are described in more detail below.

In some cases several dwell times came from the same participant. In order to compute a statistic on the difference between dwell times for CEVMS and standard billboards, average dwell times were computed per participant for the CEVMS and standard billboard conditions. These average values were used in a t-test assuming unequal variances. The difference in average dwell time between CEVMS ($M = 981$ ms) and standard billboards ($M = 1,386$ ms) was not statistically significant, $t(12) = -1.40$, $p > .05$.

Figure 14 through figure 23 show heat maps for the dwell-time durations to the standard billboards that were greater than 2,000 ms. These heat maps are snapshots from the DCZ and attempt to convey in two dimensions the pattern of gazes that took place in a three dimensional world. The heat maps are set to look back approximately one to two seconds and integrate over time where the participant was gazing in the scene camera video. The green color in the heat map indicates the concentration of gaze over the past one to two seconds. The blue line indicates the gaze trail over the past one to two seconds.

Figure 14 through figure 16 are for a DCZ on an arterial at night. The standard billboard was on the right side of the road (indicated by a pink rectangle). There were eight fixations to this billboard, and the single fixations were between 200 to 384 ms in duration. The dwell time for this billboard was 2,019 ms. At the start of the DCZ (see figure 14), the driver was directing his/her gaze to the forward roadway. Approaching the standard billboard, the driver began to fixate on the billboard. However, the billboard was still relatively close to the road ahead ROI.

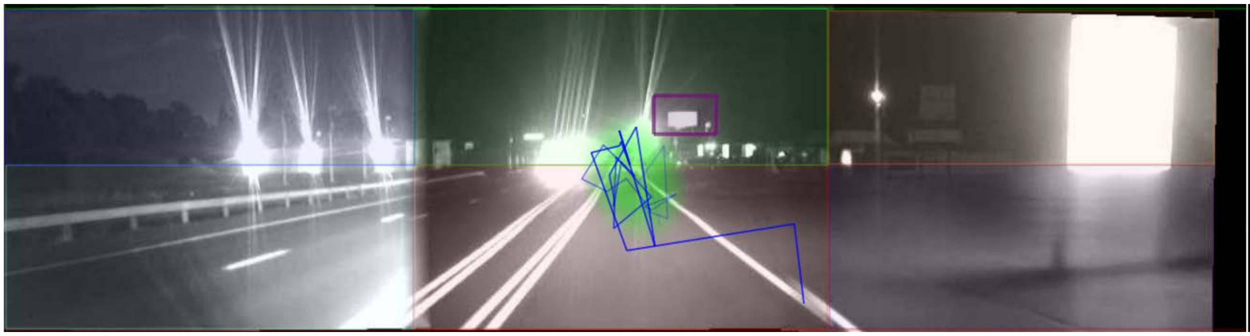

Figure 14. Heat map for the start of a DCZ for a standard billboard at night on an arterial.

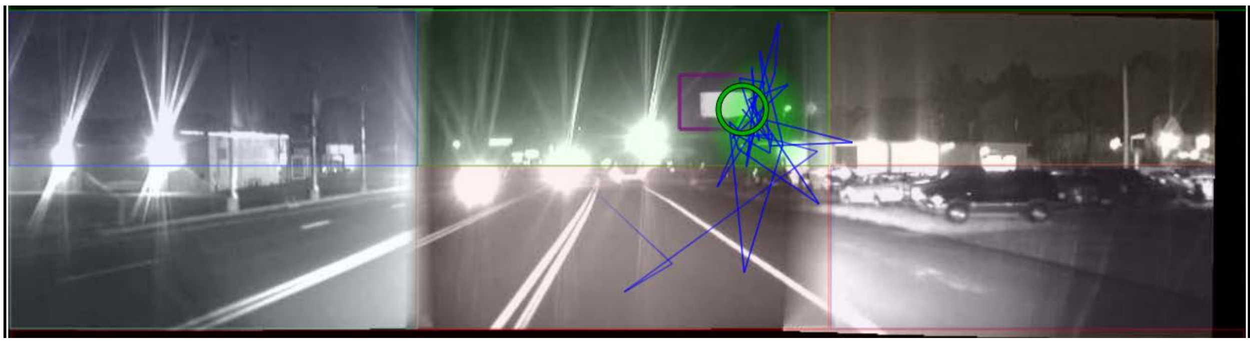

Figure 15. Heat map for the middle of a DCZ for a standard billboard at night on an arterial.

Figure 16. Heat map near the end of a DCZ for a standard billboard at night on an arterial.

Figure 17 through figure 19 are for a DCZ on a freeway at night. The standard billboard was on the right side of the road (indicated by a green rectangle). There were six consecutive fixations to this billboard, and the single fixations were between 200 and 801 ms in duration. The dwell time for this billboard was 2,753 ms. At the start of the DCZ (see figure 17), the driver was directing his/her gaze to a freeway guide sign in the road ahead and the standard billboard was to the left of the freeway guide sign. As the driver approached the standard billboard, his/her gaze was directed toward the billboard. The billboard was relatively close to the top and bottom road ahead ROIs. Near the end of the DCZ (see figure 19), the billboard was accurately portrayed as being on the right side of the road.

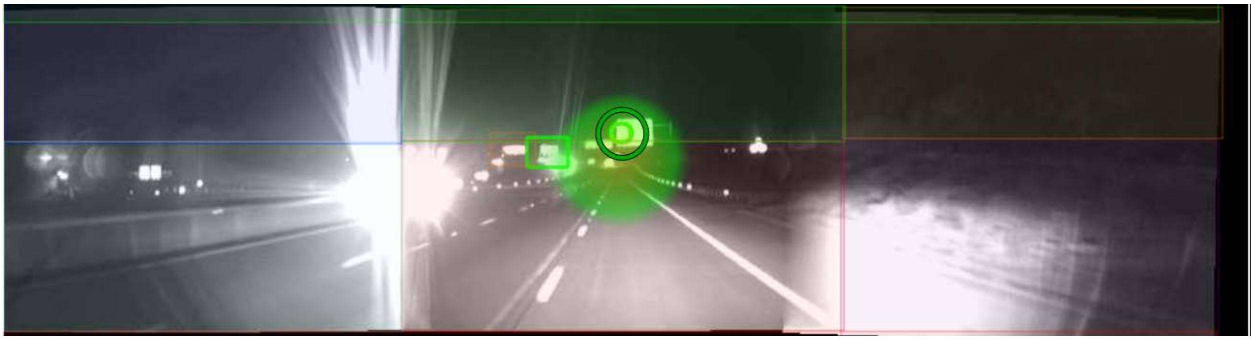

Figure 17. Heat map for start of a DCZ for a standard billboard at night on a freeway.

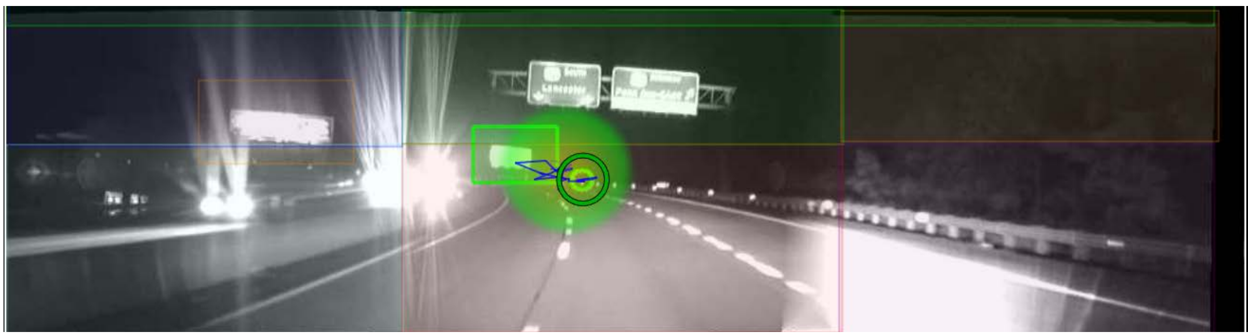

Figure 18. Heat map for middle of a DCZ for a standard billboard at night on a freeway.

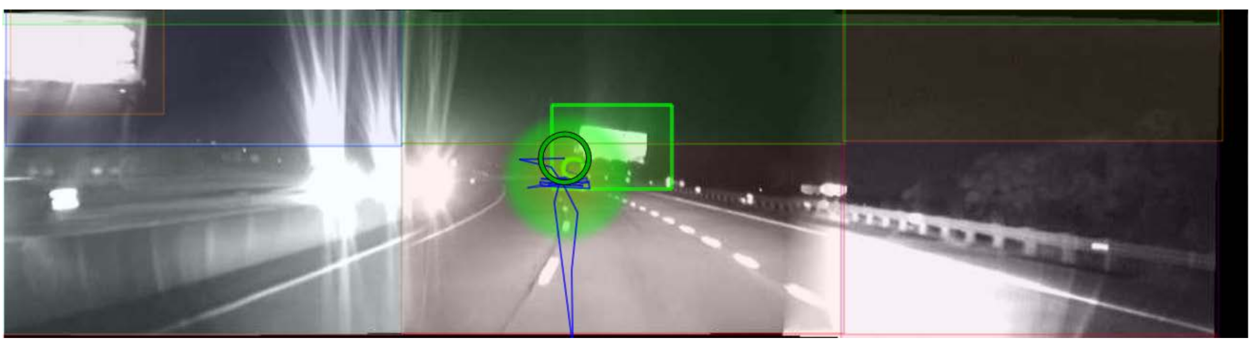

Figure 19. Heat map near the end of a DCZ for a standard billboard at night on a freeway.

Figure 20 through figure 23 are for a DCZ on a freeway during the day. The standard billboard was on the right side of the road (indicated by a pink rectangle). This is the same DCZ that was discussed in figure 17 through figure 19. There were six consecutive fixations to this billboard, and the single fixations were between 217 and 767 ms in duration. The dwell time for this billboard was 3,319 ms. At the start of the DCZ (see figure 20), the driver was principally directing his/her gaze to the road ahead. Figure 21 and figure 22 show the location along the DCZ where gaze was directed toward the standard billboard. The billboard was relatively close to the top and bottom road-ahead ROIs. As the driver passed the standard billboard, his/her gaze returned to the road ahead (see figure 23).

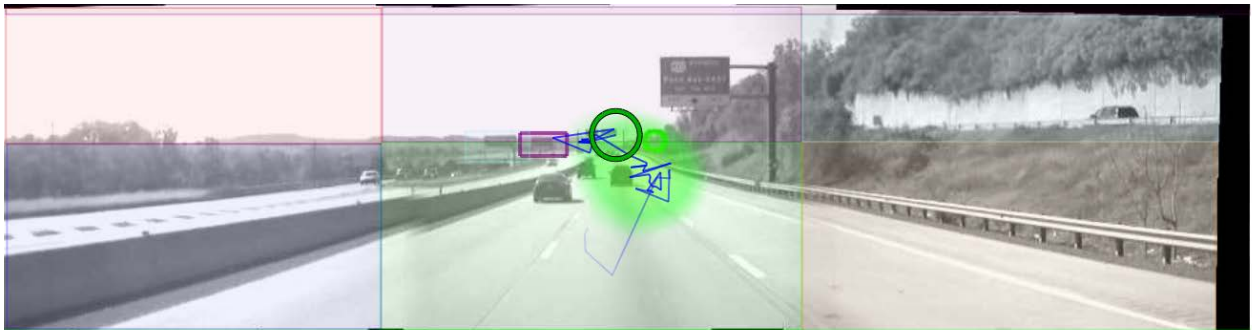

Figure 20. Heat map for the start of a DCZ for a standard billboard in the daytime on a freeway.

Figure 21. Heat map near the middle of a DCZ for a standard billboard in the daytime on a freeway.

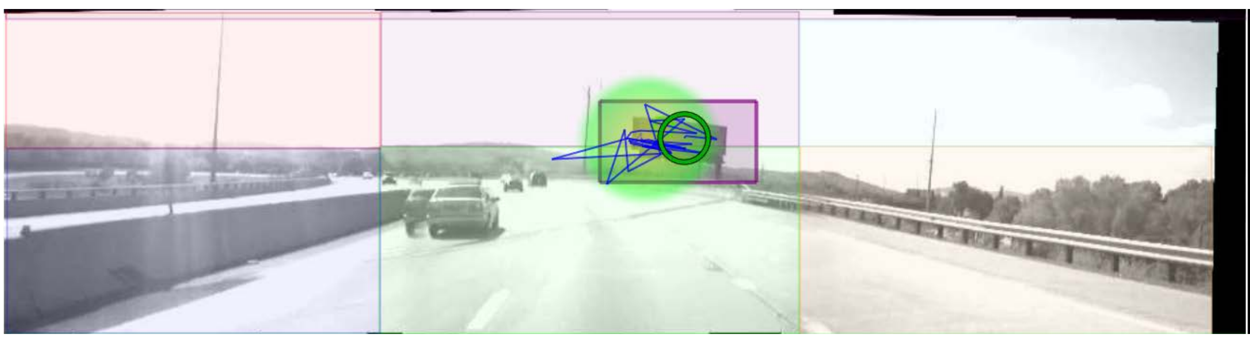

Figure 22. Heat map near the end of DCZ for standard billboard in the daytime on a freeway.

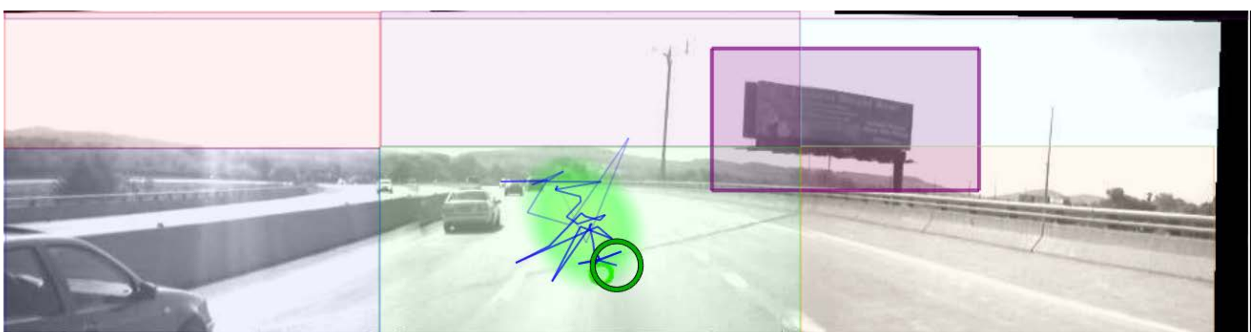

Figure 23. Heat map at the end of DCZ for standard billboard in the daytime on a freeway.

Comparison of Gazes to CEVMS and Standard Billboards

The GEE were used to analyze whether a participant gazed more toward CEVMS than toward standard billboards, given that the participant was gazing at off-premise advertising. With this analysis method, a logistic regression model for repeated measures was generated by using a binomial response distribution and Logit link function. First, the data was partitioned to include only those instances when a participant was gazing toward off-premise advertising (either to a CEVMS or to a standard billboard); all other gaze behavior was excluded from the input data set. Only two possible outcomes are allowed when selecting a binomial response distribution. Thus, a variable (SBB_CEVMS) was created to classify a participant's gaze behavior. If the participant gazed toward a CEVMS, the value of SBB_CEVMS was set to one. If the participant gazed toward a standard billboard, then the value of SBB_CEVMS was set to zero.

Logistic regression typically models the probability of a success. In the current analysis, a success would be a gaze to a CEVMS (SBB_CEVMS = 1) and a failure would be a gaze to a standard billboard (SBB_CEVMS = 0).[2] A success probability greater than 0.5 indicates there were more successes than failures in the sample. Therefore, if the sample probability of the response variable (i.e., SBB_CEVMS) was greater than 0.5, this would show that participants gazed more toward CEVMS than toward standard billboards when the participants gazed at off-premise advertising. In contrast, if the sample probability of the response variable was less than 0.5, then participants showed a preference to gaze more toward standard billboards than toward CEVMS when directing gazes to off-premise advertising.

Time of day (i.e., day or night), road type (i.e., freeway or arterial), and the corresponding interaction were explanatory variables in the logistic regression model. Road type was the only predictor to have a significant effect, $\chi^2(1) = 13.17$, $p < 0.001$. On arterials, participants gazed more toward CEVMS than toward standard billboards (M = 0.63). In contrast, participants gazed more toward standard billboards than toward CEVMS when driving on freeways (M = 0.33).

Observation of Driver Behavior

No near misses or driver errors were observed in Reading.

Level of Service

The mean vehicle densities were converted to level of service as shown in table 6.[(45)] As expected, less congestion occurred at night than in the day. In general, there was traffic during the data collection runs. Review of the scene camera data verified that all eye tracking data within the DCZs were recorded while the vehicle was in motion.

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[2] Success and failure are not used to reflect the merits of either type of sign, but only for statistical purposes.

Table 6. Level of service as a function of advertising type, road type, and time of day.

	Arterial		***Freeway***	
	Day	Night	Day	Night
Control	B	A	C	B
CEVMS	C	A	B	A
Standard	A	A	B	A

DISCUSSION OF READING RESULTS

Overall the probability of gazing at the road ahead was high and similar in magnitude to what has been found in other field studies addressing billboards.[11,9,12] For the DCZs on freeways, CEVMS showed a lower proportion of gazes to the road ahead than the standard billboard condition, and both off-premise advertising conditions had lower probability of gazes to the road ahead than the control. On the other hand, on the arterials, the CEVMS and standard billboard conditions did not differ from each other but were significantly different from their respective control condition. Though the CEVMS condition on the freeway had the lowest proportion of gazes to the road ahead, in this condition there was a lower proportion of gazes to CEVMS as compared to the arterials (see table 5 for the trade-off of gazes to the different ROIs). A greater proportion of gazes to other ROIs (left side of the road, right side of the road, and participant vehicle) contributed to the decrease in proportion of gazes to the road ahead. Also, for the CEVMS on freeways, there were a few gazes to a standard billboard located in the same DCZ and there were more gazes distributed to the left and right side of the road than in standard billboard and control conditions. The gazes to ROIs other than CEVMS contributed to the lower probability of gazes to the road ahead in this condition.

The control condition on the arterial had buildings along the sides of the road and generally presented a visually cluttered area. As was presented earlier, the feature congestion measure computed on a series of photographs from each DCZ showed a significantly higher feature congestion score for the control condition on arterials as compared to all of the other DCZs. Nevertheless, the highest probability for gazing at the road ahead was seen in the control condition on the arterial.

The area with the highest feature congestion, especially on the sides of the road, had the highest probability for drivers looking at the road ahead. Bottom-up or stimulus driven measures of salience or visual clutter have been useful in predicting visual search and the effects of visual salience in laboratory tasks.[34,46] These measures of salience basically consider the stimulus characteristics (e.g., size, color, brightness) independent of the requirements of the task or plans that an individual may have. Models of visual salience may predict that buildings and other prominent features on the side of the road may be visually salient objects and thus would attract a driver's attention.[47] Figure 24 shows an example of a roadway photograph that was analyzed with the Salience Toolbox based on the Itti et al. implementation of a saliency based model of bottom-up attention.[48,49] The numbered circles in figure 24 are the first through fifth salient areas selected by the software. Based on this software, the most salient areas in the photographs are the buildings on the sides of the road where the road ahead (and a car) is the fifth selected salient area.

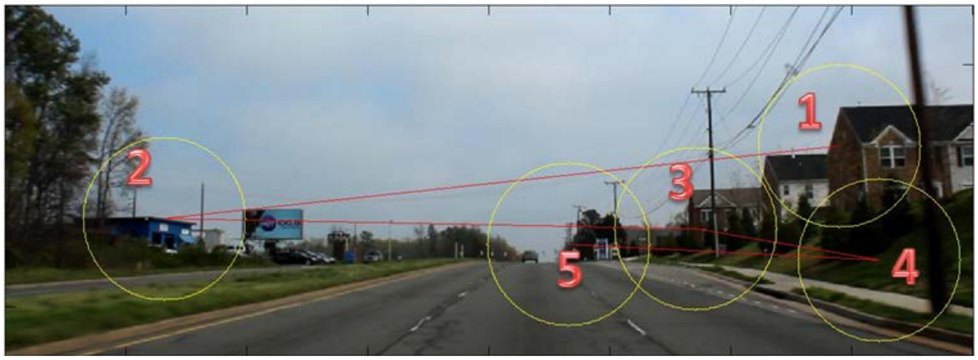

Figure 24. Example of identified salient areas in a road scene based on bottom-up analysis.

It appears that in the present study participants principally kept their eyes on the road even in the presence of visual clutter on the sides of the road, which supports the hypothesis that drivers tend to look toward information relevant to the task at hand.(50,26,22) In the case of the driving task, visual clutter may be more of an issue with respect to crowding that may affect the driver's ability to detect visual information in the periphery.(51) Crowding is generally defined as the negative effect of nearby objects or features on visual discrimination of a target.(52) Crowding impairs the ability to recognize objects in clutter and principally affects perception in peripheral vision. However, crowing effects were not analyzed in the present study.

Stimulus salience, clutter, and the nature of the task at hand interact in visual perception. For tasks such as driving, the task demands tend to outweigh stimulus salience when it comes to gaze control. Clutter may be more of an issue with the detection and recognition of objects in peripheral vision (e.g., detecting a sign on the side of the road) that are surrounded by other stimuli that result in a crowding effect.

The mean fixation durations to CEVMS, standard billboards, and the road ahead were found to be very similar. Also, there were no long fixations (greater than 2,000 ms) to CEVMS or standard billboards. The examination of multiple sequential fixations to CEVMS yielded average dwell times that were less than 1,000 ms. However, when examining the tails of the distribution, there were three dwell times to standard billboards that were in excess of 2,000 ms (the three dwell times came from three different participants to two different billboards). These three standard billboards were dwelled upon when they were near the road ahead area but drivers quit gazing at the signs as they neared them and the signs were no longer near the forward field of view. Though there were three dwell times for standard billboards greater than 2,000 ms, the difference in average dwell times for CEVMS and standard billboards was not significant.

Using a gaze duration of 2,000 ms away from the road ahead as a criterion indicative of increased risk has been developed principally as it relates to looking inside the vehicle to in-vehicle information systems and other devices (e.g., for texting) where the driver is indeed looking completely away from the road ahead.(14,53,54) The fixations to the standard billboards in the present case showed a long dwell time for a billboard. However, unlike gazing or fixating inside the vehicle, the driver's gaze was within the forward roadway where peripheral vision could be used to monitor for hazards and for vehicle control. Peripheral vision has been shown to be important for lane keeping, visual search orienting, and monitoring of surrounding objects.(55,56)

The results showed that drivers were more likely to gaze at CEVMS on arterials and at standard billboards on freeways. Though every attempt was made to select CEVMS and standard billboard DCZs that were equated on important parameters (e.g., which side of the road the sign was located on, type of road, level of visual clutter), the CEVMS DCZs on freeways had a greater setback from the road (133 ft for both CEVMS) than the standard billboards (10 and 35 ft). Signs with greater setback from the road would in a sense move out of the forward view (road ahead) more quickly than signs that are closer to the road. The CEVMS and standard billboards on the arterials were more closely matched with respect to setback from the road (12 and 43 ft for CEVMS and 20 and 40 ft for standard billboards).

The differences in setback from the road for CEVMS and standard billboards may also account for differences in dwell times to these two types of billboards. However, on arterials where the CEVMS and standard billboards were more closely matched there was only one long dwell time (greater than 2,000 ms) and it was to a standard billboard at night.

RICHMOND

The objectives of the second study were the same as those in the first study, and the design of the Richmond data collection effort was very similar to that employed in Reading. This study was conducted to replicate as closely as possible the design of Reading in a different driving environment. The independent variables included the type of DCZ (CEVMS, standard billboard, or no off-premise advertising), time of day (day or night) and road type (freeway or arterial). As with Reading, the time of day was a between-subjects variable and the other variables were within subjects.

METHOD

Selection of DCZ Limits

Selection of the DCZ limits procedure was the same as that employed in Reading.

Advertising Type

Three DCZ types (similar to those used in Reading) were used in Richmond:

- **CEVMS.** DCZs contained one target CEVMS.
- **Standard billboard.** DCZs contained one target standard billboard.
- **Control conditions.** DCZs did not contain any off-premise advertising.

There were an equal number of CEVMS and standard billboard DCZs on freeways and arterials. Also, there two DCZ that did not contain off-premise advertising with one located on a freeway and the other on an arterial.

Table 7 is an inventory of the target employed in this second study.

Table 7. Inventory of target billboards in Richmond with relevant parameters.

DCZ	*Advertising Type*	*Copy Dimensions (ft)*	*Side of Road*	*Setback from Road (ft)*	*Other Standard Billboards*	*Approach Length (ft)*	*Roadway Type*
5	CONTROL	N/A	N/A	N/A	N/A	710	Arterial
3	CONTROL	N/A	N/A	N/A	N/A	845	Freeway
9	CEVMS	14'0" x 28'0"	L	37	0	696	Arterial
13	CEVMS	14'0" x 28'0"	R	37	0	602	Arterial
2	CEVMS	12'5" x 40'0"	R	91	0	297	Freeway
8	CEVMS	11'0 x 23'0"	L	71	0	321	Freeway
10	Standard	14'0" x 48'0"	L	79	1	857	Arterial
12	Standard	10'6" x 45'3"	R	79	2	651	Arterial
1	Standard	14'0" x 48'0"	L	87	0	997	Freeway
7	Standard	14'0" x 48'0"	R	88	0	816	Freeway

** N/A indicates that there were no off-premise advertising in these areas and these values are undefined.*

Figure 25 through figure 30 below represent various pairings of DCZ type and road type. Target off-premise billboards are indicated by red rectangles.

Figure 25. Example of a CEVMS DCZ on a freeway.

Figure 26. Example of CEVMS DCZ an arterial.

Figure 27. Example of a standard billboard DCZ on a freeway.

Figure 28. Example of a standard billboard DCZ on an arterial.

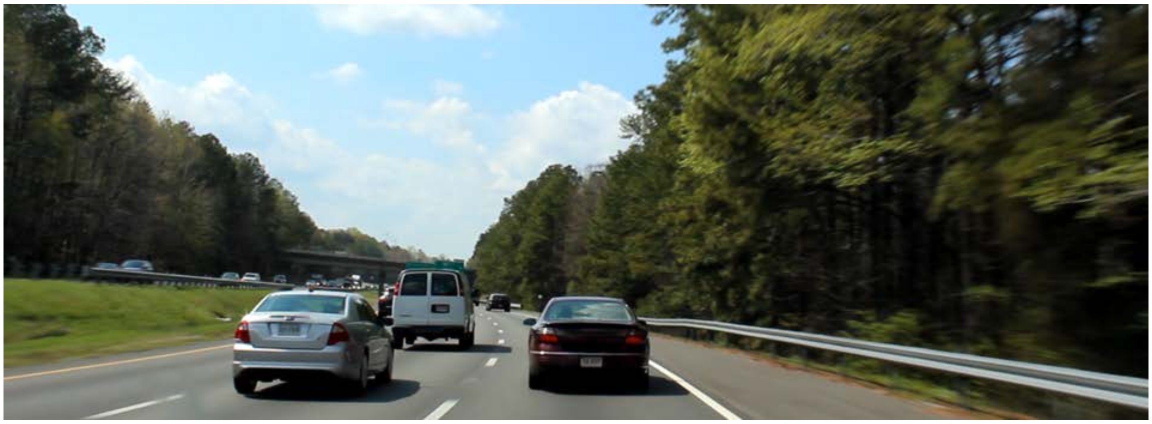

Figure 29. Example of a control DCZ on a freeway.

Figure 30. Example of a control DCZ on an arterial.

Photometric Measurement of Signs

The methods and procedures for the photometric measures were the same as for Reading.

Visual Complexity

The methods and procedures for visual complexity measurement were the same as for Reading.

Participants

A total of 41 participants were recruited for the study. Of these, 6 participants did not complete data collection because of an inability to properly calibrate with the eye tracking system, and 11 were excluded because of equipment failures. A total of 24 participants (13 male, M = 28 years; 11 female, M = 25 years) successfully completed the drive. Fourteen people participated during the day and 10 participated at night.

Procedures

Research participants were recruited locally by means of visits to public libraries, student unions, community centers, etc. A large number of the participants were recruited from a nearby university, resulting in a lower mean participant age than in Reading.

Participant Testing

Two people participated each day. One person participated during the day beginning at approximately 12:45 p.m. The second participated at night beginning at around 7:00 p.m. Data collection ran from November 20, 2009, through April 23, 2010. There were several long gaps in the data collection schedule due to holidays and inclement weather.

Pre-Data Collection Activities

This was the same as in Reading.

Practice Drive

Except for location, this was the same as in Reading.

Data Collection

The procedure was much the same as in Reading. On average, each test route required approximately 30 to 35 minutes to complete. As in Reading, the routes included a variety of freeway and arterial driving segments. One route was 15 miles long and contained two target CEVMS, two target standard billboards, and two DCZs with no off-premise advertising. The second route was 20 miles long and had two target CEVMS and two target standard billboards.

The data collection drives in this second study were longer than those in Reading. The eye tracking system had problems dealing with the large files that resulted. To mitigate this technical difficulty, participants were asked to pull over in a safe location during the middle of each data collection drive so that new data files could be initiated.

Upon completion of the data collection, the participant was instructed to return to the designated meeting location for debriefing.

Debriefing

This was the same as in Reading.

DATA REDUCTION

Eye Tracking Measures

The approach and procedures were the same as used in Reading.

Other Measures

The approach and procedures were the same as used in Reading.

RESULTS

Photometric Measurement of Signs

The photometric measurements were performed using the same equipment and procedures that were employed in Reading with a few minor changes. Photometric measurements were taken during the day and at night. Measurements of the standard billboards were taken at an average distance of 284 ft, with maximum and minimum distances of 570 ft and 43 ft, respectively. The average distance of measurements for the CEVMS was 479 ft, with maximum and minimum distances of 972 ft and 220 ft, respectively. Again, the distances employed were significantly affected by the requirement to find a safe location on the road from which to take the measurements.

Luminance

The mean luminance of CEVMS and standard billboards, during daytime and nighttime are shown below in table 8. The results here are similar to those for Reading.

Contrast

The daytime and nighttime Weber contrast ratios for both types of billboards are shown in table 8. During the day, the contrast ratios of both CEVMS and standard billboards were close to zero (the surroundings were about equal in brightness to the signs). At night, the CEVMS and standard billboards had positive contrast ratios. Similar to Reading, the CEVMS showed a higher contrast ratio than the standard billboards at night.

Table 8. Summary of luminance (cd/m^2) and contrast (Weber ratio) measurements.

	Luminance (cd/m^2)		***Contrast***	
Day	Mean	St. Dev.	Mean	St. Dev.
CEVMS	2134	798.70	-0.20	0.53
Standard Billboard	3063	2730.92	0.03	0.32
Night				
CEVMS	56.44	16.61	69.70	59.18
Standard Billboard	8.00	5.10	6.56	3.99

Visual Complexity

As with Reading, the feature congestion measure was used to estimate the level of visual complexity/clutter in the DCZs. The analysis procedures were the same as for Reading.

Figure 31 shows the mean feature congestion measures for each of the advertising types (standard errors are included in the figure). Unlike the results for Reading, the selected off-premise advertising DCZs for Richmond differed in terms of mean feature congestion; $F(3, 36) = 3.95$, $p = 0.016$. Follow up t-tests with an alpha of 0.05 showed that the CEVMS DCZs on arterials had significantly lower feature congestion than all of the other off-premise advertising conditions. None of the remaining DCZs with off-premise advertising differed from each other. The selection of DCZs for the conditions with off-premise advertising took into account the type of road, the side of the road the target billboard was placed, and the perceived level of visual clutter. Based on the feature congestion measure, these results indicated that the conditions with off-premise advertising were not equated with respect to level of visual clutter.

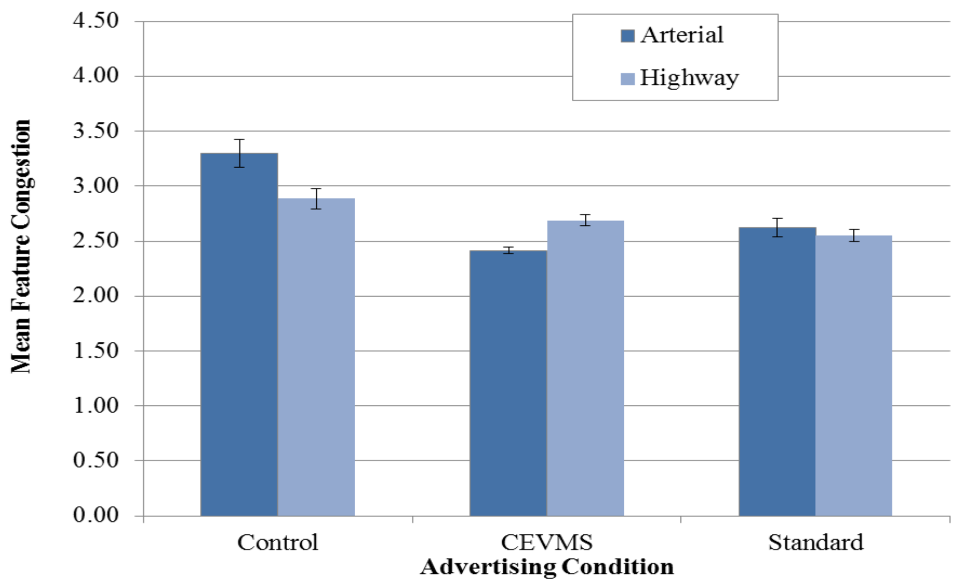

Figure 31. Mean feature congestion as a function of advertising condition and road type.

Effects of Billboards on Gazes to the Road Ahead

As was done for the data from Reading, GEE were used to analyze the probability of a participant gazing at the road ahead. A logistic regression model for repeated measures was generated by using a binomial response distribution and Logit link function. The resultant value was the probability of a participant gazing at the road ahead (as previously defined).

Time of day (day or night), road type (freeway or arterial), advertising type (CEVMS, standard billboard, or control), and all corresponding second-order interactions were explanatory variables in the logistic regression model. The interaction of advertising type by road type was statistically significant, $\chi^2(2) = 14.19$, $p < 0.001$. Table 9 shows the corresponding probability of gazing at the road ahead as a function of advertising condition and road type.

Table 9. The probability of gazing at the road ahead as a function of advertising condition and road type.

Advertising Condition	*Arterial*	*Freeway*
Control	0.78	0.92
CEVMS	0.76	0.82
Standard	0.81	0.85

Follow-up analyses for the interaction used Tukey-Kramer adjustments with an alpha level of 0.05. The freeway control had the greatest probability of gazing at the road ahead (M = 0.92). This probability differed significantly from the remaining five probabilities. On arterials, there were no significant differences among the probabilities of gazing at the road ahead among the three advertising conditions. On freeways, there was no significant difference between the probability associated with CEVMS DCZs and the probability associated with standard billboard DCZs.

Additional descriptive statistics were computed for the three advertising types to determine the probability of gazing at the ROIs that were defined in the panoramic scene. As was done with the data from Reading, some of the ROIs were combined for ease of analysis. Table 10 presents the probability of gazing at the different ROIs.

Table 10. Probability of gazing at ROIs for the three advertising conditions on arterials and freeways.

Road Type	*ROI*	*CEVMS*	*Standard Billboard*	*Control*
Arterial	*CEVMS*	0.06	N/A	N/A
	Left Side of Vehicle	0.03	0.05	0.04
	Road ahead	0.76	0.81	0.78
	Right Side of Vehicle	0.07	0.06	0.09
	Standard Billboard	N/A	0.02	N/A
	Participant Vehicle	0.07	0.06	0.09
Freeway	*CEVMS*	0.05	N/A	N/A
	Left Side of Vehicle	0.03	0.01	0.01
	Road ahead	0.82	0.85	0.92
	Right Side of Vehicle	0.04	0.04	0.03
	Standard Billboard	N/A	0.04	N/A
	Participant Vehicle	0.06	0.06	0.05

The probability of gazing away from the forward roadway ranged from 0.08 to 0.24. In particular, the probability of gazing toward a CEVMS was slightly greater on arterials (M = 0.06) than on freeways (M = 0.05). In contrast, the probability of gazing toward a standard billboard was greater on freeways (M = 0.04) than on arterials (M = 0.02). In both situations, the probability of gazing at the road ahead was greatest on freeways.

Fixations to CEVMS and Standard Billboards

About 2.5 percent of the fixations were to CEVMS. The mean fixation duration to a CEVMS was 371 ms and the maximum fixation duration was 1,335 ms. Figure 32 shows the distribution of fixation durations to CEVMS during the day and at night. In the daytime, the mean fixation duration to a CEVMS was 440 ms and at night it was 333 ms. Approximately 1.5 percent of the fixations were to standard billboards. The mean fixation duration to standard billboards was 318 ms and the maximum fixation duration was 801 ms. Figure 33 shows the distribution of fixation durations for standard billboards. The mean fixation duration to a standard billboard was 313 ms and 325 ms during the day and night, respectively. For comparison purposes, figure 34 shows the distribution of fixation durations to the road ahead during the day and night. In the daytime, the mean fixation duration to the road ahead was 378 ms and at night it was 358 ms.

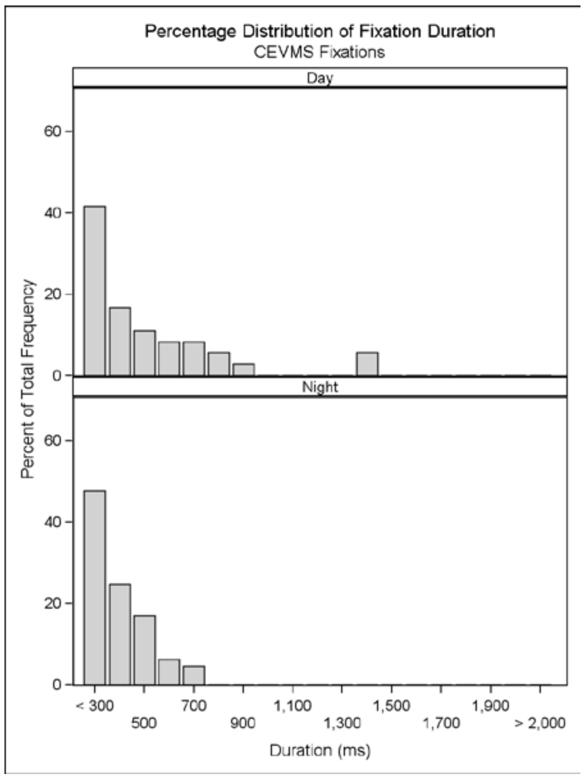

Figure 32. Fixation duration for CEVMS in the day and at night.

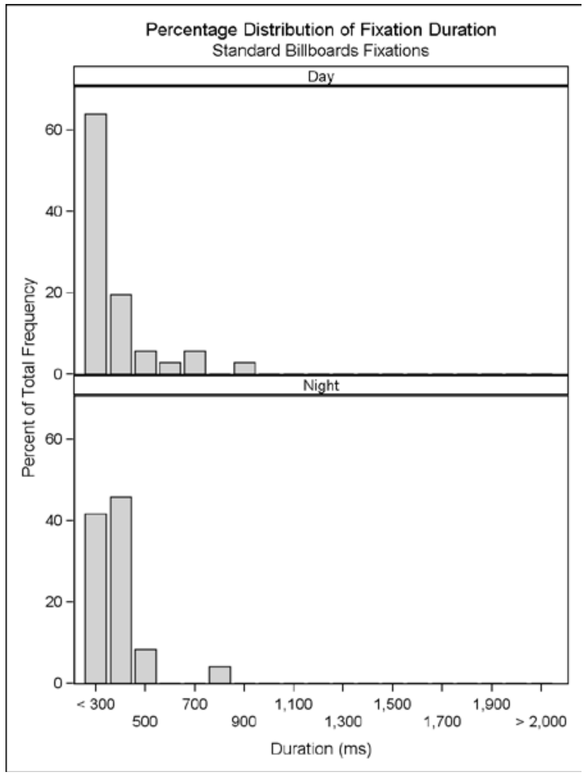

Figure 33. Fixation duration for standard billboards in the day and at night.

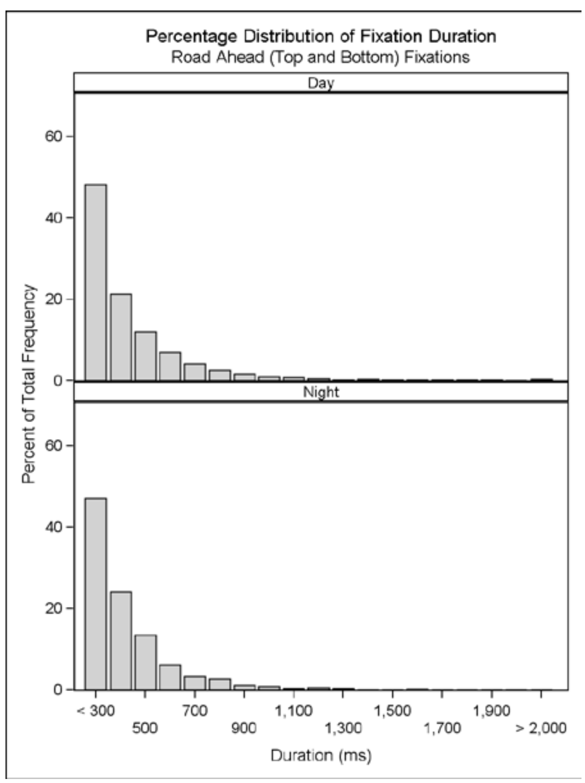

Figure 34. Fixation duration for the road ahead in the day and at night.

As was done with the data for Reading, the record of fixations was examined to determine dwell times to CEVMS and standard billboards. There were a total of 21 separate dwell times to CEVMS with a mean of 2.86 sequential fixations (minimum of 2 fixations and maximum of 6 fixations). The 21 dwell times came from 12 different participants and four different CEVMS. The mean dwell time duration to the CEVMS was 1,039 ms (minimum of 500 ms and maximum of 2,720 ms). There was one dwell time greater than 2,000 ms to CEVMS. To the standard billboards there were 13 separate dwell times with a mean of 2.31 sequential fixations (minimum of 2 fixations and maximum of 3 fixations). The 13 dwell times came from 11 different participants and four different standard billboards. The mean dwell time duration to the standard billboards was 687 ms (minimum of 450 ms and maximum of 1,152 ms). There were no dwell times greater than 2,000 ms to standard billboards.

In some cases several dwell times came from the same participant. To compute a statistic on the difference between dwell times for CEVMS and standard billboards, average dwell times were computed per participant for the CEVMS and standard billboard conditions. These average values were used in a *t*-test assuming unequal variances. The difference in average dwell time between CEVMS (M = 1,096 ms) and standard billboards (M= 674 ms) was statistically significant, $t(14) = 2.23$, $p = .043$.

Figure 35 through figure 37 show heat maps for the dwell-time durations to the CEVMS that were greater than 2,000 ms. The DCZ was on a freeway during the daytime. The CEVMS is located on the left side of the road (indicated by an orange rectangle). There were three fixations to this billboard, and the single fixations were between 651 ms and 1,335 ms. The dwell time for this billboard was 2,270 ms. Figure 35 shows the first fixation toward the CEVMS. There are no vehicles near the participant in his/her respective travel lane or adjacent lanes. In this situation, the billboard is relatively close to the road ahead ROI. Figure 36 shows a heat map later in the DCZ where the driver continues to look at the CEVMS. The heat map does not overlay the CEVMS in the picture since the heat map has integrated over time where the driver was gazing. The CEVMS has moved out of the area because of the vehicle moving down the road. However, visual inspection of the video and eye tracking statistics showed that the driver was fixating on the CEVMS. Figure 37 shows the end of the sequential fixations to the CEVMS. The driver returns to gaze directly in front of the vehicle. Once the CEVMS was out of the forward field of view, the driver quit looking at the billboard.

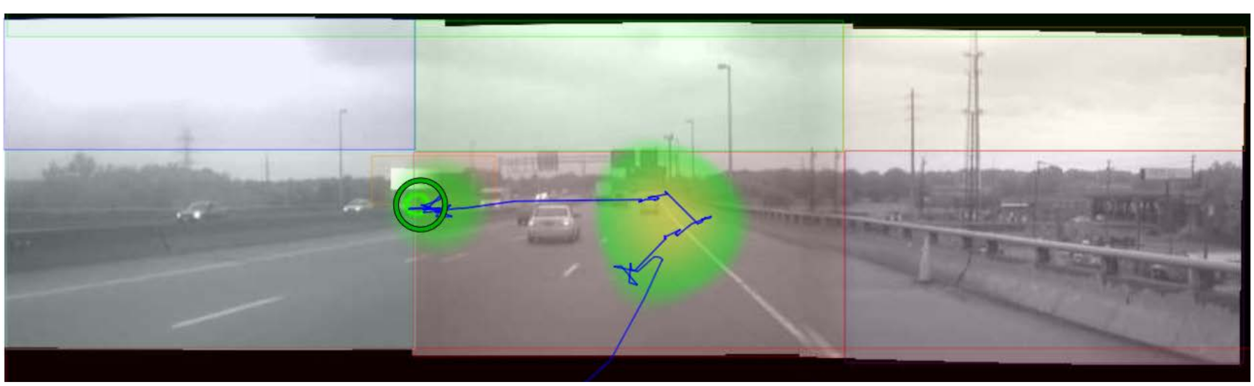

Figure 35. Heat map for first fixation to CEVMS with long dwell time.

Figure 36. Heat map for later fixations to CEVMS with long dwell time.

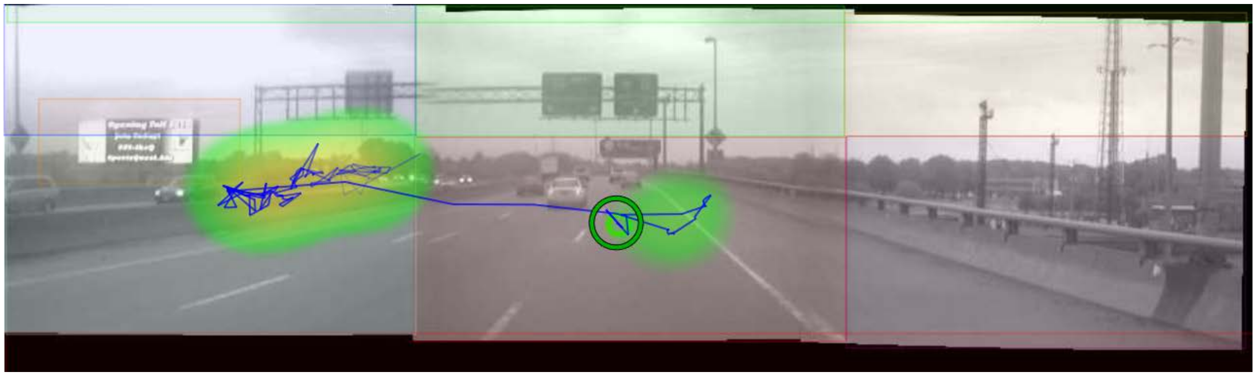

Figure 37. Heat map at end of fixations to CEVMS with long dwell time.

Comparison of Gazes to CEVMS and Standard Billboards

As was done for the data from Reading, GEE were used to analyze whether a participant gazed more toward CEVMS than toward standard billboards, given that the participant was looking at off-premise advertising. Recall that a sample probability greater than 0.5 indicated that participants gazed more toward CEVMS than standard billboards when the participants gazed at off-premise advertising. In contrast, if the sample probability was less than 0.5, participants showed a preference to gaze more toward standard billboards than CEVMS when directing visual attention to off-premise advertising.

Time of day (i.e., day or night), road type (i.e., freeway or arterial), and the corresponding interaction were explanatory variables in the logistic regression model. Time of day had a significant effect on participant gazes toward off-premise advertising, $\chi^2(1) = 4.46$, $p = 0.035$. Participants showed a preference to gaze more toward CEVMS than toward standard billboards during both times of day. During the day the preference was only slight (M = 0.52), but at night the preference was more pronounced (M = 0.71). Road type was also a significant predictor of where participants directed their gazes at off-premise advertising, $\chi^2(1) = 3.96$, $p = 0.047$. Participants gazed more toward CEVMS than toward standard billboards while driving on both types of roadways. However, driving on freeways yielded a slight preference for CEVMS over standard billboards (M = 0.55), but driving on arterials resulted in a larger preference in favor of CEVMS (M = 0.68).

Observation of Driver Behavior

No near misses or driver errors occurred.

Level of Service

Table 11 shows the level of service as a function of advertising type, type of road, and time of day. As expected, there was less congestion during the nighttime runs than in the daytime. In general, there was traffic during the data collection runs; however, the eye tracking data were recorded while the vehicles were in motion.

Table 11. Estimated level of service as a function of advertising condition, road type, and time of day.

	Arterial		Freeway	
	Day	Night	Day	Night
Control	B	A	C	B
CEVMS	B	A	B	A
Standard	C	A	C	C

DISCUSSION OF RICHMOND RESULTS

Overall the probability of looking at the forward roadway was high across all conditions and consistent with the findings from Reading and previous related research.[11,9,12] In this second study the CEVMS and standard billboard conditions did not differ from each other. For the DCZs on arterials there were no significant differences among the control, CEVMS, and standard billboard conditions. On the other hand, while the CEVMS and standard billboard conditions on the freeways did not differ from each other, they were significantly different from their respective control conditions. The control condition on the freeway principally had trees along the sides of the road and the signs that were present were freeway signs located in the road ahead ROI.

Measures such as feature congestion rated the three DCZs on freeways as not being statistically different from each other. These types of measures have been useful in predicting visual search and the effects of visual salience in laboratory tasks.[34] Models of visual salience may predict that, at least during the daytime, trees on the side of the road may be visually salient objects that would attract a driver's attention.[47] However, it appears that in the present study, participants principally kept their eyes on the road ahead.

The mean fixations to CEVMS, standard billboards, and the road ahead were found to be similar in magnitude with no long fixations. Examination of dwell times showed that there was one long dwell time for a CEVMS greater than 2,000 ms and it occurred in the daytime on a sign located on the left side of the road on a freeway DCZ. Furthermore, when averaging among participants the mean dwell time for CEVMS was significantly longer than to standard billboards, but still under 2,000 ms. For the dwell time greater than 2,000 ms, examination of the scene camera video and eye tracking heat maps showed that the driver was initially looking toward the forward roadway and made a first fixation to the sign. Three fixations were made to the sign and then the driver started looking back to the road ahead as the sign moved out of the forward field of view. On the video there were no vehicles near the subject driver's own lane or in adjacent lanes.

Only the central 2 degrees of vision, foveal vision, provide resolution sharp enough for reading or recognizing fine detail.(57) However, useful information for reading can be extracted from parafoveal vision, which encompasses the central 10 degrees of vision.(57) More recent research on scene gist recognition[3] has shown that peripheral vision (beyond parafoveal vision) is more useful than central vision for recognizing the gist of a scene.(58) Scene gist recognition is a critically important early stage of scene perception, and influences more complex cognitive processes such as directing attention within a scene and facilitating object recognition, both of which are important in obtaining information while driving.

The results of this study do show one duration of eyes off the forward roadway greater than 2,000 ms, the duration at which Klauer et al. observed near-crash/crash risk at more than twice those of normal, baseline driving.(14,53) When looking at the tails of the fixation distributions, few fixations were greater than 1,000 ms, with the longest fixation being equal to 1,335 ms.(53,54) The one long dwell time on a CEVMS that was observed was a rare event in this study, and review of the video and eye tracking data suggests that the driver was effectively managing acquisition of visual information while driving and fixated on the advertising. However, additional work needs to be done to derive criteria for gazing or fixating away from the forward road view where the road scene is still visible in peripheral vision.

The results showed that drivers are more likely to look at CEVMS than standard billboards during the nighttime across the conditions tested (at night the average probability of gazing at CEVMS was M= 0.71). CEVMS do have greater luminance than standard billboards at night and also have higher contrast. The CEVMS have the capability of being lit up so that they would appear as very bright signs to drivers (for example, up to about10,000 cd/m^2 for a white square on the sign.). However, our measurements of these signs showed an average luminance of about 56 cd/m^2. These signs would be conspicuous in a nighttime driving environment but significantly less so than other light sources such as vehicle headlights. Drivers were also more likely to look at CEVMS than standard billboards on both arterials and freeways, with a higher probability of gazes on arterials.

In this second study, CEVMS and standard billboards were more nearly equated with respect to setback from the road. Gazes to the road ahead were not significantly different between CEVMS and standard billboard DCZs across conditions and the proportion of gazes to the road ahead were consistent with previous research. One long dwell time for a CEVMS was observed in this study; however, it occurred in the daytime where the luminance and contrast (affecting the perceived brightness) of these signs are similar to those for standard billboards.

[3] "Scene gist recognition" refers to the element of human cognition that enables us to determine the meaning of a scene and categorize it by type (e.g., a beach, an office) almost immediately upon seeing it.

GENERAL DISCUSSION

This study was conducted to investigate the effect of CEVMS on driver visual behavior in a roadway driving environment. An instrumented vehicle with an eye tracking system was used. Roads containing CEVMS, standard billboards, and control areas with no off-premise advertising were selected. The CEVMS and standard billboards were measured with respect to luminance, location, size, and other relevant variables to characterize these visual stimuli. Unlike previous studies on digital billboards, the present study examined CEVMS as deployed in two United States cities and did not contain dynamic video or other dynamic elements. The CEVMS changed content approximately every 8 to 10 seconds, consistent within the limits provided by FHWA guidance.[2] In addition, the eye tracking system used had nearly a 2-degree level of resolution that provided significantly more accuracy in determining what objects the drivers were gazing or fixating on as compared to some previous field studies examining CEVMS.

CONCLUSIONS

Do CEVMS attract drivers' attention away from the forward roadway and other driving relevant stimuli?

Overall, the probability of looking at the road ahead was high across all conditions. In Reading, the CEVMS condition had a lower proportion of gazes to the road ahead than the standard billboard condition on the freeways. Both of the off-premise advertising conditions had a lower proportion of gazes to the road ahead than the control condition on the freeway. The lower proportion of gazes to the road ahead can be attributed to the overall distribution of gazes away from the road ahead and not just to the CEVMS. On the other hand, for the arterials the CEVMS and standard billboard conditions did not differ from each other, but both had a lower proportion of gazes to the road ahead compared to the control. In Richmond there were no differences among the three advertising conditions on the arterials. However, for the freeways the CEVMS and standard billboard conditions did not differ from each other but had a lower proportion of gazes to the road ahead than the control.

The control conditions differed across studies. In Reading, the control condition on arterials showed 92 percent for gazing at the road ahead while on the freeway it was 86 percent. On the other hand, in Richmond the control condition for arterials was 78 percent and for the freeway it was 92 percent. The control conditions on the freeway differed across the two studies. In Reading there were businesses off to the side of the road; whereas in Richmond the sides of the road were mostly covered with trees. The control conditions on the arterials also differed across cities in that both contained businesses and on-premise advertising; however, in Reading arterials had four lanes and in Richmond arterials had six lanes. The reason for these differences across cities was that these control conditions were selected to match the other conditions (CEVMS and standard billboards) that the drivers would experience in the two respective cities. Also, the selection of DCZs was obviously constrained by what was available on the ground in these cities.

The results for the off-premise advertising conditions are consistent with Lee et al., who observed that 76 percent of drivers' time was spent looking at the road ahead in the CEVMS scenario and 75 percent in the standard billboard scenario.[9] However, it should be kept in mind that drivers did gaze away from the road ahead even when no off-premise advertising was present and that the presence of clutter or salient visual stimuli did not necessarily control where drivers gazed.

Do glances to CEVMS occur that would suggest a decrease in safety?

In DCZs containing CEVMS, about 2.5 percent of the fixations were to CEVMS (about 2.4 percent to standard billboards). The results for fixations are similar to those reported in other field data collection efforts that included advertising signs.[12,11,9,13] Fixations greater than 2,000 ms were not observed for CEVMS or standards billboards.

However, an analysis of dwell times to CEVMS showed a mean dwell time of 994 ms (maximum of 1,467 ms) for Reading and a mean of 1,039 ms (maximum of 2,270 ms) for Richmond. Statistical comparisons of average dwell times between CEVMS and standard billboards were not significant in Reading; however, in Richmond the average dwell times to CEVMS were significantly longer than to standard billboards, though below 2,000 ms. There was one dwell time greater than 2,000 ms to a CEVMS across the two cities. On the other hand, for standard billboards there were three long dwell times in Reading; there were no long dwell times to these billboards in Richmond. Review of the video data for these four long dwell times showed that the signs were not far from the forward view when participants were fixating. Therefore, the drivers still had access to information about what was in front of them through peripheral vision.

As the analyses of gazes to the road ahead showed, drivers distributed their gazes away from the road ahead even when there were no off-premise billboards present. Also, drivers gazed and fixated on off-premise signs even though they were generally irrelevant to the driving task. However, the results did not provide evidence indicating that CEVMS were associated with long glances away from the road that may reflect an increase in risk. When long dwell times occurred to CEVMS or standard billboards, the road ahead was still in the driver's field of view.

Do drivers look at CEVMS more than at standard billboards?

The drivers were generally more likely to gaze at CEVMS than at standard billboards. However, there was some variability between the two locations and between type of roadway (arterial or freeway). In Reading, the participants looked more often at CEVMS when on arterials, whereas they looked more often at standard billboards when on freeways. In Richmond, the drivers looked at CEVMS more than standard billboards no matter the type of road they were on, but as in Reading the preference for gazing at CEVMS was greater on arterials (68 percent on arterials and 55 percent on freeways). The slower speed on arterials and sign placement may present drivers with more opportunities to gaze at the signs.

In Richmond, the results showed that drivers gazed more at CEVMS than standard billboards at night; however, for Reading no effect for time of day was found. CEVMS do have higher luminance and contrast than standard billboards at night. The results showed mean luminance of about 56 cd/m^2 in the two cities where testing was conducted. These signs would appear clearly visible but not overly bright.

SUMMARY

The results of these studies are consistent with a wealth of research that has been conducted on vision in natural environments.(26,22,21) In the driving environment, gaze allocation is principally controlled by the requirements of the task. Consistent results were shown for the proportion of gazes to the road ahead for off-premise advertising conditions across the two cities. Average fixations were similar to CEVMS and standard billboards with no long single fixations evident for either condition. Across the two cities, four long dwell times were observed: one to a CEVMS on a freeway in the day, two to the same standard billboard on a freeway (once at night and once in the daytime), and one to a standard billboard on an arterial at night. Examination of the scene video and eye tracking data indicated that these long dwell times occurred when the billboards were close to the forward field of view where peripheral vision could still be used to gather visual information on the forward roadway.

The present data suggest that the drivers in this study directed the majority of their visual attention to areas of the roadway that were relevant to the task at hand (i.e., the driving task). Furthermore, it is possible, and likely, that in the time that the drivers looked away from the forward roadway, they may have elected to glance at other objects in the surrounding environment (in the absence of billboards) that were not relevant to the driving task. When billboards were present, the drivers in this study sometimes looked at them, but not such that overall attention to the forward roadway decreased.

LIMITATIONS OF THE RESEARCH

In this study the participants drove a research vehicle with two experimenters on board. The participants were provided with audio turn-by-turn directions and consequently did not have a taxing navigation task to perform. The participants were instructed to drive as they normally would. However, the presence of researchers in the vehicle and the nature of the driving task do limit the degree to which one may generalize the current results to other driving situations. This is a general limitation of instrumented vehicle research.

The two cities employed in the study appeared to follow common practices with respect to the content change frequency (every 8 to 10 seconds) and the brightness of the CEVMS. The current results would not generalize to situations where these guidelines are not being followed.

Participant recruiting was done through libraries, community centers and at a university. This recruiting procedure resulted in a participant demographic distribution that may not be representative of the general driving population.

The study employed a head-free eye tracking device to increase the realism of the driving situation (no head-mounted gear). However, the eye tracker had a sampling rate of 60 Hz, which made determining saccades problematic. The eye tracker and analyses software employed in this effort represents a significant improvement in technology over previous similar efforts in this area.

The study focused on objects that were 1,000 feet or less from the drivers. This was dictated by the accuracy of the eye tracking system and the ability to resolve objects for data reduction. In addition, the geometry of the roadway precluded the consideration of objects at great distances.

The study was performed on actual roadways, and this limited the control of the visual scenes except via the route selection process. In an ideal case, one would have had roadways with CEVMS, standard billboards, and no off-premise advertising and in which the context surrounding digital and standard billboards did not differ. This was not the case in this study, although such an exclusive environment would be inconsistent with the experience of most drivers. This presents issues with the interpretation of the specific contributions made by billboards and the environment to the driver's behavior.

Sign content was not investigated (or controlled) in the present study, but may be an important factor to consider in future studies that investigate the distraction potential of advertising signs. Investigations about the effect of content could potentially be performed in driving simulators where this variable could be systematically controlled and manipulated.

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Memorandum

U.S. Department
of Transportation
Federal Highway Administration

Subject: **<u>INFORMATION</u>:** Guidance on Off-Premise Changeable Message Signs

Date: September 25, 2007

Original signed by:
From: Gloria M. Shepherd
Associate Administrator for
Planning, Environment, and Realty

In Reply Refer To:
HEPR -20

To: Division Administrators
Attn: Division Realty Professionals

Purpose

The purpose of this memorandum is to provide guidance to Division offices concerning off-premises changeable message signs adjacent to routes subject to requirements for effective control under the Highway Beautification Act (HBA) codified at 23 U.S.C. 131. It clarifies the application of the Federal Highway Administration (FHWA) July 17, 1996 memorandum on this subject. This office may provide further guidance in the future as a result of additional information received through safety research, stakeholder input, and other sources.

Pursuant to 23 CFR 750.705, a State DOT is required to obtain FHWA Division approval of any changes to its laws, regulations, and procedures to implement the requirements of its outdoor advertising control program. A State DOT should request and Division offices should provide a determination as to whether the State should allow off-premises changeable electronic variable message signs (CEVMS) adjacent to controlled routes, as required by our delegation of responsibilities under 23 CFR 750.705(j). Those Divisions that already have formally approved CEVMS use on HBA controlled routes, as well as those that have not yet issued a decision, should re-evaluate their position in light of the following considerations. The decision of the Division should be based upon a review and approval of a State's affirmation and policy that: (1) is consistent with the existing Federal/State Agreement (FSA) for the particular State, and (2) includes but is not limited to consideration of requirements associated with the duration of message, transition time, brightness, spacing, and location, submitted for FHWA approval, that evidence reasonable and safe standards to regulate such signs are in place for the protection of the motoring public. **Proposed laws, regulations, and procedures that would allow permitting CEVMS subject to acceptable criteria (as described below) do not violate a prohibition against "intermittent" or "flashing" or "moving" lights as those terms are used in the various FSAs that have been entered into during the 1960s and 1970s.**

This Guidance is applicable to conforming signs, as applying updated technology to nonconforming signs would be considered a substantial change and inconsistent with the requirements of 23 CFR 750.707(d)(5). As noted below, all of the requirements in the HBA and its implementing regulations, and the specific provisions of the FSAs, continue to apply.

Background

The HBA requires States to maintain effective control of outdoor advertising adjacent to certain controlled routes. The reasonable, orderly and effective display of outdoor advertising is permitted in zoned or unzoned commercial or industrial areas. Signs displays and devices whose size, lighting and spacing are consistent with customary use determined by agreement between the several States and the Secretary, may be erected and maintained in these areas (23 U.S.C. § 131(d)). Most of these agreements between the States and the Secretary that determined the size, lighting and spacing of conforming signs were signed in the late 1960's and the early 1970's.

On July 17, 1996, this Office issued a Memorandum to Regional Administrators to provide guidance on off-premise changeable message signs and confirmed that FHWA has "always applied the Federal law 23 U.S.C. 131 as it is interpreted and implemented under the Federal regulations and individual Federal/State agreements.". It was expressly noted that "in the twenty-odd years since the agreements have been signed, there have been many technological changes in signs, including changes that were unforeseen at the time the agreements were executed. While most of the agreements have not changed, the changes in technology require the State and FHWA to interpret the agreements with those changes in mind". The 1996 Memorandum primarily addressed tri-vision signs, which were the leading technology at the time, but it specifically noted that changeable message signs "regardless of the type of technology used" are permitted if the interpretation of the FSA allowed them. Further advances in technology and affordability of LED and other complex electronic message signs, unanticipated at the time the FSAs were entered into, require the FHWA to confirm and expand on the principles set forth in the 1996 Memorandum.

The policy espoused in the 1996 Memorandum was premised upon the concept that changeable messages that were fixed for a reasonable time period do not constitute a moving sign. If the State set a reasonable time period, the agreed-upon prohibition against moving signs is not violated. Electronic signs that have stationary messages for a reasonably fixed time merit the same considerations.

Discussion

Changeable message signs, including Digital/LED Display CEVMS, are acceptable for conforming off-premise signs, if found to be consistent with the FSA and with acceptable and approved State regulations, policies and procedures.

This Guidance does not prohibit States from adopting more restrictive requirements for permitting CEVMS to the extent those requirements are not inconsistent with the HBA, Federal regulations, and existing FSAs. Similarly, Divisions are not required to concur with State proposed regulations, policies, and procedures if the Division review determines, based upon all relevant information, that the proposed regulations, policies and procedures are not consistent with the FSA or do not include adequate standards to address the safety of the motoring public. If the Division Office has any question that the FSA is being fully complied with, this should be discussed with the State and a process to change the FSA may be considered and completed before such CEVMS may be allowed on HBA controlled routes. The Office of Real Estate Services is available to discuss this process with the Division, if requested.

If the Division accepts the State's assertions that their FSA permits CEVMS, in reviewing State-proposed regulations, policy and procedures for acceptability, Divisions should consider all relevant information, including but not limited to duration of message, transition time, brightness, spacing, and location, to ensure that they are consistent with their FSA and that there are adequate standards to address safety for the motoring public. Divisions should also confirm that the State provided for appropriate public input, consistent with applicable State law and requirements, in its interpretation of the terms of their FSA as allowing CEVMS in accordance with their proposed regulations, policies, and procedures.

Based upon contacts with all Divisions, we have identified certain ranges of acceptability that have been adopted in those States that do allow CEVMS that will be useful in reviewing State proposals on this topic. Available information indicates that State regulations, policy and procedures that have been approved by Divisions to date, contain some or all of the following standards:

- Duration of Message
  - Duration of each display is generally between 4 and 10 seconds – 8 seconds is recommended.
- Transition Time
  - Transition between messages is generally between 1 and 4 seconds – 1-2 seconds is recommended.
- Brightness
  - Adjust brightness in response to changes in light levels so that the signs are not unreasonably bright for the safety of the motoring public.
- Spacing
  - Spacing between such signs not less than minimum spacing requirements for signs under the FSA, or greater if determined appropriate to ensure the safety of the motoring public.
- Locations
  - Locations where allowed for signs under the FSA except such locations where determined inappropriate to ensure safety of the motoring public.

Other standards that States have found helpful to ensure driver safety include a default designed to freeze a display in one still position if a malfunction occurs; a process for modifying displays and lighting levels where directed by the State DOT to assure safety of the motoring public; and requirements that a display contain static messages without movement such as animation, flashing, scrolling, intermittent or full-motion video.

Conclusion

This Memorandum is intended to provide information to assist the Divisions in evaluating proposals and to achieve national consistency given the variations in FSAs, State law, and State regulations, policies and procedures. It is not intended to amend applicable legal requirements. Divisions are strongly encouraged to work with their State in its review of their existing FSAs and, if appropriate, assist in pursuing amendments to address proposed changes relating to CEVMS or other matters. In this regard, our Office is currently reviewing the process for amending FSAs, as established in 1980, to determine appropriate revisions to streamline requirements while continuing to ensure there is adequate opportunity for public involvement.

For further information, please contact your Office of Real Estate Point of Contact or Catherine O'Hara (Catherine.O'Hara@dot.gov).

An Examination of the Relationship between Digital Billboards and Traffic Safety in Reading, Pennsylvania Using Empirical Bayes Analyses

Michael W. Tantala, P.E. and Albert M. Tantala, Sr., P.E.

Abstract. This paper examines the statistical relationship between advertising digital billboards and traffic safety using Empirical Bayes Method analyses. Specifically, this paper analyzes traffic and accident data near 26 existing, non-accessory, advertising digital billboards along routes with periods of comparison as long as 8 years in the greater Reading area, Berks County, Pennsylvania. These studied digital billboards are one type of commercial electronic variable message signs (CEVMS) which display static messages, include no animation, flashing lights, scrolling, or full-motion video, and have duration times of 6, 8, or 10 seconds.

Temporal (when and how frequently) and spatial (where and how far) statistics are summarized within multiple vicinity ranges as large as one mile near billboards. The study uses the Empirical Bayes (EB) method to predict the "expected" range of accidents at locations assuming that no digital billboard technology was introduced. The method analyzes data near 26 billboard locations, incorporates data using 51 non-digital comparison sites, and establishes a multivariate Crash Estimation Model (CEM) with a negative binomial distribution to estimate expected numbers of crashes near locations. Predictive methods in the AASHTO Highway Safety Manual are used with PennDOT highway, geometric, and crash data.

Keywords. Digital billboards, CEVMS, Duration Time, Crash Estimation Model, Empirical Bayes Method, Crash Rates, GIS

INTRODUCTION

Digital billboards are a relatively new technology of outdoor advertising in the transportation milieu. Digital billboards display static messages that have durations for typically six to ten seconds, and include no animation, flashing lights, scrolling, or full motion video. As a growing technology in the transportation environment, the research of its effect on traffic safety is also growing; a partial list of some work follows. There have been several papers that have reviewed collections of research on the relationship between billboards and traffic safety: Andreassen (1), Farbry *et al.* (2), Wallace (3), Garvey *et al.* (4), Birdsall (5), Molina *et al.* (6), *inter alia*.

In 2007, Lee *et al.* (7) performed a naturalistic, human factors study of digital and conventional billboards in Cleveland, Ohio which concluded that driving performance measures (eye glance patterns, speed maintenance and lane keeping) in the presence of digital billboards are comparable with those associated with everyday driving. In 2009, Molina *et al.* (6) issued a report on research concerning the possible effects of CEVMS used for outdoor advertising on driver safety, including possible attention and distraction effects. Additional research is anticipated from the FHWA.

Concerning research of accident statistics, Tantala and Tantala (8) performed a statistical examination of the relationship between conventional billboards and traffic accidents along the New Jersey Turnpike. The research in this study adopted a statistical analysis method which addressed temporal and spatial statistics. Tantala and Tantala performed similar analyses of digital billboards in Cuyahoga County, Ohio (9, 11), Rochester, Minnesota (10), Albuquerque, New Mexico (12), Berks County, Pennsylvania (13) and Henrico County and Richmond, Virginia (14). Accident statistics and metrics remain consistent near digital billboard locations and these studies examined the age of driver, daytime and nighttime accidents, various duration times and other comparisons. More detailed discussion, analysis and results are available in the technical report of this research (13).

STUDY REGION

The Greater Reading Area was chosen as a study region, because it has multiple digital billboards in close proximity that were in service for extended periods of time. The roads adjacent to these billboards are well traveled; approximately 703 thousand vehicles traveled per day collectively on the sections of road near the digital billboards. In 2008, some 162 thousand licensed drivers drove to work in the Greater Reading Area with an average commute time of 22 minutes. Several federal and state highways allow entry to and egress from Reading. US Route 222 Business is designated as Lancaster Avenue, Bingaman Street, South 4th Street, and 5th Street. US Route 422 Business is designated as Penn Street, Cherry Street, Franklin Street, and Perkiomen Avenue. US Route 422, the major east-west artery, circles the western edge of the city and is known locally as The West Shore Bypass. PA Route 12 is known as the Warren Street Bypass, and bypasses the city to the north.

BILLBOARD CHARACTERISTICS

Digital billboards display static messages which, when viewed, resemble conventional painted or printed billboards. With digital technology, there is a static copy which includes no animation, flashing lights, scrolling, or full-motion video. The static display on each of these digital billboards has duration times of 6, 8 or 10 seconds. The digital billboards use red, green, and blue light-emitting-diode (LED) technology to present text and graphics. The digital billboards compensate for varying light levels, including day and night viewing, by automatically monitoring and adjusting overall display brightness and gamma levels. A photocell is mounted on each digital billboard to measure ambient light. Twenty of the digital billboards that were studied are owned and operated by Lamar; six, by Land Displays. Generally, the digital billboards operated by Lamar have duration times of six or eight seconds for the smaller poster-sized boards and ten seconds for the larger, bulletin-sized boards. Digital billboards operated by Land Displays have duration times of eight seconds.

The twenty digital, billboard locations in Reading are shown in Figure 1 which summarizes direction, configuration and other sign characteristics. The digital boards and their surroundings were observed during day and night conditions. A majority of the digital billboards are freestanding, single-pole, structures with one digital face; six locations have two digital boards on the same upright. Nine of the twenty-six billboards were converted to digital format circa December 2005 and the remaining were converted on various dates in 2007, 2008 and 2009. These dates allow for before/after comparisons as long as 8.1 years (or 98 months).

Figure 2 shows photos and aerials of locations 1, 2 and 3. For example, Location No. 1 is located on the east side of Route 61, approximately 0.2 miles south of Route 662. The structure is a double-face, free standing, center-mount, vee configuration. The north face is a digital bulletin and a cross reader. The north face was converted from a conventional format on 29Nov08 using the existing location. The south face is a digital bulletin and a right-hand reader. The face was converted from a conventional format on 22Sep06 using the existing location. Each face is operated by Lamar and has a 10.5x36 size with a duration time of 10 seconds. Figure 3 shows the locations of the digital billboards studied. More detailed discussion and information of the other billboards studied are available in the technical report of this research (13).

TRAFFIC VOLUME AND ACCIDENT DATA

Traffic volume data for the Greater Reading Area were obtained from the Pennsylvania Department of Transportation (PennDOT) and includes the annual average daily traffic (AADT), which is the average of 24-hour counts collected throughout the year. The AADT volumes were recorded in the Greater Reading area between 2002 and 2009 (15). Figure 3 shows the 2009 AADT volumes in the Greater Reading Area. AADT ranges individually near the 20 digital locations from 9 to 71 thousand vehicles per day, or equivalently 3 to 26 million vehicles per year; this collectively represents approximately 703 thousand vehicles per day or 256 million vehicles per year.

	Location	Configuration	Road Side	Digital Facing	Reader Side	Face Size (feet)	Duration Time (seconds)
1	Rte 61, 0.2 miles south of Rte 662	Free standing, Center-mount, Vee	E	N S	cross right	10.5x36 10.5x36	10 10
2	Rte 222 N, 0.1 miles north of Leesport Avenue	Free standing, Center-mount	E	S	right	14x48	10
3	Rte 222 N Bypass, 1.0 mile south of Rte 61 Exit	Free standing, Center-mount	E	N	cross	14x48	10
4	Rte 222 N Bypass, 1.0 mile north of Rte 61 Exit	Free standing, Center-mount, Vee	W	N	right	20x20	8
5	5th Street & Amity Street	Free standing, Center-mount, Back-to-Back	E	N	left	10.5x22.75	6
6	Rte 12 (Warren Street Bypass) at Rte 183	Roof-top, Frame, Back-to-Back	S	W	right	14x48	8
7	Warren Street west of Allegheny Avenue	Free standing, Flag, Vee	S	E W	cross right	10.5x36 10.5x36	10 10
8	Rte 422 Bypass, 0.2 miles west of Bern Road Exit	Free standing, Flag, Vee	S S	E W	cross right	14x48 14x48	10 10
9	West Shore Drive, 0.3 miles east of Penn Street	Free standing, Center-mount, Vee	S	E W	cross right	10.5x36 10.5x36	10 10
10	Rte 422 Bypass, 0.6 miles west of State Hill Rd	Free standing, Center-mount, Vee	S	W	right	10.5x22.75	10
11	Rte 724, 1000 feet south of Rte 422	Free standing, Center-mount, Vee	W	S	right	10.5x36	8
12	Rte 422 west, 0.1 miles east of Green Valley Rd	Free standing, Center-mount, Back-to-Back	N	E W	right cross	10.5x22.75 10.5x22.75	8 8
13	Lancaster Avenue (Rte 422) at Rte 10	Free standing, Center-mount, Back-to-Back	W	S	cross	10.5x36	8
14	West Shore Drive, 0.4 miles east of Lancaster Exit	Free standing, Center-mount, Vee	N	E	right	10.5x22.75	6
15	West Shore Drive, 0.5 miles of Exit 176	Free standing, Center-mount, Single-face	N	W	cross	10.5x22.75	6
16	Rte 222 S, 0.3 miles south of Rte 724	Free standing, Center-mount, Vee	W	N S	right cross	11x23 11x23	8 8
17	Rte 222, 0.13 miles north of Gouglersville Exit	Free standing, Center-mount, Single-face	E	N	cross	12x25	8
18	Rte 222 S, 1.0 miles north of Rte 272 / 568	Free standing, Center-mount, Vee	E	S	right	14x48	10
19	Rte 422, 3.0 miles west of Rte 662	Free standing, Center-mount, Double-face	S	W	right	10x20	8
20	Rte 422 east, 0.1 mi west of Old Airport Road	Free standing, Center-mount, Vee	S	W	right	10.5x22.75	8

Figure 1 - Digital Billboard Direction, Sizes and Other Sign Characteristics

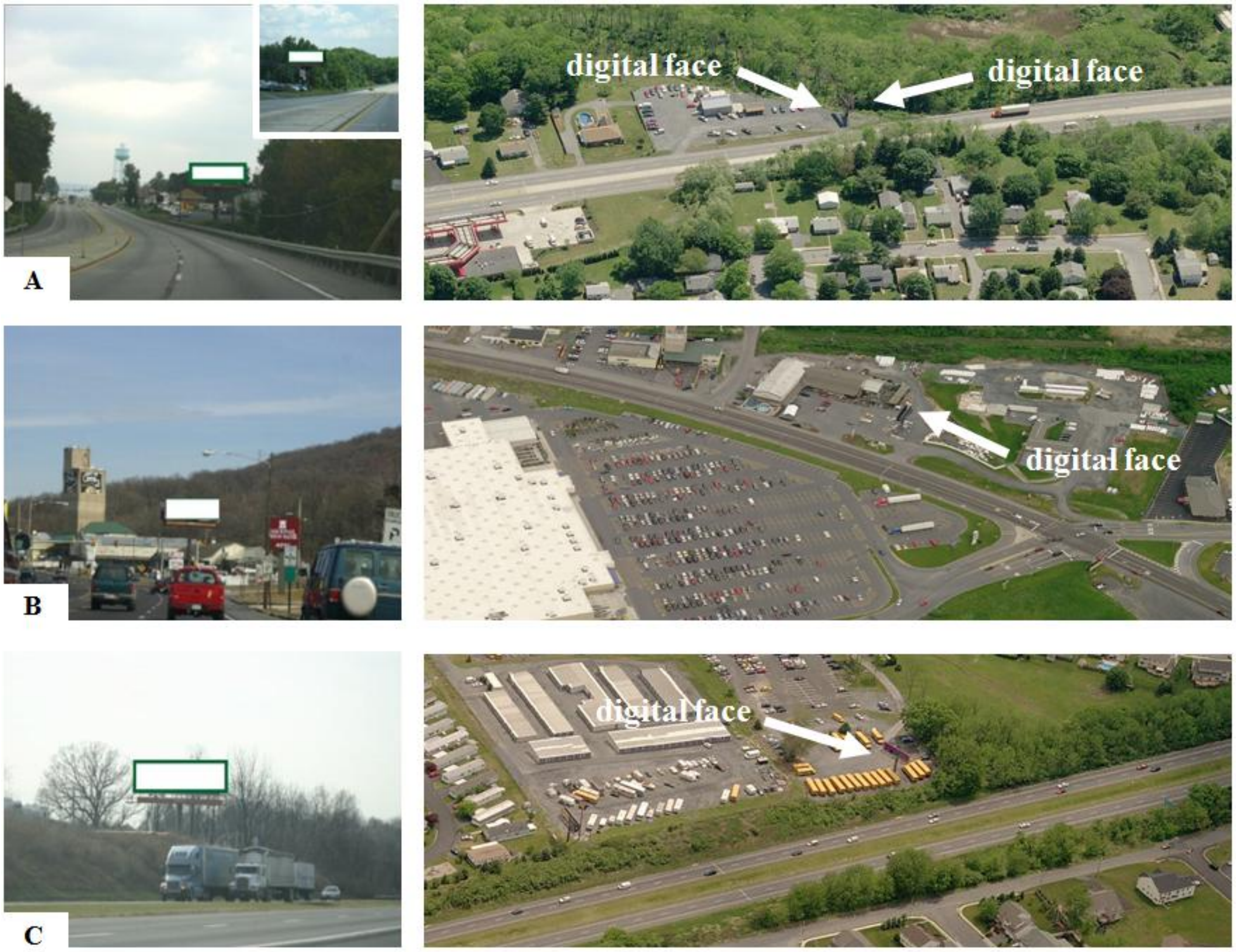

Figure 2 - Photographs of Locations 1, 2 and 3. (A) Location No. 1. View on Route 61 with inset that shows opposite-face digital, left; Oblique Aerial of location, right. (B) Location No. 2. View on Route 222 North, left, Oblique Aerial of location right. (C) Location No. 3. View on Route 222 North Bypass, left, Oblique Aerial of location right.

In the Greater Reading Area, the majority of accident reports are investigated and recorded by each Township's Police Department. Data were maintained by those Police Departments and compiled by the Pennsylvania Department of Transportation (16). Law-enforcement officials are required to submit reports on crashes they investigate which meet reporting thresholds provided by statue, or in which someone was injured or killed in the crash. Data generally conform to the American National Standards Institute (ANSI) Standard D16.1 – 1996, Manual on Classification of Motor Vehicle Traffic Accidents (17). The accident data sets provided by PennDOT include 35,000 accidents during the eight years between 2001 and 2009 and near digital billboard locations. Figure 4 shows the geocoded accident locations generally within Berks County.

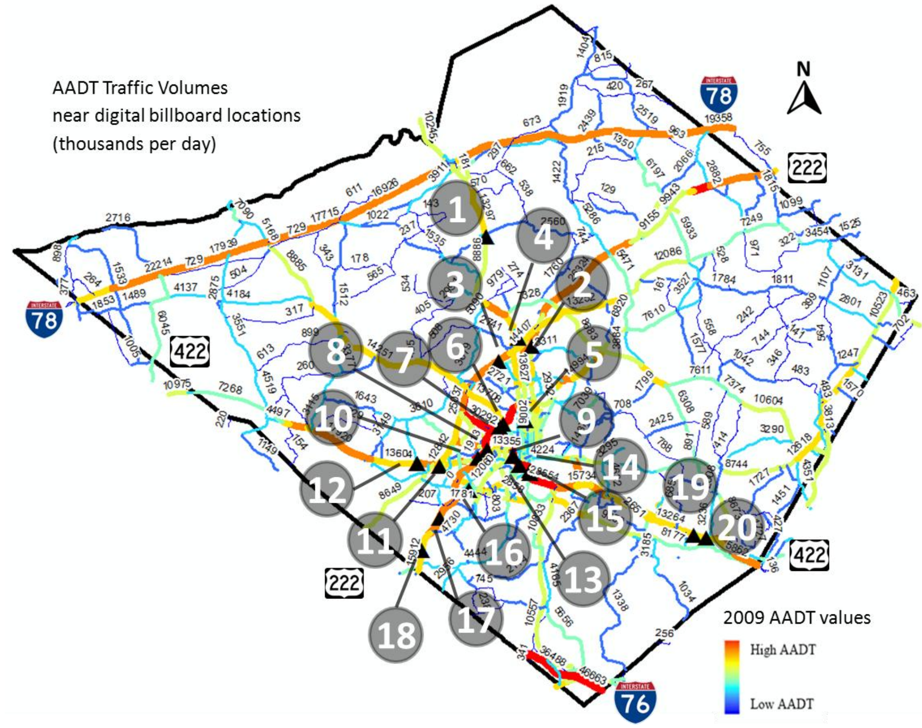

Figure 3 - Digital Billboard Locations in the Greater Reading Area with AADT Volume Data Thematically Mapped for 2009

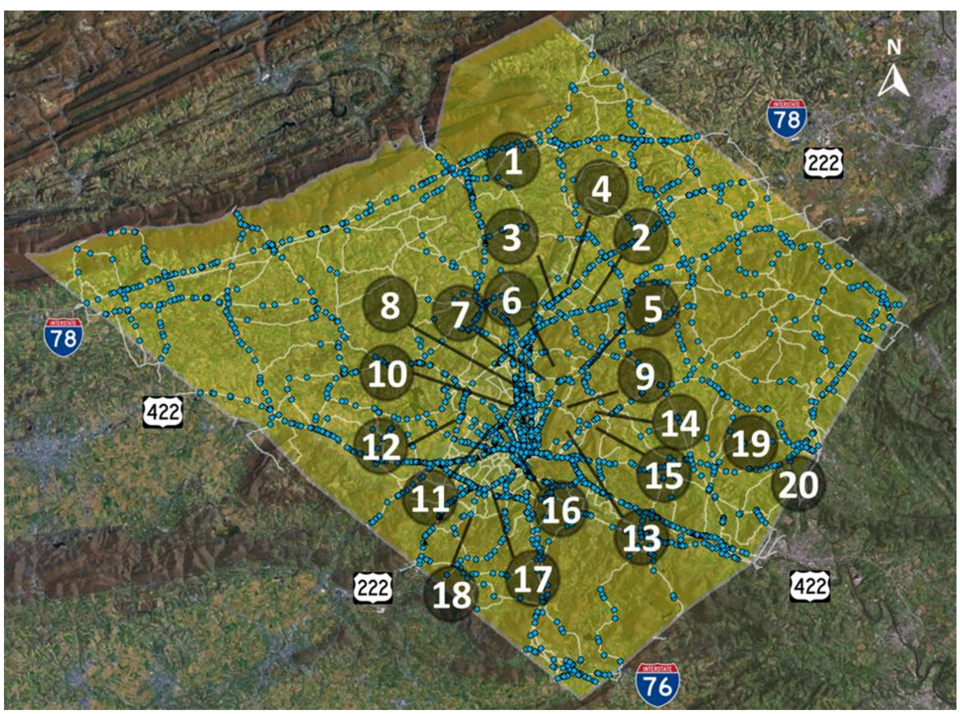

Figure 4 - Traffic Accidents (blue dots) near Digital Billboard Locations in the Greater Reading Area from 2001 to 2009

ANALYSIS

The analysis of this robust data involves an engineering-statistics based approach and uses widely accepted methods to show what happened when these 26 digital billboard faces were installed in the Greater Reading Area. The analysis has three parts. Part 1 is a temporal analysis which compares before and after changes in crash rates and other metrics. Part 2 is a spatial analysis which compares where and how far data to establish statistical correlation coefficients for various scenarios accounting for accident density and billboard proximity. Part 3 uses the Empirical Bayes (EB) method. This method uses the 'before' accident statistics to predict the number of accidents "expected" at the locations assuming that no digital billboard technology was introduced. The method is the basis of the safety analysis and science-based, predictive models introduced within the 2010 Highway Safety Manual of the American Association of State Highway Official (18). This paper quantifies what the actual 'after' accident statistics are and compares them with what the predicted values are from the EB analysis. This method analyzes data from the twenty billboard location and incorporates data using non-digital comparison sites.

The first part is a temporal analysis. The incidence of traffic accidents near the digital billboards is examined for an equal length of time before and after the digital billboards were installed and activated. This part is for the purpose of establishing if traffic accidents occurred more or less frequently in the presence of these digital billboards. With information collected from police accident reports, the temporal analysis also uses metrics such as traffic volumes, the accident-rate values, the maximum number of accidents during any given month, etc. For comparison, accident statistics were summarized near the digital billboards within multiple vicinity ranges of 0.1, 0.2, 0.3, 0.4, and 0.5 miles both upstream and downstream of each billboard.

The second part is a spatial analysis. This establishes statistical correlation coefficients between the digital billboards and accidents. Correlation coefficients are statistical measures of the “association” between two sets of data. The results are analyzed for various scenarios accounting for accident density and billboard proximity. Additionally, subsets of accident data for age of driver and for daytime and nighttime accidents are analyzed for before and after comparisons. For a more lengthy discussion of analysis methods, please refer to previous studies (13).

The third part of the analysis uses the Empirical Bays (EB) method. An Empirical Bayes (EB) Method analysis is performed to estimate the number of accidents that could statistically be expected without the introduction of digital signs. Research literature suggests that the EB method is appropriate for this type of analysis and is a widely accepted method in the field of traffic safety (18, 19, 20). The method is the basis of the safety analysis and science-based, predictive models introduced within the 2010 Highway Safety Manual of the American Association of State Highway Official (18). The negative binomial distribution is established by researchers as an accurate description of yearly crash variation between sites and was previously used to model and evaluate various transportation safety projects (18, 20). The correction for regression to the mean and the use of a negative binomial distribution are strengths of the EB method.

The empirical bayes method is used to estimate the number of crashes before the site change (i.e., before the introduction of digital technology). These "before" estimates are then used to predict the number of crashes that could be expected to occur at a certain location, during a specified year, without the introduction of digital technology.

The change in safety at a location is given as:

$$\Delta\, safety = B - A$$

where $\Delta\, safety$ is the change in the number of crashes, B is the expected number of crashes in the after period without the introduction of digital technology, and A is the actual number of crashes reported in the after period. After identifying digital locations, a statistical crash estimate model (CEM) is developed. The CEM model is a multivariate, regression model used to estimate the mean and variance of the annual number of crashes that could be expected at each location. Various multivariate models were tested through an iterative process by fitting the available traits. The analysis uses a negative binomial distribution by fitting a generalized, linear model to the data by maximum likelihood estimation of the parameter vector, B. The p-value is used as an indicator of the significance of the individual traits. The traits that produced a statistically sound model include the annual average daily traffic (AADT) for the location. The resulting CEM is then:

$$P = \alpha_{\lambda}(AADT)^{\beta_1}\,(LANE)^{\beta_2}(Speed)^{\beta_3}$$

The model parameters and the over-dispersion parameter (theta) are then calculated. The over-dispersion parameter is a measure of the extra variation in the negative binomial distributions compared to a traditional Poisson distribution; this parameter is commonly used in the calculation of the variance, or

$$variance = mean * \left(1 + \frac{mean}{\phi}\right)$$

Using the model, analyzed parameters and data, the expected number of crashes is estimated for each location, had there been no digital technology introduced. For each location, the first year for available data was used as a base year and a normalized mean number of crashes for each year, y is calculated as

$$C_y = \frac{P_y}{P_b}$$

Where, P_y and P_b are the predicted total number of crashes from the CEM for the year y and the base year, respectively for each location. The projection of the number of crashes is independent of the choice of the base year. The variance of the expected number of crashes, $Var(P)$ is calculated using the overdispersion parameter, as

$$Var(P) = (1 + \phi * P) * P$$

The relative weight, α, is calculated as

$$\alpha = \frac{P}{Var(P)}$$

Actual location crash counts, K, are then used to determine the EB estimate of mean and variance of the number of crashes for a site; EB and $Var(EB)$, respectively are:

$$EB = \alpha * P + (1 - \alpha) * K$$

$$Var(EB) = (1 - \alpha) * EB$$

The projection of the expected "after" treatment number of crashes is based on the weighted average of the EB estimates of number of crashes of all "before" treatment years for conversion to digital technology. The estimate of the baseline mean and the variance number of crashes, PC_b and $Var(PC_b)$ is determined as:

$$PC_b = \frac{\sum_{before} EB}{\sum_{before} C_y}$$

$$Var(PC_b) = \frac{\sum_{before} Var(EB)}{\left(\sum_{before} C_y\right)^2}$$

The projected number of crashes for the conversion locations in the "after" conversion period is calculated by multiplying the normalized number of crashes/year, C_y, by the baseline projected number of crashes, PC_b. The mean and variance of the projected crash count in the "after" conversion period for year, y, B and $Var(B)$, are calculated as

$$B = C_y * PC_b$$

$$Var(B) = C_y^2 * Var(PC_b)$$

The overall index of effectiveness, theta, is then calculated by comparing the total projected number of crashes (B) in the after period to the total actual number of crashes (A) in the after period as

$$\theta = \frac{\sum A}{\sum B}$$

The unbiased estimate, θ_u, is then

$$\theta_u = \frac{\theta}{1+\frac{\sum Var(B)}{(\sum B)^2}}$$

The percent change in total crashes due to the introduction of digital technology is

$$\Delta\, crashes\,(\%) = (1 - \theta_u) * 100$$

If the change of introducing digital technology causes crashes to be increased, then θ_u will be significantly larger than one and $\Delta\, crashes$ will be a negative value significantly lower than zero. This analysis is applied to the data at 77 locations representing the twenty digital locations and 57 comparison sites.

ANALYSES AND RESULTS

Figure 5 shows a comparison of the accident metrics for before and after conversions near all twenty digital billboards in the Greater Reading Area. The statistics are summarized for vicinity ranges of 0.1, 0.2, 0.3, 0.4, and 0.5 miles of the digital locations with 6, 8 and 10 second duration times. The metrics in Figure 5 include the total number of accidents, the average number of accidents in any given month, the peak number of accidents in any given month, etc. Other metrics shown in Figure 6, and including rates and vehicle-miles traveled, were also analyzed. For 6, 8 and 10 second-duration locations, the number of accidents and rates of accidents near the twenty, digital billboards decreased in all vicinity ranges. The benchmark, 0.5-mile vicinity experienced an 11.1% decrease in the number of accidents over the eight year span for all location; this includes 13.0% decrease in accident rates per million AADT vehicles. A statistical t-test is used to determine whether the average difference between the two, time periods is really significant or if it is due to random difference. Using a 95% confidence interval indicates no statistically significant difference in the accident statistics evaluated between conventional and digital billboards at these digital locations.

Separate results and distributions for 6-or-8-second-duration locations and 10-second-duration locations are discussed in the technical report of this research (13). For 6-or-8-second-duration locations, the number of accidents and rates of accidents near these twelve digital locations decreased in all vicinity ranges. The benchmark 0.5 mile vicinity experienced an 11.9% decrease in the number of accidents over the eight year span; this includes 12.2% decrease in accident rates per million AADT vehicles. For 10-second-duration locations, the number of accidents and rates of accidents near these eight digital locations decreased in all vicinity ranges. The benchmark 0.5 mile vicinity experienced a 10.4% decrease in the number of accidents over the eight year span; this includes 13.4% decrease in accident rates per million AADT vehicles. Similar decreases and trends in both averages and peaks were observed for both smaller and larger vicinity ranges.

		Vicinity Range from Digital Location (miles)				
		0.1	**0.2**	**0.3**	**0.4**	**0.5**
Prior to Installation	Total Number of Accidents for Equal Periods Before Conversion	203	501	693	872	1063
	Average Number of Accidents per Month at Each Location	0.31	0.76	1.06	1.33	1.62
	Rate of Accidents per Million Vehicles (by million AADT)	0.29	0.72	0.99	1.25	1.52
	Standard Deviation of Number of Accidents in any given month at locations	0.64	1.09	1.35	1.52	1.68
	Peak Number of Accidents in any given Month per Location	5	8	8	9	10
	Minimun Number of Accidents per Month per Location	0	0	0	0	0
	Average Number of Accident-Free Months at Locations	80%	58%	48%	40%	34%
As Digital Location	Total Number of Accidents for Equal Periods After Conversion	167	412	540	707	925
	Average Number of Accidents per Month at Each Location	0.25	0.63	0.82	1.08	1.41
	Rate of Accidents per Million Vehicles (by million AADT)	0.24	0.60	0.79	1.03	1.35
	Standard Deviation of Number of Accidents in any given month at locations	0.59	1.05	1.21	1.43	1.69
	Peak Number of Accidents in any given Month per Location	4	6	7	8	9
	Minimun Number of Accidents per Month	0	0	0	0	0
	Average Number of Accident-Free Months at Locations	84%	67%	59%	51%	43%
Comparison	Change in Number of Accidents	-36	-89	-153	-165	-138
	Change in Average per Month	-0.05	-0.14	-0.23	-0.25	-0.21
	Change in Rate per million vehicles (by million AADT)	-0.05	-0.11	-0.20	-0.21	-0.17
	Percent Change in Number of Accidents	-17.7%	-17.8%	-22.1%	-18.9%	-13.0%
	Percent Change in Rate of Accidents	-15.9%	-16.0%	-20.4%	-17.1%	-11.1%

Figure 5 - Summary Accident Statistics within Vicinity Ranges near Twenty Digital-Billboards Locations with 6, 8 and 10 second Duration Times in the Greater Reading Area

		Vicinity Range from Digital Location (miles)				
		0.1	0.2	0.3	0.4	0.5
Prior to Installation	Number of Accidents per million vehicles (by million AADT)	0.29	0.72	0.99	1.25	1.52
As Digital Location	Number of Accidents per million vehicles (by million AADT)	0.24	0.60	0.79	1.03	1.35
Comparison	Change in Rate per million vehicles (by million AADT)	-0.05	-0.11	-0.20	-0.21	-0.17
	Percent Change in Rate of Accidents	-15.9%	-16.0%	-20.4%	-17.1%	-11.1%

Figure 6 - Summary Accident Rates within Vicinity Ranges near Twenty Digital Billboards Locations with 6, 8 and 10 Second-duration Times between 2001 and 2009 for equal periods before and after at each location in the Greater Reading Area

The accident statistics were also analyzed to determine if the age of the drivers involved in the accidents near digital billboards was a factor. The data were specifically studied to determine if there are increases in the accident frequency of young drivers (under 17 and under 21) or elderly drivers (65 and older). Correlation coefficients were calculated and indicated a very strong correlation of accident patterns for age-of-driver factors.

The accident statistics are also analyzed to determine if the time of day of the accidents near digital billboards is a factor. The data were studied to determine if any increases in the accident rates during dawn, daylight, dusk and dark/nighttime conditions occurred. The daylight accident rate experienced an 8.9% decrease after conversion; the nighttime accident rate experienced an 11.7% decrease. Correlation coefficients were calculated and indicated a very strong correlation of accident patterns for time-of-day factors.

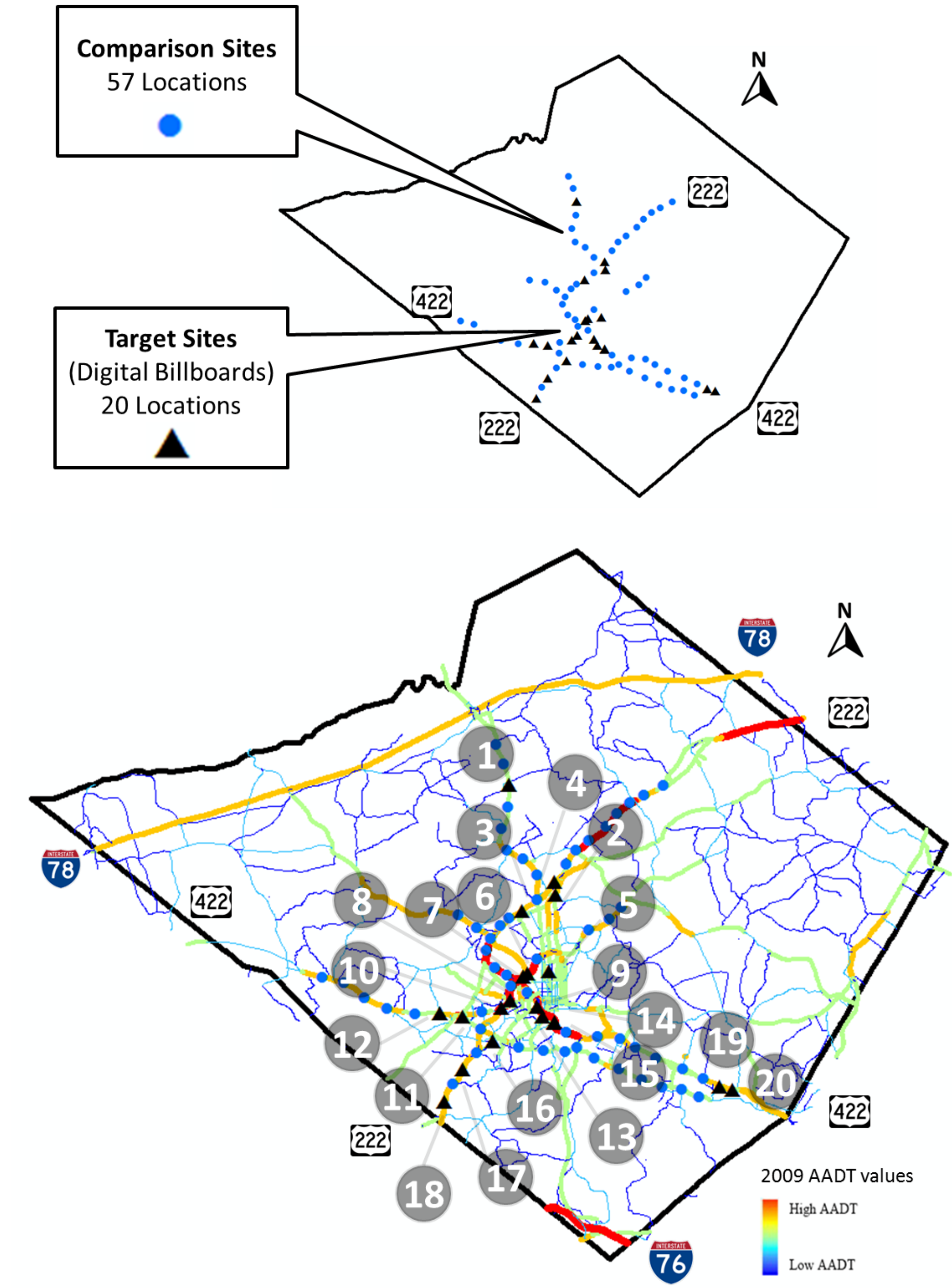

Figure 7 – Locations for 20 Target (Digital) and 57 Comparison (non-Digital) Locations in the Greater Reading Area that were studied as part of the Empirical Bayes Analyses (Top), Target and Comparison Locations mapped with 2009 AADT Values (Bottom)

The Empirical Bayes (EB) method is used to analyze available crash data for Berks County, Pennsylvania. The EB method is a rigorous method capable of estimating the safety impact of changes at a location. The EB method is well documented and used in numerous traffic-safety studies (18, 19, 20). Simply stated, the method estimates the number of crashes at a location that would have occurred without the introduction of digital billboards. The expected number of crashes as estimated by the Crash Estimation Model (CEM) and using the SAS statistical package and the parameters discussed in our methodology were computed. A multivariate, regression model was developed to estimate the mean of the expected number of crashes at a location. Our general CEM is shown in Figure 8 and models Average Annual Daily Traffic (AADT), Number of Lanes (Lane), and the posted Speed Limit (Speed) as independent variables; β_1, β_2 and β_3 are model parameters of the independent variables. The model is fit using the maximum likelihood method and includes 77 sites representing 20 digital billboard locations and 57 comparison sites. Figure 7 shows these locations. Figure 8 summarizes the CEM parameters using a maximum likelihood estimates for a multivariate regression model with negative binomial distribution. The CEM parameters are significant at α=0.05. The resulting CEM equation is also presented in Figure 8.

General CEM: $$P = (AADT)^{\beta_1} (LANE)^{\beta_2} (Speed)^{\beta_3} e^{\beta_0}$$

Explicit CEM: $$P = (AADT)^{0.1291} (LANE)^{0.2584} (Speed)^{-0.0231} e^{2.8671}$$

Variable		Coefficient	Standard Error	Chi-square statistic	Pr > Chi-square	Wald 90% confidence limits	
						Lower	Upper
Intercept		2.8671	0.2490	132.63	<.0001	2.3792	3.3551
AADT	β_1	0.1291	0.0157	67.27	<.0001	0.0982	0.1599
Lanes	β_2	0.2584	0.0757	11.66	0.0006	0.1101	0.4067
Speed	β_3	-0.0231	0.0040	33.76	<.0001	-0.0309	-0.0153
Dispersion	ϕ	0.5207	0.0329			0.4562	0.5852

Note: SAS Goodness of fit measures: deviance (value/d.f.) = 669.094 (1.0933); Pearson Chi-square (value/d.f.) = 712.7582 (1.1646); Number of observations = 616

Figure 8 - General and Explicit Crash Estimation Model (CEM) and CEM Model Parameters from SAS Output

The projected, total crash counts were estimated for the “after” periods to represent what the number of crashes would have been in future period without the introduction of digital billboards. These were compared with the crash data that actually occurred after the introduction of digital billboards at each location to determine the overall index of effectiveness. The statistical evaluation of the Empirical Bayes method and results show that the total number of accidents is approximately equivalent to what would be statistically expected with or without the introduction of digital technology and that the safety near these locations are consistent with the model benchmarked by 77 locations within Berks County.

The Empirical Bayes results in Figure 9 indicate a 0.87% (0.0087) difference between the “after” conversion crashes that occurred near the 20 digital locations and the statistically predicted Empirical Bayes mean estimate of those same locations had no digital billboards been installed. This comparison has a p-value less than 0.0001. The analysis of this data indicates that the actual and predicted means are almost statistically identical. A large sample size was used with 20 digital locations, 57 treatment or comparison sites with eight years of accident data. The statistical evaluation of the Empirical Bayes analysis shows that the total number of accidents is approximately equivalent to what would be statistically expected with or without the introduction of digital technology and that the safety near these locations are consistent with the model benchmarked by 77 locations within Berks County.

Parameter	**Value**
Total Crashes for the "After" Period with Digital Conversion (Actual Values)	925
Total Crashes for the "After" Period assuming no Digital Conversion ever occurred (Estimate by Empirical Bayes Method)	917
Overall Index of Effectiveness	1
Percent Change in Crashes between actual and estimate	-0.87%

Figure 9 - Results of the Empirical Bayes Estimation in Berks County with 20 digital locations, 57 treatment or comparison sites and with eight years of accident data

As a comparison study to this research, Tantala and Tantala (13) performed similar analyses of digital billboards in Henrico County and Richmond, Virginia. The Virginia study analyzes traffic and accident data along routes near 10 locations with 14 digital billboard faces with ten second duration times and includes more than seven years of accident data. A large sample size was used with 10 digital locations, 80 treatment or comparison sites with seven years of accident data. The Empirical Bayes Method results of the Richmond study indicate a 0.0142 (1.42%) difference between the “after” conversion crashes that occurred near the 10 digital locations and the statistically predicted Empirical Bayes mean estimate of those same locations had no digital billboards been installed. Accident statistics and metrics remain consistent near digital billboard locations and these studies examined the age of driver, daytime and nighttime accidents, various duration times and other comparisons. More detailed discussion, analysis and results are available in the technical reports of this research (13 and 14). Additional studies should be considered with other independent variables, consider for lower volume roads, other robust crash estimation models, and cross-comparison of results between digital.

CONCLUSIONS

The Greater Reading Area of Berks County, Pennsylvania, is a unique opportunity for this study about the statistical associations between digital billboards and traffic safety using robust data-sets and analyzing multiple locations for periods of as long as eight years. The overall conclusion is that these digital billboards in Reading have no statistically significant relationship with the occurrence of accidents. This conclusion is based on local Police and PennDOT data and an objective statistical analysis; the data show no statistically significant increase in accident rates. This study also finds that the duration time of 6, 8 or 10 seconds, the age of the driver (younger, older) and the time of day (nighttime, daytime) are neutral factors which show no increase in accident rates the near digital billboards along the local roads in the Greater Reading Area. The specific conclusions of this study indicate the following.

- The before and after rates of accidents near the twenty digital billboards show an 11.1% decrease within 0.5 miles of all digital billboards over eight years near twenty locations. Similar decreases and trends in both averages and peaks are observed for both smaller and larger vicinity ranges, and for specific groups of locations by duration time.

- The accident statistics and metrics remain consistent, exhibiting statistically insignificant variations at each of the digital billboards. The metrics include the total number of accidents in any given month, the average number of accidents, the peak number of accidents in any given month, and the number of accident-free months. These conclusions account for variations in traffic-volume and other metrics.

- The statistical evaluation of the Empirical Bayes method and actual versus predicted results show that the total number of accidents is comparable to what would be statistically expected with or without the introduction of digital technology and that the safety near this locations are consistent with the model benchmarked by 77 locations within Berks County.

This study also finds that the age of drivers (younger/elderly) and the time of day (daytime/nighttime) are neutral factors which show no significant increase in accident rates near the digital billboards. The results are consistent for the 6, 8 and 10 second duration times. These conclusions are based on the collected Police Department data and an objective statistical analysis.

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Driving Performance and Digital Billboards

FINAL REPORT

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ABSTRACT

The results of a naturalistic study showed that several driving performance measures in the presence of digital billboards are on a par with those associated with everyday driving, such as the on-premises signs located at businesses. These performance measures included eyeglance performance, speed maintenance, and lane keeping. The current study was conducted in Cleveland, OH following the model of a previous study conducted in Charlotte, NC (which showed no measurable effects of conventional billboards on eyeglance patterns, speed maintenance, or lane keeping). Thirty-six drivers drove an instrumented vehicle on a 50-mile loop route in the daytime along some of the interstates and surface streets in Cleveland. Participants were not informed about the true purpose of the experiment, and were told that the purpose was to help understand the way people drive in a natural environment. Along the route, participants encountered five digital billboards, 15 conventional billboards, 12 comparison sites (similar to items you might encounter in everyday driving), and 12 baseline sites (sites with no signs). Twelve participants returned for a nighttime session to explore the potential effects of the digital billboards at night.

The eight seconds leading up to the events of interest were then analyzed in terms of eyeglance patterns, speed maintenance behavior, and lane keeping behavior. In a post-drive questionnaire, 42% of drivers mentioned billboards as one of the top five items that caught their attention (out of 18 choices). Eyeglance results showed that there were no differences in the overall glance patterns (percent eyes-on-road and overall number of glances) between event types. Drivers also did not glance more frequently in the direction of digital billboards than in the direction of other event types, but drivers did take longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites. However, the mean glance length towards the digital billboards was less than one second. Various researchers have proposed that glance lengths of 1.6 seconds, 2.0 seconds, and longer may pose a safety hazard. An examination of longer individual glances showed no differences in distribution of longer glances between the four event types. There were only minor differences in speed maintenance or lane keeping performance for the four event types.

The overall conclusion, supported by both the eyeglance results and the questionnaire results, is that the digital billboards seem to attract more attention than the conventional billboards and baseline sites. Because of the lack of crash causation data, no conclusions can be drawn regarding the ultimate safety of digital billboards. Although there are measurable changes in driver performance in the presence of digital billboards, in many cases these differences are on a par with those associated with everyday driving, such as the on-premises signs located at businesses.

EXECUTIVE SUMMARY

The most notable findings from this study are as follows:

- Eyeglance results showed that there were no differences in the overall glance patterns between digital billboards, conventional billboards, comparison events, and baseline events during the daytime.
- Drivers did not glance more frequently in the direction of digital billboards than in the direction of other event types during the daytime.
- Drivers took longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites during the daytime.
- An analysis of glances lasting longer than 1.6 seconds indicated that these longer glances were distributed evenly across the digital billboards, conventional billboards, comparison events, and baseline events during the daytime
- The nighttime results indicate that digital billboards and comparison events may be associated with more active glance patterns, as well as with more frequent and longer glances towards the digital billboards and comparison events.
- For the post-drive questionnaire, 42% of drivers mentioned billboards as one of the top five items that caught their attention; note that drivers did not know this was billboard study.
- In an open-ended question, three drivers mentioned billboards as the single most memorable item on the trip, and two referred specifically to the digital billboards as being memorable.

The motivation for the current study was to examine driver performance in the presence of digital billboards, as compared to other driving locations without them. There is a long history of studying billboards in the context of traffic safety but, although the research record covers many years (1951 until the present), it is lacking in volume and is primarily focused on conventional billboards. There were a few epidemiological studies performed in the early 1950's examining traffic accidents in the presence and absence of billboards; however, much of this early work was methodologically flawed. After a long gap in research, there were a few additional studies in the 1960's through the 1980's, none of which demonstrated that billboards are unsafe. More recent studies conducted in Canada have shown that there may be changes in driver behavior associated with video billboards (those with full motion), but those studies do not address the digital billboards of interest in the current study (with a static message that changes instantaneously without special effects).

Traffic accident analysis techniques have improved in recent years with the creation and maintenance of national crash databases. A careful examination of these databases shows that distraction caused by billboards fails to show up in any of the accident databases as an accident cause. Likewise, an examination of numerous driver distraction studies demonstrates that billboards fail to show up as a cause of driver distraction. The overall conclusion from all past research is that conventional billboards in general have not been shown to cause traffic accidents or change driver behavior. However, the question of whether digital billboards change driver behavior in some way cannot be answered by these previous studies; this is the motivation for the current study.

The current study was conducted in Cleveland, OH to assess the effects, if any, of digital billboards on driver behavior and performance. The study was conducted following the model of a previous study conducted in Charlotte, NC that showed no measurable effects of conventional billboards on eyeglance patterns, speed maintenance, or lane keeping. Thirty-six drivers were recruited with males and females equally represented; they were also equally divided by age (older: 50-75, younger: 18-35). Participants drove an instrumented vehicle on their own (without an experimenter in the vehicle) on a 50-mile loop route in the daytime along some of the interstates and surface streets in Cleveland. Participants were not informed about the true purpose of the experiment, and were told that the purpose was to help understand the way people drive in a natural environment. Along the route, participants encountered the following items:

- 5 digital billboards (all that were available on the route). The digital billboards were the standard bulletin size (14 ft x 48 ft) and the copy changed instantaneously every eight seconds (there were no special effects during the transition).
- 15 conventional billboards (similar to those studied in the Charlotte study).
- 12 comparison sites (similar to items you might encounter in everyday driving; comparable to digital billboards in terms of visual activity/attractiveness, including on-premises signs [some with digital elements], logo placards, landmark buildings, and murals).
- 12 baseline sites (sites with no signs).

After the drive, participants completed a questionnaire regarding which types of items and activities they had noticed along the route. Participants were paid a nominal amount for their participation. Twelve participants returned for a nighttime session to explore the potential effects of the digital billboards at night.

The eight seconds leading up to the events of interest were then analyzed in terms of eyeglance patterns, speed maintenance behavior, and lane keeping behavior. With 36 participants and 44 sites, there were 1,584 events available for analysis from approximately 63 hours of data collection. A small amount of data was lost due to cell phone use, sensor outages, sun angle, and vehicle stoppages, leaving 1,540 events for eyeglance analyses. Altogether, 124,740 video frames were analyzed and 10,073 individual glances were identified. The speed data were filtered to remove events as described above, and then further filtered to remove low speed events, leaving 1,494 events in this dataset, with 121,014 data points. The lane position dataset was further filtered to remove events indicating a possible lane change or lane position sensor failure (often due to poor lane markings). After filtering, there were 1,188 events remaining in the lane position dataset, with 96,228 data points.

In terms of demographics, the average age was 28 years for younger drivers and 59 years for older drivers. Most had completed high school, but few had attended college. All participants lived in the Cleveland area, and were familiar with at least some parts of the route. For the post-drive questionnaire, 42% of drivers mentioned billboards as one of the top five items that caught their attention (out of 18 choices). In a later open-ended question, three drivers mentioned billboards as the single most memorable item on the trip, and two referred specifically to the digital billboards as being memorable. By way of contrast, only 25% of drivers in the Charlotte study checked off billboards in their top five list (of 18 choices), and none mentioned billboards as being the most memorable aspect of the trip. Recall that drivers did not know that the purpose of the study was to examine performance in the presence of billboards; in fact, they did not know that the study had anything to do with billboards.

Eyeglance results showed that there were no differences in the overall glance patterns (percent eyes-on-road and overall number of glances) between event types (digital billboard, conventional billboard, comparison events, and baseline events). Drivers also did not glance more frequently in the direction of digital billboards than in the direction of other event types. However, drivers did take longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites. Given that three of the comparison sites had digital components, the similar eyeglance findings for these two event types are not surprising. An analysis of glances lasting longer than 1.6 seconds showed no obvious differences in the distribution of these longer glances across event types.

There were differences in speed maintenance, with conventional billboards showing greater variation in speed than digital billboards. However, this was thought to be the result of a road type interaction, given that all of the digital billboards were on interstates. When only interstate events were considered in the analysis, there were no significant differences in speed maintenance across event types. There was a trend towards poorer lane keeping performance for digital billboards and conventional billboards; however, this trend failed to reach significance.

A smaller exploratory study was also conducted at nighttime using a slightly shortened route. Given that the digital signs being studied were intrinsically illuminated, this was felt to be an important first step in determining whether there are driver performance differences in the presence of these signs under different levels of ambient illumination. Twelve drivers were used, again divided equally by age and gender. All of the nighttime drivers had previously driven the route during the daytime and were thus somewhat familiar with the route (so were unlikely to get lost or go off route). The nighttime study was exploratory in nature with fewer data points, so these data were examined descriptively rather than analyzed statistically (due to lack of statistical power).

Four eyeglance measures were examined for the nighttime data: eyes-on-road percent, overall glance frequency, mean glance duration in the direction of an event, and mean number of glances in the direction of an event. The eyes-on-road measure showed that digital billboards and comparison events tended to have less eyes-on-road time at nighttime than either baseline events or conventional billboards. The overall glance frequency was also higher in the presence of digital billboards and comparison events than in the presence of baseline events and conventional billboards. These two findings taken together show a more active glance pattern at nighttime in the presence of these two event types. The mean glance duration for glances in the direction of an event also showed higher values for digital billboards and comparison events. Finally, the mean number of glances in the direction of an event also showed digital billboards and comparison events as having higher values than either baseline events or conventional billboards. Taken together, these four findings indicate that digital billboards and comparison events *may* result in more active glance patterns overall, as well as more frequent and longer glances towards the digital billboards and comparison events at nighttime.

Two driving performance measures were examined for the nighttime data: standard deviation of speed and standard deviation of lane position. The standard deviation of speed appeared to be higher in the presence of both conventional and digital billboards than for baseline and comparison events. Lane keeping also showed a trend towards greater lane deviations in the presence of both digital billboards and conventional billboards.

The luminance values of many of the billboards, comparison events, and baseline events were also measured at nighttime. The digital billboards had noticeably higher luminance values than any of the other event types, even though their luminance was automatically reduced at night. This probably explains some of the driver performance findings in the presence of the digital billboards. The overall ranking of luminance by event (digital billboards were the highest, followed in order by comparison events, conventional billboards, and baseline events) closely mirrors the rankings of many of the performance measures for both daytime and nighttime, including eyeglance, speed maintenance, and lane keeping.

The overall conclusion, supported by both the eyeglance results and the questionnaire results, is that the digital billboards seem to attract more attention than the conventional billboards and baseline sites (as shown by a greater number of spontaneous comments regarding the digital billboards and by longer glances in the direction of the billboards). The comparison events, 25% of which included signs with digital components, showed very similar results to the digital billboards. Thus, there appears to be some aspect of the digital billboards and comparison events that holds the driver's attention, once the driver has glanced that way. This is most likely the result of the intrinsic lighting of these signs, which is noticeable even during the daytime. Drivers may also have maintained longer glances towards the digital billboards in the hopes of catching the next message (knowing that the message changes periodically). Although exploratory in nature, the nighttime results were very similar to the daytime results, with indications of degraded driving performance for digital billboards and comparison events.

These particular LED billboards were considered safety-neutral in their design and operation from a human factors perspective: they changed only once every eight seconds, they changed instantaneously with no special effects or video, they looked very much like conventional billboards, and their luminance was attenuated at night. It is thus quite likely that digital signs with video, movement, higher luminance, shorter on-message duration, longer transition times, and special effects would also be related to differences in driver behavior and performance. Because of the lack of crash causation data, no conclusions can be drawn regarding the ultimate safety of digital billboards. Although there are measurable changes in driver performance in the presence of digital billboards, in many cases these differences are on a par with those associated with everyday driving, such as the on-premises signs located at businesses. Conventional billboards were shown both in the current study and in the Charlotte study to be very similar to baseline and comparison events in terms of driver behavior and performance; thus, the design of digital billboards should be kept as similar as possible to conventional billboards.

INTRODUCTION

There is a long history of studying billboards in the context of traffic safety, but although the research record covers many years (1951 until the present), it is lacking in volume. There were a few epidemiological studies performed in the early 1950's examining traffic accidents in the presence and absence of billboards. As will be seen, much of this early work was methodologically flawed. After a long gap in research, there were a few additional studies in the 1960's through the 1980's, none of which demonstrated that billboards are unsafe. Traffic accident analysis techniques have improved in recent years with the creation and maintenance of national crash databases. A careful examination of these databases shows that distraction caused by billboards fails to show up in any of the accident databases as an accident cause. Likewise, an examination of numerous driver distraction studies demonstrates that billboards fail to show up as a cause of driver distraction. The lead author of this report recently participated on an expert panel charged with providing recommendations for a minimal data set to be included on police accident reports; billboards were never raised as a possible distraction or as an item that should be included on these accident reports.

As will be seen, there has been relatively little research on billboards and their effect on driver behavior, and little original research on digital billboards of the type discussed in this report. The current project was therefore undertaken to fill this research gap and to determine whether digital billboards do in fact cause a change in driver behavior as he/she passes a billboard location. Several measures of eyeglance location were used as primary measures of driver visual behavior. Additional measures of driver performance were included to provide further insight--these included speed variation and lane deviation. Drivers in this study used an instrumented vehicle, drove the route alone, and were uninformed as to the purpose of the study.

The report is organized as follows: a literature review, covering topics such as early accident analysis studies, sign conspicuity studies, and later safety and driver distraction studies; a methods section; a results section; conclusions; references; and supporting material contained in appendices.

REVIEW OF PREVIOUS RESEARCH

Early studies from the 1950's attempted to correlate the occurrence and frequency of accidents with the location of billboards or other roadway or roadside features. For example, a series of studies by the Minnesota Highway Department (Rykken, 1951) analyzed accident features in order to determine whether there was any direct relationship between accident frequency and type and several elements of roadway and roadside design, including advertising sign type and location. While a relationship between frequency of access points and accident occurrence was evident, no apparent relationship was found between accident occurrence and advertising sign type or location.

Rykken (1951) added that more accurate accident reports might reveal an unexpected relationship between signs and accidents: the absence of signs when no other roadside objects are present may increase the likelihood of accidents by decreasing the driver's sense of a need for caution. Immediately after 45 miles of highway with no billboards or advertising signs in viewable distance, a roadside interviewing station investigated driver response. Because drivers expressed a feeling of fatigue and unease after having driven the section, the author postulated that the combination of a small number of distracting features and the complete absence of billboards produced a feeling of security, which tends to result in higher average driving speed. Several severe accidents that occurred over that stretch were attributed to excessive speed.

McMonagle, a researcher with the Michigan State Highway Department, analyzed 2,675 accidents on a 70-mile strip of highway from 1947 to 1948 in order to measure the relationship between accidents and highway design and roadside features (McMonagle, 1951). The strip of road included a variety of roadside features and design characteristics, including the number of lanes and traffic volume. Findings showed that the highest incidence of crashes occurred near intersections, particularly when gas stations, restaurants and other establishments were clustered nearby. Only a slight association (correlation coefficient .11) existed between large advertising signs and accidents. While total advertising signs correlated with accident frequency to a greater degree (correlation coefficient .41), advertising signs still contributed less to accident frequency than did groupings of design features or roadside features such as gas stations.

In an attempt to correlate accident frequency with density of advertising and roadside business, Rusch (1951) analyzed crash reports originating in 1947 and 1948 that examined sections of highway distributed across Iowa. The accidents were assigned one of three causes: 1) roadside business, 2) inattention or misdirected attention, or 3) "other causes." Roadside business was listed as the cause of an accident only if the business was specifically named in the accident report, as in the case of a vehicle exiting a gas station and being struck by oncoming traffic. Results showed that twice as many collisions occurred on the portions of road in the high-density category than occurred on the other parts of the test stretches put together. More accidents were attributed to inattention than to any other cause in the high-density category. In the low-density category, more accidents were attributable to miscellaneous causes than to business and inattention combined. Sections of highway in the low-density category showed lower accident rates than those in the high-density category, even when traffic volume was held constant. In addition, accidents on low-density stretches occurred more sporadically with less of a tendency to recur in the same locations the following year. In reference to this study, Andreassen (1985) later claimed that “the greatest number of inattention accidents occurred on the sections where business and advertising predominated as the roadside property usage, but this does not prove anything about the effect of advertising signs on accident occurrence.”

Overall, these early studies provided some initial insight into accident causation, but did not demonstrate that billboards or other advertising signs were a possible cause of accidents. Intersections and high-density roadways combined with inattention were most commonly associated with an increased number of accidents. Interestingly, later analysts using modern statistical techniques critiqued these early studies as being methodologically flawed (e.g., Wachtel and Netherton, 1980; Andreassen, 1985).

A critical research review sponsored by the Federal Highway Administration (FHWA; Wachtel and Netherton, 1980) summarized knowledge concerning commercial electronic variable-message signage (CEVMS) in an effort to recommend national standards for their regulation. Because there was little research available in the area of CEVMS, their literature review focused on standard (conventional) billboards. Wachtel and Netherton (1980) opined that roadside advertising research based on accident studies has had limited value owing to either insufficient information concerning location and traffic or problems with statistical analysis and sampling error. While some studies have found positive relationships between outdoor advertising and accident frequency, others have arrived at the opposite conclusion.

According to Wachtel and Netherton (1980), human factors laboratory research techniques are capable of gathering much more precise, reliable, and valid data in the attempt to measure and explain the effect of outdoor advertising on driver behavior. Literature from several related fields indicated that outdoor advertising probably does not hurt driving performance noticeably when driving conditions are favorable (in terms of weather, traffic, road, vehicle, etc.). This is because the driver has sufficient spare processing capacity to pay attention to the signs without compromising the primary task. When stimulation is extremely low, as when there is very little traffic and very little to look at or to decide, unusual environmental features such as road signs may increase the driver’s arousal and improve driving performance. When the driving task becomes highly demanding, the outdoor advertising must compete with more vital information sources such as traffic, weather, and official signage.

In a review of published literature relating accidents to advertising signs, Andreassen (1985) brought attention to weaknesses in the small amount of research that has been conducted in this area. Almost all studies have relied on correlations and/or subjectively assigned “inattention” factors, which can only produce very tenuous evidence for a causal link between advertising and accident frequency.

Garvey, Thompson-Kuhn, and Pietrucha (1995) reviewed the studies that attempted to evaluate directly the relationship between traffic accidents and advertising signs. The common problem with these studies is attributing accident causation; high-advertising and low-advertising sites may have different accident frequencies because of differing traffic densities, pedestrian activity, and roadway geometry. Although most evidence argues against a strong causative link, it is still not possible to ascertain the existence or nature of the relationship between advertising and accidents.

Recently, much attention has been focused on the causes and effects of distraction on driving, especially in the area of cellular phones and other in-vehicle technology. A review of the recent driver distraction literature failed to reveal any studies in which outdoor advertising was mentioned as a cause for driver distraction. As a matter of fact, this report's lead author recently served on the advisory panel for the revised Model Minimum Uniform Crash Criteria in which transportation safety experts recommended revisions to the minimum set of data to be collected as part of every crash report. There were lengthy discussions over which distraction variables should be recommended, and the words "billboard" or "advertising" were never mentioned.

The national crash databases do not mention billboards in their list of driver distractions. The two most prominent databases are the General Estimates System (GES), which estimates the number of all crashes based on a representative sample, and the Fatal Accident Reporting System (FARS), which is a true census of every fatal crash. The only mention of billboards in the 216 page user's manual for the GES database is in the Driver's Vision Obscured By variable, which has a category of Building, Billboard, or Other Design Features (GES, 2002). In other words, if an accident was caused by a driver's vision being obscured, billboards would be lumped together with buildings and other design features, both of which are much more common than billboards. The same holds true for the FARS user's manual of 458 pages – billboards are only mentioned in the Driver's Vision Obscured By variable, and are lumped together with buildings (Tessmer, 2002).

One recent study of driver distraction (Glaze and Ellis, 2003) reported one mention of the word "billboard" in the context of an accident caused by driver distraction. Glaze and Ellis performed a study to determine the nature of distraction/inattention crashes in the state of Virginia. A complex system of accident report sampling was administered via surveys sent to all seven Virginia state police divisions, four selected counties, and 14 independent cities. Roughly 2,800 crash scenes were reported, involving a total of almost 4,500 drivers. At least one distracted driver was involved in 98% of those crashes. Every accident report had a space to write an open-ended description of the main distracting factor in the accident, and over 1,400 responses were recorded. One response (out of 2,800 crashes) included a billboard being repaired as a causal factor for driver distraction leading to a crash. No mention of outdoor advertising was made in any other place in the study, despite the fact that 35% of distracters were outside of the vehicle in question (62% were in-vehicle and 3% were unknown). Typical in-vehicle distracters included passenger/children distraction (8.7%), adjusting radio/changing CD or tape (6.5%), eating or drinking (4.2%), and cell phone (3.9%). Typical out of vehicle distracters included looking at crash, other roadside incident, or traffic (13.1%), looking at scenery or landmarks (9.8%), and weather conditions (1.9%). There were also 25 cases of drivers being distracted by traffic signs or signals (<1%).

Tantala and Tantala (2005) have been the most recent researchers to attempt a rigorous examination of the relationship between advertising signs and traffic accidents. They used methods intended to control for the analytical issues noted with early studies of this type. They conducted two analyses for this research. In the first situation, a highway (New Jersey Turnpike) with advertising signs was selected and studied, including analysis of sign location, road conditions, and traffic-accident locations, to determine whether traffic accidents were more prevalent at or near existing signs. More than four years of data and 23,000 accidents were used in this analysis. Statistical correlation coefficients showed that the correlation was statistically low for all analyses conducted, including accident density and sign density (with and without interchanges included), accident distance and viewer reaction distance (again with and without interchanges included), and accident density and proximity to the sign. They also found that these correlation values were consistent from year to year. This section of the analysis led them to conclude that there are no statistical or causal relationships between advertising signs and accidents.

In the second analysis by Tantala and Tantala (2005), the location of a recently installed sign was identified, and the incidence of traffic accidents near the sign was examined. Accidents before and after sign installation were examined to determine whether traffic accidents occurred more frequently in the presence of the sign. The sign was installed at a busy intersection near a mall in Pennsylvania. The intersection was controlled by a traffic signal. One year of pre-installation and one year of post-installation data were compared. There were no other changes to the intersection during the two year study period. After installation of the sign, the traffic volume increased, the accident rate decreased, the maximum number of accidents in any given day or week decreased, and the number of days without accidents increased. There were no statistically significant changes in accident occurrences after the installation of the advertising sign.

Researchers are beginning to conduct more studies of driver performance in the presence of various types of advertising signs. For example, Beijer, Smiley, and Eizenman (2004) studied video advertising signs (those with full motion displays) in Toronto using eyeglance analysis similar to that used in the Charlotte study. They compared the video signs to two other types of active signs (scrolling text and roller bar) and to conventional billboards. Significantly more glances, and even more importantly, significantly more glances that lasted $\geq$ 0.75 s were made to video signs than to scrolling text, roller bar, or conventional billboard signs. Taking all active signs together, these received significantly more glances and significantly more long glances per sign than the conventional billboards. However, there were no digital billboards of the type studied in the current research effort.

The most recent research paper in this area was conducted by Crundall, Van Loon, and Underwood (2006). They conducted a laboratory study to examine the differences between street level advertising (such as advertising on bus shelters) and raised level advertising (the same sorts of signs, but raised 10 ft above the ground). They concluded that street level advertisements attract and hold attention at inappropriate times as compared to raised level advertising. Since the billboards studied in the current report were never at ground level, this paper provided no new useful information.

It should be noted that the Virginia Tech Transportation Institute (VTTI) undertook another project for the Foundation for Outdoor Advertising Research and Education (FOARE) (Lee, Olsen, and DeHart, 2004). This project was undertaken in Charlotte, NC using methods similar to those used in the current study to determine whether there is any change in driving behavior in the presence or absence of conventional billboards. Several measures of eyeglance location were used as primary measures of driver visual performance. Additional measures were included to provide further insight into driving performance; these included speed variation and lane deviation. The overall conclusion from this study was that there is no measurable evidence that billboards cause changes in driver behavior in terms of visual behavior, speed maintenance, and lane keeping. A rigorous examination of individual billboards that could be considered to be the most visually attention-getting demonstrated no measurable relationship between glance location and billboard location. Driving performance measures in the presence of these specific billboards generally showed less speed variation and lane deviation.

Participants in this study drove a vehicle equipped with cameras in order to capture the forward view and two views of the driver's face and eyes. The vehicle was also equipped with a data collection system that would capture vehicle information such as speed, lane deviation, Global Positioning System (GPS) location, and other measures of driving performance. Thirty-six drivers participated in the study, driving a 35-mile loop route in Charlotte, NC. A total of 30 billboard sites along the route were selected, along with six comparison sites and six baseline sites. Several measures were used to examine driving performance during the seven seconds preceding the billboard or other type of site. These included measures of driver visual performance (forward, left, and right glances) and measures of driving performance (lane deviation and speed variation).

With 36 participants and 42 sites, there were 1,512 events available for analysis. A small amount of data was lost due to sensor outages, sun angle, and lane changes, leaving 1,481 events for eyeglance analysis and 1,394 events for speed and lane position analysis. Altogether, 103,670 video frames were analyzed and 10,895 glances were identified. There were 97,580 data points in the speed and lane position data set.

The visual performance results indicate that billboards do not differ measurably from comparison sites such as logo boards, on-premises advertisements, and other roadside items. No measurable differences were found for visual behavior in terms of side of road, age, or familiarity, while there was one difference for gender. Not surprisingly, there were significant differences for road type, with surface streets showing a more active glance pattern than interstates. There were also no measurable differences in speed variability or lane deviation in the presence of billboards as compared to baseline or comparison sites. An analysis of specific, high attention-getting billboards showed that some sites show a more active glance pattern than other sites, but the glance locations did not necessarily correspond to the side of the road where the billboards were situated. Taken as a whole, the results of the previous research conducted for FOARE support the overall conclusion that driving performance does not change measurably in the presence or absence of billboards.

The only currently available research report related to electronic billboards is a literature review sponsored by the FHWA (Farbry, Wochinger, Shafer, Owens, and Nedzesky, 2001). The motivation for this report was to fill the knowledge gap in this area since the last attempt by Wachtel and Netherton in 1980. However, the material does not appear to address the instantaneously changing digital billboards of the type discussed in the current report. Examples shown pictorially in Farbry et al. (2001) are signs with changeable elements (such as time and temperature signs), tri-vision signs, and video digital billboards of the type studied by Beijer et al. (2004). Farbry et al. (2001) raised questions about safety implications with regard to driver distraction, summarized current knowledge in this research field, assessed areas needing exploration, and developed a research plan to address them. While some electronic billboards (EBBs) display motion and color with fine detail, others just show a short sequence of words in which each letter is composed of a matrix of LEDs (Farbry et al., 2001). This type of display is also used by governmental agencies to present information to drivers and is known by several different acronyms: variable message sign (VMS); dynamic message sign (DMS); and changeable message sign (CMS). A tri-panel sign, also known as a tri-vision sign, is composed of triangular cylinders that rotate periodically, showing a different composite image in between each rotation. The only movement is that of the images in transition.

Studies attempting to draw causality from correlation between dynamic billboards and accident frequency run into the same difficulties found by studies investigating conventional billboards and accidents (Farbry et al., 2001). Common obstacles include consistently confounding traffic conditions in areas with heavy advertising, incomplete or inaccurate accident reports, and driver motivation to omit distraction when reporting crash causality. Even given these stumbling blocks, the correlation is still statistically clear: after a *dynamic*, illuminated billboard is installed, crash rates go up. A common trend was exemplified when a 35% increase in sideswipe and rear-end accidents on an interstate occurred after a variable message advertising sign was put up on the side of a sports stadium. The correlation, while rarely this dramatic, is a consistent one. However, even a correlation this strong is not sufficient evidence to assume causality. Enough other variables were held to be confounding the situation that the sports stadium sign was not deemed a traffic hazard in and of itself, and it remained in place for 16 years.

Farbry et al. (2001) caution that correlations alone provide little fodder for the development of countermeasures. Researchers hypothesize that a safety hazard is posed by dynamic advertising because it may cause greater distraction, which can be measured in several formal ways. One common method is to ask the driver to perform another task while driving, then to measure the degree to which the safe operation or control of the vehicle is affected. Lack of control is typically quantified by one of three measures: lateral deviation, maintenance of appropriate speed, and/or braking for emergencies. Lateral deviation is defined as either the degree to which the vehicle swerves away from the center of the appropriate lane or a measure of the variability in steering wheel position. Maintenance of appropriate speed refers to the headway between the vehicle and the vehicle ahead; if the lead vehicle slows down, the participant vehicle should also slow down and maintain an appropriate speed to keep the headway constant. Some experiments present an emergency and measure distraction by the amount of time it takes the participant to respond appropriately.

The literature review by Farbry et al. (2001) also revealed that the two demographic groups most susceptible to the dangers of distraction while driving are drivers over the age of 65 or under the age of 24. Older drivers' visual processing speed and attention degrade with age, resulting in little to no spare resources with which to encode and process anything but the most important information in the driving environment. Younger drivers usually have faster processing speeds, but they are less experienced and less efficient at resource allocation. Among other weaknesses, younger drivers take more risks, may not recognize hazards, and have poor focus on the driving task itself. Because of this, they may be more vulnerable to having their attention drawn by irrelevant but attention-getting stimuli.

Other than age, a variable that may influence the degree to which a sign distracts a driver is route familiarity (Farbry et al., 2001). A driver who is new to a road may be looking for navigational or service cues, and this task may be take longer in a more complex visual environment containing numerous advertising signs. On the same road, a familiar driver may not look around much since he already has all of the information that he needs. Familiar signs may be less likely to attract the attention of a driver who knows the roadway well and whose primary navigational interests may be traffic conditions and incidents. According to this theory, a visitor would be more likely to be distracted by an advertising sign than would a commuter.

Research regarding distraction, conspicuity, and legibility revealed that an increase in distraction, a decrease in conspicuity, or a decrease in the legibility of a sign may cause an increase in the crash rate (Farbry et al., 2001). The review shows that, at this point, there is no effective technique for evaluating safety effects of EBBs on driver attention or distraction. Crash studies may show a positive correlation between dynamic signs and crash rates, but driver age and route familiarity are examples of confounding variables whose interference may hide the fact that very little causality can be proven.

The final recommendation of the Farbry et al. (2001) report is for further research in this area. They recommend research using several methods, including crash analysis of the sort conducted by Tantala and Tantala (2005), simulator research, test track research, and field studies. Simulator and test track research both have limitations with regard to sign research, especially in regard to digital billboards. For example, it can be difficult to achieve the visual effect of an internally illuminated sign in a simulator. For test tracks, only a limited amount of driving performance data could be obtained, which would likely not be worth the expense of installing a digital billboard on the test track. However, both test track and simulator research are more appropriate for highly controlled experiments in which the goal is to obtain information about the design and content of the billboard copy, the timing of the change, and other design elements. If the goal is to evaluate driver performance and behavior in the presence of digital billboards that occur in the natural course of driving, then a field study is the appropriate technique, and this was the technique selected for the current study.

The overall conclusion from all past research is that conventional billboards in general have not been shown to cause traffic accidents or change driver behavior. However, the question of whether digital billboards change driver behavior in some way cannot be answered by these previous studies; this is the motivation for the current study.

METHOD

Selection of City

Both Pittsburgh, PA and Cleveland, OH were scouted as possible locations for conducting this study. The Pittsburgh streets where the digital billboards were located were generally very curvy and hilly, often with nearby intersections. The digital billboards were often situated at the bottom of a hill, at a curve, or just beyond an intersection. It would have thus been difficult to conduct meaningful eyeglance and speed analyses under these conditions (i.e., the signs were situated in most cases such that the driver had to look straight forward to see the signs). The Cleveland digital billboards, on the other hand, were located off to the side of the roadway in straight-away sections of interstate with no interference from hills, curves, or intersections. It was thus apparent that choice of Cleveland would allow for a more robust analysis with fewer dropped data points.

Digital Billboards

The item of interest in this study was digital Billboards. These billboards are illuminated from within via a matrix of LEDs. These devices are capable of displaying several messages in a rotation. The digital billboards are also capable of video and special transition effects (such as fades or wipes from one message to the next). However, the digital billboards used in this study simply transitioned from one message to the next in less than one second, using no transition special effects or video; in other words, there was no motion or apparent motion used in displaying the messages or transitioning between them. Messages changed once every eight seconds. The billboards appeared very similar to conventional billboards, except that the copy was crisper and easier to read from a distance even during the daytime, likely due to the intrinsic lighting. The lighting level was automatically dimmed at night to adjust to the ambient lighting level. Light measurements taken at night are presented in a different section of the report.

Experimental Design

This study was conducted as a mixed-factors research design (a 2 x 2 x 2 x 2 x 4 design, with four between-subjects cells). There were five independent variables: gender, age, route familiarity (determined post-hoc, so not balanced across subjects), event type, and road type. The between-subjects independent variables were gender (male or female) and age (younger or older). For the within-subjects variables, the levels were as follows: route familiarity (familiar or unfamiliar, defined later), event type (digital billboard, conventional billboard, baseline, and comparison, also defined later), and road type (interstate or surface roads). All of the participants drove each of the segments and were exposed to all of the billboards and comparison sites. A representation of the experimental design is included in Figure 1.

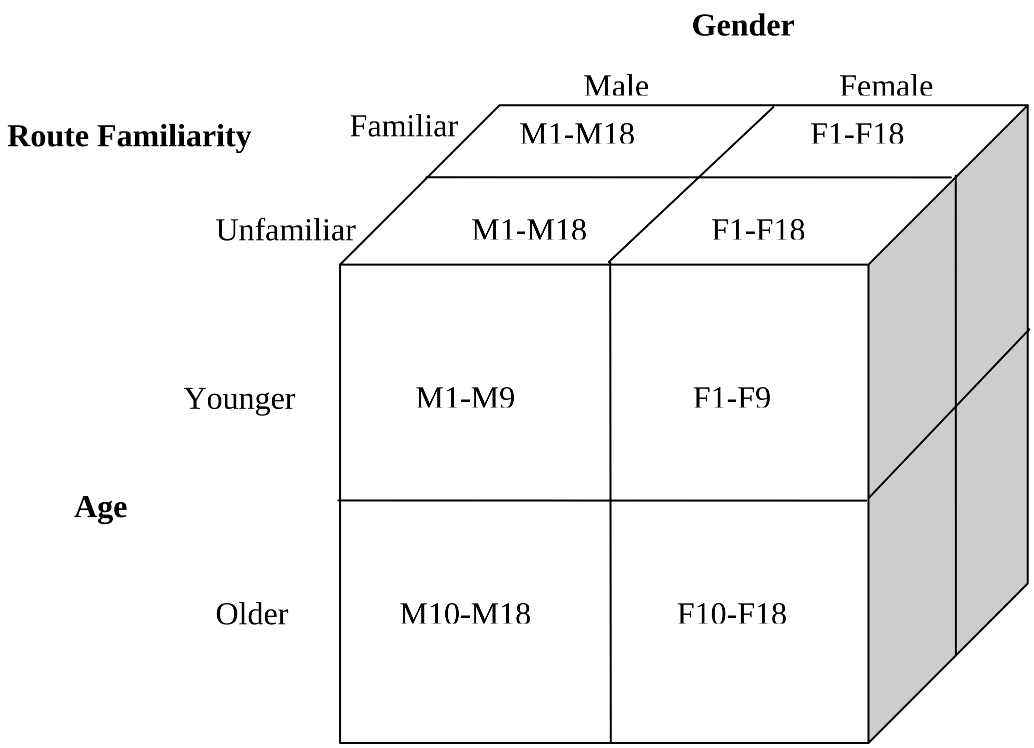

Figure 1. Assignment of Participants to Experimental Conditions.

Independent Variables

The five independent variables are listed in Table 1.

Table 1. Independent Variables.

Independent Variable	Levels
Age	Younger (18-35) or Older (50-75)
Gender	Male or Female
Route Familiarity	Unfamiliar or Familiar (familiarity with at least 4 segments determined for each subject)
Event Type	Digital Billboard, Conventional Billboard, Baseline (no billboards or other large signs) or Comparison (other signs or landmarks)
Road Type	Interstate or Surface Street

Age and Gender. Of the 36 participants, eighteen were younger drivers (18 to 35 years old) and eighteen were older drivers (50 to 75 years old). Eighteen of the participants were male and eighteen were female. Age was equally balanced across gender, as is illustrated by Figure 1 (e.g., of the 18 younger participants, 9 were male and 9 were female).

Route Familiarity. Route familiarity referred to how often a section was normally driven by the participant per week (unfamiliar = drove section less than once per week; familiar = drove section at least once per week). Route familiarity was ascertained after the drive by asking participants how familiar they were with the various segments they had just driven. Thus, this variable was not balanced across the participant population.

Road Type. The two road types were interstates and surface roads. All of the participants were exposed to both road types. Approximately 85% of the route consisted of interstate segments, with the remainder being classified as surface streets.

Event Type. The four event types included digital Billboard, Conventional Billboard, Comparison, and Baseline. All of the participants were exposed to all four event types. Events were 8 seconds long (chosen because the digital billboards were programmed to change messages instantaneously once every 8 seconds; an event length of 8 seconds thus made it highly likely that a message change would be captured during the event). The end of an event was the point at which the experimental vehicle passed the object, and the start of the event was then defined as 8 seconds before the end point. All events on the route are listed and described in Table 2.

<u>Digital Billboards.</u> Five digital billboards were included along the driving route. Displays on the billboards changed instantaneously (i.e., no special effects such as fades, wipes, or shuttering occurred when the message changed) every 8 seconds; the signs followed standards for color, brightness, and placement. These five locations are shown in Figure 2 with the black dots (●).

<u>Conventional Billboards.</u> Conventional billboard events were defined as areas in which designated billboards were visible. These were identified by GPS coordinates (latitude and longitude) associated with their exact location near the roadway. Most of the billboards were the bulletin size, 14 ft (h) by 48 ft (w). Of the total set of billboards available on the route, a sample of 15 billboards was selected for efficiency of data reduction and to ensure a balanced sample. The sample was selected so that it was balanced in terms of side of the road, media type, road type, and (where possible) varying degrees of "visual clutter." None of the selected boards were located directly prior to or after a road exit or entry (preliminary review of the video indicated that drivers were likely to be changing lanes or monitoring items such as road signs during these times, which could confound the results of the analysis). Each side of the road was equally represented to the degree possible, and most of the digital and conventional billboards were 14 ft x 48 ft bulletins. The remaining few were smaller boards, including standard poster, junior paint, and 10'6" x 36' bulletins. Table 3 lists the selected billboards, while the locations of the selected billboards are indicated by red dots (●) in Figure 2.

<u>Comparison Sites</u>. Comparison events were areas with visual elements other than billboards. Examples include on-premise signs, logo placards, interesting landmark buildings, large wall murals, and variable message signs. Several events had digital components. The events were chosen before data collection began and were selected based on the experimenters' perception that these vents were comparable to the digital billboards in the visual attractiveness. These 12 sites are shown as aqua blue dots (●) in Figure 2.

<u>Baseline events.</u> The baseline event type referred to areas with no billboards or other large signs visible (except for perhaps speed limit and other small traffic control signs). These 12 areas

served as locations with which to compare velocity, lane position, and glance patterns and are indicated by blue dots (●) in Figure 2.

Table 2. Event Types Indicating Description, Side of the Road, Latitude, Longitude, and Specific Site Location Information.

	Event Type	Description	Side	Latitude	Longitude	Site	Road Type
1	4	Baseline	Both	41.41208267	-81.6701355	480 W, W/O Lancaster Dr.	I
2	2	Static Billboard	Left	41.42123795	-81.69820404	480 W, W/O Broadview Rd.	I
3	3	On Prem/Logo	Right	41.42151642	-81.70906067	480 W, E/O State Rd.	I
4	2	Static Billboard	Left	41.42173767	-81.71897125	480 W, E/O Pearl Rd.	I
5	4	Baseline	Both	41.42321014	-81.74341583	480 W, W/O Ridge Rd.	I
6	2	Static Billboard	Left	41.42559433	-81.76654053	480 W, W/O Tiedeman Rd.	I
7	2	Static Billboard	Right	41.42352295	-81.77274323	480 W, E/O W. 130th St.	I
8	1	LED Billboard	Left	41.42056274	-81.78245544	480 W, W/O W. 130th St.	I
9	3	On Prem/Logo	Left	41.42053986	-81.7904892	480 W, @ W. 139th St.	I
10	2	Static Billboard	Left	41.42324829	-81.80148315	4866 West 150th	S
11	4	Baseline	Both	41.4307785	-81.80125427	4545 West 150th	S
12	2	Static Billboard	Left	41.43348694	-81.79000854	13986 Puritas Ave	S
13	4	Baseline	Both	41.43657303	-81.78400421	13456 Bellaire Rd	S
14	3	On Prem/Logo	Left	41.43969727	-81.77674103	12686 Bellaire Rd	S
15	3	Tri-Vision Billboard	Right	41.44282913	-81.77227783	12071Bellaire Rd	S
16	4	Baseline	Both	41.45092773	-81.76893616	3757 West 117th	S
17	2	Static Billboard	Left	41.46089554	-81.76893616	3370 West 117th	S
18	4	Baseline	Both	41.46966553	-81.75019836	90 E, @ W. 97th St.	I
19	1	LED Billboard	Right	41.47394943	-81.72478485	90 E, @ W. 55th St.	I
20	2	Static Billboard	Left	41.47385406	-81.70856476	90 E, W/O Fulton Rd.	I
21	3	On Prem/Logo	Left	41.48424911	-81.69098663	90 E, S/O Abbey Ave.	I
22	1	LED Billboard	Right	41.4903717	-81.68776703	90 E, @ W. 3rd St.	I
23	3	On Prem LED Billboard	Left	41.49866867	-81.67558289	2071 Carnegie Ave.	S
24	3	On Prem/Logo	Left	41.49928284	-81.67251587	2351 Carnegie Ave.	S
25	3	On Prem LED Billboard	Left	41.52510452	-81.66101074	90 E, E/O E. 49th St.	I
26	3	Building	Right	41.53549194	-81.64455414	90 E, W/O E. 72nd St.	I
27	2	Static Billboard	Right	41.54089737	-81.62488556	90 E, W/O E. 99th St.	I
28	2	Static Billboard	Right	41.54464722	-81.61724854	90 E, W/O E. 105th St.	I
29	4	Baseline	Both	41.5479126	-81.60997009	90 E, @ E. 109th St.	I
30	3	On Prem/Logo	Right	41.55478668	-81.59642029	90 E, @ Coit Rd.	I
31	4	Baseline	Both	41.56173325	-81.59170532	90 E, W/O E. 140th St.	I
32	4	Baseline	Both	41.56638718	-81.57984161	90 E, W/O E. 152nd St.	I
33	2	Static Billboard	Right	41.57143021	-81.56455994	90 E, @ E. 167th St.	I
34	3	On Prem/Logo	Right	41.57068634	-81.56790924	90 W, @ E. 161st St.	I
35	4	Baseline	Both	41.56744385	-81.57712555	90 W, W/O E. 152nd St.	I
36	4	Baseline	Both	41.55927277	-81.59375763	90 W, W/O E. 140th St.	I
37	1	LED Billboard	Left	41.54701233	-81.61243439	90 W, W/O E. 105th St.	I
38	2	Static Billboard	Left	41.54128647	-81.62450409	90 W, W/O E. 99th St.	I
39	3	On Prem LED Billboard	Right	41.52567673	-81.66069031	90 W, W/O E. 55th St.	I
40	2	Static Billboard	Left	41.49006653	-81.66697693	77S, S/O Woodland Ave.	I
41	2	Static Billboard	Right	41.48295593	-81.66287231	77 S, @ I-490 Exit	I
42	1	LED Billboard	Right	41.46414566	-81.65770721	77 S, S/O Pershing Ave.	I
43	4	Baseline	Both	41.45179367	-81.65712738	77 S, N/O Harvard Ave. Exit	I
44	2	Static Billboard	Left	41.4439621	-81.65229797	77 S, N/O Grant Ave. Exit	I

Event Type: 1=LED Billboard, 2=Static Billboard, 3=Comparison, 4=Baseline
Road Type: I=Interstate, S=Surface Street

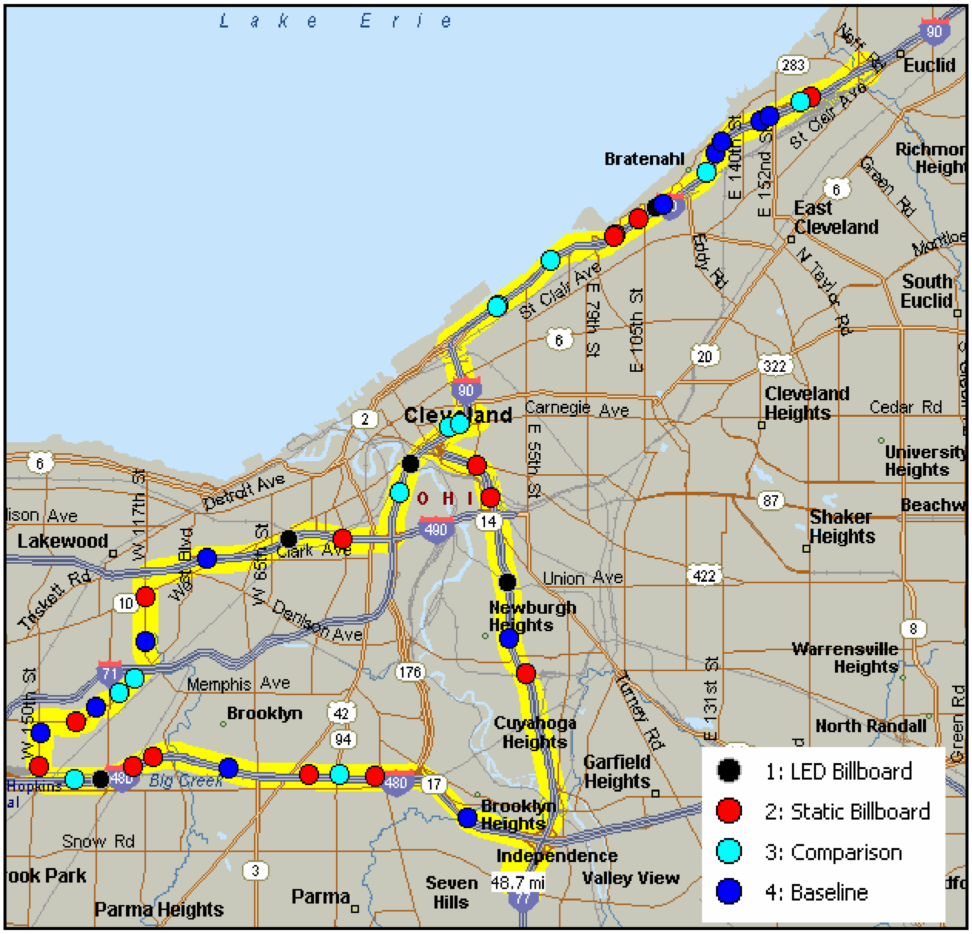

Figure 2. Map Illustrating Digital Billboards (black), Conventional Billboards (red), Comparison Sites (aqua blue), and Baseline Sites (blue).

Dependent Variables

The dependent variables are discussed in more detail in the results section, but they are reviewed briefly here. The purpose of the study was to determine if there are changes in driver behavior in the presence of billboards. Eleven dependent measures were used as indicators of driver behavior: nine eyeglance measures and two driving performance measures. The nine eyeglance measures included: total number of glances for center forward, left forward, and right forward; total glance duration for center forward, left forward, and right forward; and average glance duration for center forward, left forward, and right forward. Keep in mind that all glance locations reported here were out of the front windshield, but varied in location within the forward view. The two driving performance measures were speed deviation (standard deviation of speed over the 8 seconds of the event) and lane deviation (standard deviation of lane position over the 8 seconds of the event). Additional analyses examined driver glance behavior to certain other locations, including interior locations and exterior locations other than forward. The next section is a supplement to the literature review presented earlier, and lays the groundwork for the selection of these dependent variables, which are similar to those typically used in transportation safety research.

Selection of Dependent Variables Based on Previous Driving Studies

Measures of Visual Demand

According to Farber, Blanco, Foley, Curry, Greenburg, and Serafin (2000), typical measures of visual demand include: 1) glance frequency, 2) glance duration, 3) average duration per glance, and 4) total eyes-off-road time. Such measures are time-consuming to record and analyze but are typically used to measure visual attention. For example, previous research has reported on driver performance of in-car tasks such as adjusting the radio, viewing in-car displays (e.g., speedometer) or interacting with a navigation system (Wierwille, Antin, Dingus, & Hulse, 1988; Gellatly & Kleiss, 2000; Kurokawa & Wierwille, 1990; Tijerina, Palmer, & Goodman, 1999). Visual glance duration and the number of glances per task were investigated while performing conventional in-vehicle tasks and navigation tasks (Wierwille, Antin, Dingus, & Hulse, 1988). Findings indicated that glance frequency varied depending upon the task, and that glance duration for a single glance ranged from 0.62 s to 1.63 s. The mean number of glances across all tasks was between 1.26 and 6.52 glances. Zwahlen, Adams, and DeBald (1988) reported that "out of view" glance times (rear view mirror, speedometer, etc.) ranged from 0.5 s to 2.0 s during straight driving. Another example of such research is an experiment by Parkes, Ward, and Vaughan (2001) who measured glance frequency, glance duration, and average duration per glance to evaluate two in-vehicle audio systems, in terms of total "eyes off road" time.

Search and Scan Patterns

Early research included the investigation of visual search and scan patterns while driving (Mourant, Rockwell, & Rackoff, 1969; Mourant & Rockwell, 1970; 1972). It was found that as drivers became familiar with a route, they spent more time looking ahead, they confined their sampling to a smaller area ahead, and they were better able to detect potential traffic threats (e.g., movement in the periphery). Mourant and Rockwell (1970) found that peripheral vision was used to monitor other vehicles and lane line markers, that novice and experienced drivers differed in their visual acquisition process, and that novice drivers may be considered to drive less safely.

A recent field study investigated the influence of fatigue on critical incidents involving local short haul truck drivers (Hanowski et al., 2003). Fatigued drivers involved in critical incidents when making lane changes spent more time looking in irrelevant locations (i.e., locations other than out-the-windshield, out-the-windows, at the mirrors, or at the instrument panel). The mean proportion of time spent looking at irrelevant locations was 8%. However, during normal lane changes (not a critical event), the mean proportion of time that drivers spent looking at irrelevant locations was 3%, a significant difference. In terms of eye behavior, it appears that fatigued drivers involved in critical incidents pay less attention to relevant locations such as the road ahead and appropriate mirrors.

Mirror Glance Duration

Based on available literature discussed in this section, mirror glance times range from 0.8 s to 1.6 s (*M* = 1.1 s). Searches to the rear (blind spot) appeared to require a minimum value of 0.8 s. Nagata and Kuriyama (1985) investigated the influence of driver glance behavior in obtaining information through door and fender mirror systems. For door mirror systems, they reported that the average glance duration to the near-side (i.e., right side in this case) mirror was 0.69 s. Rockwell (1988) reported that the average glance duration to the left mirror was 1.10 s (*SD* = 0.33 s). This finding was consistent across different participants in three different experiments over a six-year period using the same data gathering and reduction technique. Taoka (1990) modeled the eyeglance distributions of Rockwell and found they could be well represented by means of a lognormal distribution. Taoka reported that the average time for viewing the left-side mirror was also 1.10s (*SD* = 0.3 s). The 5^{th} percentile value was 0.68 s and the 95^{th} percentile was 1.65 s. For right side mirror glances, Nagata and Kuriyama (1985) reported that average glance duration was 1.38 s (angle difference from the vertical axis of 70 degrees), while Rockwell reported an average glance duration of 1.21 s (10% larger than left glances), with an approximate standard deviation of 0.36 s. For the rear view mirror, Taoka (1990) reported that the average glance time was 0.75 s (*SD* = 0.36 s). The 5^{th} percentile value was 0.32 s and the 95^{th} percentile was 1.43 s.

Velocity

Velocity (traveling speed) has been used as a measure of driving performance for several decades. For example, Brown, Tickner, and Simmonds (1969) found that driving while telephoning had a 6.6% reduction in speed as compared to driving alone, in an early closed-circuit driving experiment. They also concluded that telephoning while driving may impair perception and decision-making skills. More recently, Alm and Nilsson (1994) concluded that a mobile telephone task while driving led to a reduction in speed level. In another effort, Tijerina, Kiger, Rockwell, and Tornow (1995) assessed driver workload for commercial vehicle operators in conjunction with using an in-vehicle device. Various measures were monitored including speed variance, which was highest for activities involving radio tuning and 10-digit cell-phone dialing tasks. Another study monitored speed for a driving study involving talking on a cell phone or talking to a passenger (Waugh, Glumm, Kilduff, Tauson, Smyth, & Pillalamarri, 2000). Results indicated that driving speeds were lower when talking on the phone as compared to talking to the passenger. It is generally recognized that tasks with high visual or cognitive demand can result in large deviations in speed.

Lateral Position

Lateral lane position or deviation is one of the most common measures of driver performance and distraction (Salvucci, 2002). Lane position can be measured in terms of lane exceedances (i.e., drift across the line between the current lane and the next lane) or, in the absence of actual lane crossings, lateral position in terms of distance from the center of the lane or the side lane line markings. Various researchers have used lateral position. For example, Serafin, Wen, Paelke, and Green (1993) conducted an experiment involving a driving simulator and car phone tasks. Greater lane deviation was observed for dialing while driving as compared to tasks involving listening, talking, or mental processing. In another study, Alm and Nilsson (1994) reported that for difficult driving tasks, a mobile telephone task had an effect on the drivers' lateral position during various 500 m driving segments. Results indicated that the mobile-telephone task made drivers drive closer to the right lane line, especially for complex tracking tasks. In another study, Tijerina, Kiger, Rockwell, and Tornow (1995) evaluated various measures including lane position variance and lane exceedances. They concluded that lane keeping was degraded when performing message reading tasks. Again, multiple research findings indicate that high levels of visual and cognitive demand can result in a greater level of lane deviation.

Participants

Thirty-six participants who were familiar with the Cleveland, OH freeway system and downtown area were recruited. Participants were recruited via newspaper advertisement (Figure 3), flyers, and word of mouth. Participant selection was determined after a telephone screening and selection process. All participants were between the ages of 18 and 71, with equal gender representation (18 female, 18 male). The experimental protocol was approved by the Virginia Tech Institutional Review Board (IRB) prior to any contact with participants. Figure 4 illustrates an example of an experimenter seated in the experimental vehicle.

Driving Study

In Cleveland area, $20/hr for 2 hrs.
Must be 18-35 or 50-75 yrs old w/
driver's lic. Virginia Tech
Transportation Institute.
Call 866-454-4568 or email
drivers @vtti.vt.edu

Figure 3: Newspaper Advertisement that appeared in the Cleveland Plain Dealer.

Figure 4. Experimenter Seated in Experimental Vehicle.

Route and Equipment

Route

The pre-planned loop route was approximately 50 miles long and consisted of sections on Interstates 480, 90, and 77, as well as surface streets in downtown Cleveland, OH. Prior to collecting any data, experimenters from VTTI visited the area several times in order to determine the final route by verifying the presence of suitable billboards. A potential 65-mile route was originally recommended by associates from Clear Channel Outdoor Advertising, a local company located in Cleveland. After personal examination of the suggested route, the final 50-mile route was selected by the VTTI research team so that it could be completed in a timely manner, while still allowing participants to be exposed to a mixture of interstate, downtown, and residential road segments. This loop contained a variety of billboards and other outdoor advertisements (e.g., on-premise signs, logo placards) as well as standard department of transportation (DOT) roadway signs. Figure 5 illustrates the final route used for data collection, while Table 3 lists the driving directions used for the experiment. The directions were mounted on the dashboard as illustrated in Figure 6.

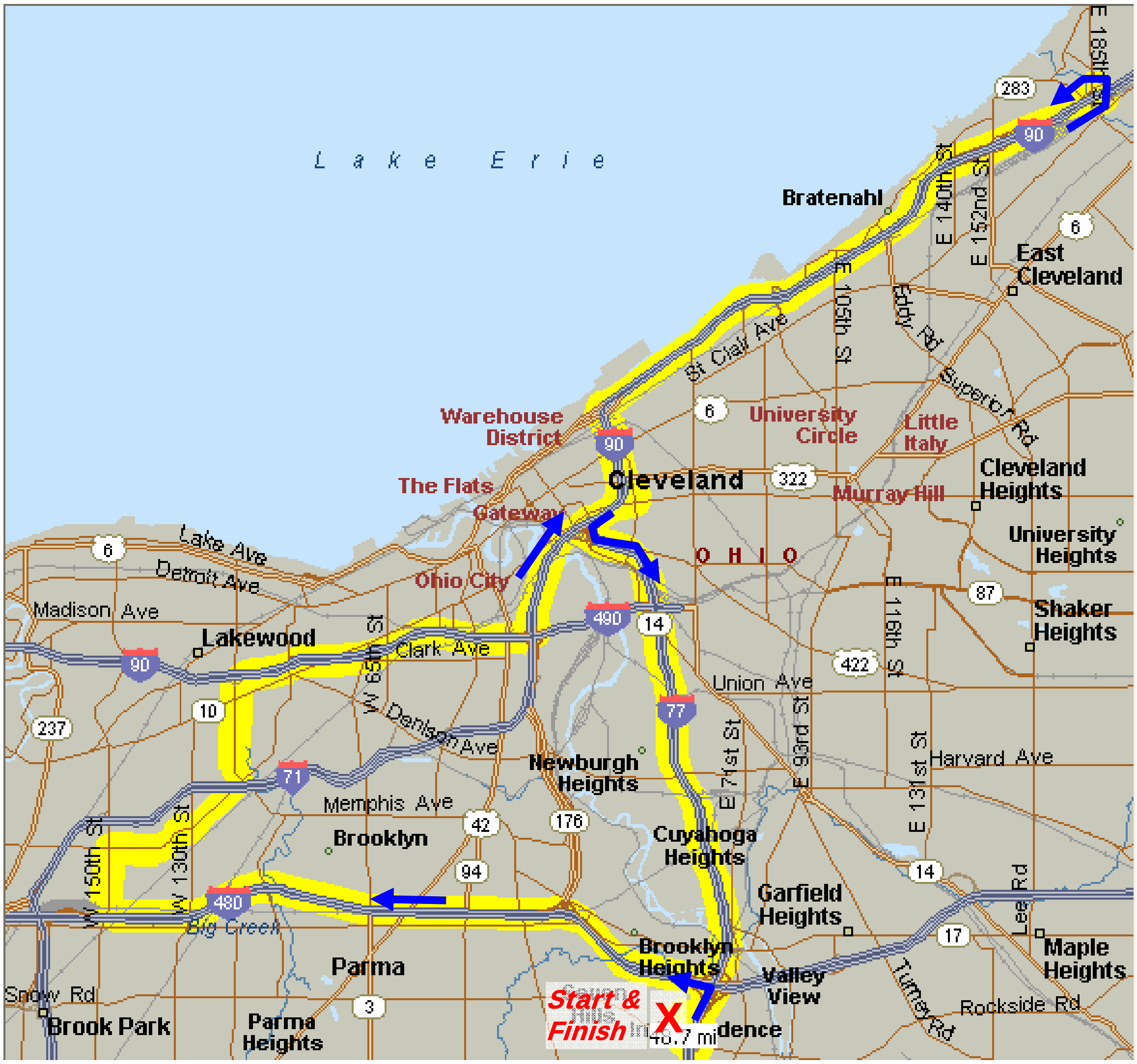

Figure 5. Map of 50-mile Daytime Loop Route in Cleveland, Ohio.

Table 3. Directions for 50-mile daytime route in Cleveland, OH.

	<u>Directions</u>	<u>Trip Distance</u>	<u>Notes</u>
←	Left out of Residence Inn onto **W. Creek Rd.**	0.0	
←	Left onto **Rockside Rd.**	0.3	
→	Right toward **I-77 North**	0.5	Go under overpass to I-77 N entrance
	Left lane onto **I-480 West /** Toledo	1.1	
EXIT 12A	Right Exit 12A, turn Right onto **W. 150th St.**	9.9	
→	Right onto **Puritas**	10.9	Curves to Left, becomes Bellaire
←	Left onto **W. 117th**	13.1	Just past entrance to I-71
→	Right onto **I-90 East** / Cleveland	14.4	
EXIT 172A	Right Exit 172-A, **East 9th St.**	20.1	Stay to Right
→	Right onto **Carnegie**	20.4	
←	Left onto **East 30th St.**	21.3	DODD Camera on far left corner
←	Go 1 block, Left onto **Prospect**	21.4	
←	Go 500 ft., Left onto **I-90 East**	21.5	
EXIT 182A	Right Exit 182A, Right onto **E. 185th St.**	30.9	
	Stay in Right Lane and get onto **I-90 West** to Downtown	31.2	Stay on 90 W when splits to left
EXIT 172A	Take Right Exit 172A to **I-77 South**	41.2	
	Follow I-77 South to **Rockside Road** exit	48.2	
EXIT 155	Take Exit 155 Rockside Road and Independence, turn Right onto **Rockside Rd.**	48.8	
→	Turn Right onto **W. Creek Rd.**	48.9	
→	Turn Right into **Residence Inn** parking lot	49.2	

Figure 6. Directions mounted on dashboard of vehicle (this picture is from a previous experiment which used the same protocol and vehicle type).

Practice Route. A short, 1.5-mile practice route was also included. This route was driven prior to data collection on the 50-mile loop route. During the practice route, the experimenter rode as a passenger with the participant to make sure that the participant was familiar with the directions and the vehicle's displays and controls. Table 4 lists the directions for the practice route, which was conducted on local streets near the hotel where the study began and ended.

Table 4. Directions for 1.5-mile Practice Route in Independence, Ohio.

	Directions	**Trip Distance**	**Notes**
➡	Right out of Residence Inn onto W. Creek Rd.		
➡	Right onto Jefferson Dr.		
↻	Go around the traffic circle		
⬅	Left onto W. Creek Rd.		
➡	Right onto Patriot's Way		
	Straight at Stop		Past Applebee's
⬅	Left into Parking lots, loop back onto Patriot's Way		
	Straight at Stop		
⬅	Left onto West Creek Rd.		
➡	Right into Residence Inn parking lot	1.5 mi	

Vehicle

A 2002 Chevrolet Malibu was used in this study and is shown in Figure 7. The vehicle had an automatic transmission, an adjustable steering wheel, and other standard features.

Figure 7. Experimental Vehicle, 2002 Chevrolet Malibu.

Data Collection System

The vehicle was instrumented with a data collection system, including cameras, a computer, and sensors that continuously collected data. The system was activated approximately 2 min after the ignition was turned on and was deactivated when the driver turned it off. A video system with four cameras was used. Two cameras were mounted on the back side of the rear-view mirror--one facing forward left and the other facing forward right (Figure 8). This captured the forward views of the roadway as well as the sides where billboards and other objects were visible. The other two cameras captured the driver's face from two perspectives. One camera was mounted on the top left corner of the windshield near the A-pillar (Figure 9). The other camera was mounted just above the rear view mirror (Figure 10). Both faced the driver and captured head and eye movements. Since data reductionists needed to review all four video channels simultaneously, a quad-splitter was used to fuse the images. This produced a single, compartmentalized image such that each camera was presented in one of four locations (Figure 11). The quad splitter, computer, monitor, and keyboard were located in the trunk of the vehicle as shown in Figure 12. Finally, Figure 13 illustrates these components and shows how they interacted with sensors. Infrared illumination was used to provide adequate illumination for a smaller nighttime data collection effort, to be described later in the report.

Figure 8. Forward Facing Cameras Mounted Behind the Center Rear View Mirror.

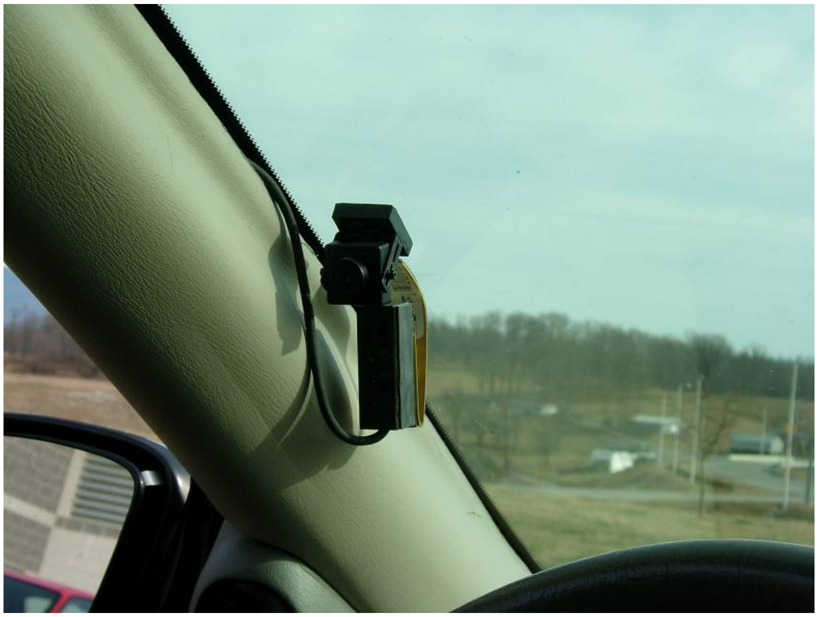

Figure 9. Driver Face Camera, Mounted near the left A-Pillar.

Figure 10. Driver Face Camera Mounted Above Rear View Mirror.

Left Forward View	Right Forward View
Driver's Face, Left Side	Driver's Face, Right Side

Figure 11. Diagram of Simultaneous Presentation of Four Camera Views.

Figure 12. Data Acquisition System Located in Trunk of Vehicle.

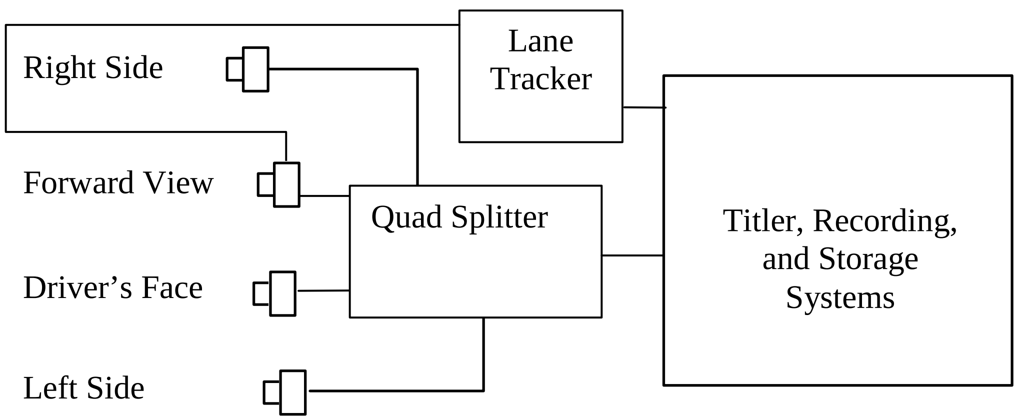

Figure 13. Components of the Data Collection System.

All video data were recorded at 30 Hz (30 frames per s), using MPEG 4 compression algorithms at a rate of 4 MB per minute. Driving performance data, including lane position and velocity, were collected at 10 Hz (10 times per s). The lane tracking system used fuzzy logic and statistical probabilities to detect lane edges in the forward camera view. Lane position was collected with a resolution of ±2 inches from the center of the lane. Raw performance data, including lane position, velocity, and video data, were saved on the hard drive of a laptop computer and then backed up onto individual DVDs for each participant. After each trial, the experimenter reviewed the data to assure that the data collection system performed to specification.

Procedure

Participant Recruitment and Screening

Straight-text newspaper advertisements were placed in the *Cleveland Plain Dealer* (Figure 3) and flyers were posted in strategic locations in Cleveland, OH to solicit volunteer participants for the study. Respondents were instructed to contact the experimenter via email or by telephone. A telephone/email screening form (Appendix A) was used to collect general information on age, gender, medical, and driving history, familiarity with the route(s), and use of corrective lenses or sunglasses. A list of potential participants was compiled as screenings were completed, and participants who met all of the required criteria were then contacted to set up an appointment for participation. The participant met the experimenter on the appropriate date and time in the hotel lobby of the Residence Inn on West Creek Road, in Independence, OH (just south of Cleveland).

Experimental Protocol

Upon arrival, each participant presented a valid driver's license for the experimenter's inspection. Each participant then completed an informed consent form (Appendix B) and a health screening questionnaire (Appendix C). Participants also completed a vision test using a Snellen eye chart. Only participants with vision of 20/40 or better were eligible to participate.

Participants received an orientation (including the practice route), drove the 50-mile experimental route, completed a post-drive questionnaire (Appendix D), and received $20/hr for their time. Most participants completed the experiment in less than two hours. All procedures for recruitment and data collection were approved by the Virginia Tech IRB, as required by federal and state law.

In all, 36 drivers were recruited for the full experiment. Another participant completed the experiment, but the data were not used because it rained during most of the session. Of the 36 drivers who completed the experiment, 3 repeated the experiment on a later date due to rain. That is, their initial data were not used and were replaced with the second driving session. The order in which participants were run in the experiment is shown in Table 5.

Table 5. Order of Participation (shown by Age and Gender).

Number	AgeGrp	Gender
1	O	M
2	O	M
3	Y	M
4	O	M
5	Y	F
6	Y	F
7	O	F
8	Y	F
9	O	F
10	Y	M
11	O	F
12	Y	M
13	O	M
14	O	M
15	Y	M
16	O	F
17	O	F
18	O	F
19	O	M
20	Y	F
21	Y	M
22	Y	F
23	Y	F
24	O	M
25	Y	F
26	O	F
27	O	M
28	Y	M
29	O	F
30	Y	F
31	Y	F
32	O	F
33	Y	M
34	Y	M
35	Y	M
36	Y	F

The informed consent form explained the general purpose of the experiment to the driver and obtained his/her permission to participate in the study. After the required paperwork was completed, the following script describing the experiment was read aloud to the participant:

> Today we will have you drive a pre-determined loop route along major freeways and highways. The vehicle that you will be operating is specially equipped with instruments that collect information about your driving habits. The purpose of this

> study is to collect information about the way people drive under normal circumstances, in order to improve driver safety. We want you to drive as you would if you were in your own vehicle and were driving, for example, to visit a friend, do an errand, or go to work. With this in mind, we will also want you to obey all typical traffic regulations as you normally would, including, but not limited to, posted speed limits, lane markings, and traffic control devices (such as stoplights).
>
> I will be riding in the passenger seat during a 5-minute orientation drive. You are welcome to ask questions if necessary, as this orientation will help you become familiar with the vehicle and its controls. As always, our first priority is your safety. If at any time you feel uncomfortable please inform me and we can make any necessary adjustments or end the study early.
>
> After the 5-minute orientation, I will exit the vehicle and have you drive the pre-determined route, which will bring you back to this location. This route will take about 1.5 hours. A map and written instructions will be provided for your reference, and I will also review the route with you before you depart. After the route is completed, I will debrief you and the session will be complete.
>
> Do you have any questions I can answer at this time?

The experimenter then reviewed the map (Figure 5) and directions (Table 4) in detail. A laminated copy of the map was stored in the glove compartment for easy reference. A laminated copy of the directions was prominently displayed on the dashboard (Figure 6). A cellular telephone was also stored in the glove compartment for emergency use only.

The experimenter then oriented the participant to the vehicle, including adjustment of the seat, seat belt, mirrors, and steering wheel. Displays and controls were also reviewed, including a review of the map, directions, and cell phone operation instructions. The participant then drove the 5-minute orientation route, with verbal reminders provided by the experimenter when required. After the orientation route was completed, the experimenter checked the data, reminded the participant to drive as he/she normally would, and then returned to the hotel. The participant drove the 50-mile loop route, which eventually brought him/her back to the hotel.

After the experiment, in-vehicle eyeglance calibration was completed in the hotel parking lot. With the vehicle parked, the experimenter sat in the passenger seat and provided verbal instructions. The protocol included having the participant sit as if driving, while alternating 3-second glances to various locations with a default forward glance location. The glances included left blind spot, left window, left mirror, left forward, forward, right forward, right mirror, right window, right blind spot, rear view mirror, instrument panel (speedometer), and climate and radio controls.

After the eyeglance calibration, the participant and the experimenter returned to the hotel lobby, where the post-drive questionnaire was completed (Appendix D). The experimenter then reviewed the questionnaire to make sure that all of the answers were legible. Item #3, "Please check the top five items that most caught your attention during your drive," included a "Billboards" option (among a list of 18 possible items). If the experimenter noticed that

“Billboards” had been marked, she asked about every checked item in an attempt to discover the details as to what caught their attention. For the billboard item specifically, the experimenter noted what aspect of the billboard caught the participant’s attention, without conveying the importance of that particular topic. Payment was then issued to the driver at a rate of $20 per hour, (2 hours in most cases, for a total of $40) and a payment log was signed to verify that funds were received. At no time was the participant made aware that this experiment was related to driving behavior regarding billboards or other roadside items.

Data for each participant were briefly reviewed to verify that all the cameras were operating correctly and that data had been recorded. Data and video files were then transferred from the data collection system’s computer to a portable laptop computer. Each participant’s data were copied onto a separate DVD as a second back-up measure. The results from the post-drive questionnaire were then entered into an Excel spreadsheet for later processing.

Data Reduction

Analyst Training

Two data analysts worked on this project under the supervision of the principal investigator. All analysts were experienced in video data reduction prior to this project. Training began with a 2-hour session in which the user manual was reviewed and the analysis software was demonstrated by the experimenter. Relevant functions were shown, and the process of how to load the map and associated GPS coordinates was explained. Prior to actual data analysis, each analyst spent an additional eight hours mastering eyeglance direction determination and spreadsheet use. This period included time with an experienced analyst present. A large part of that time was dedicated to establishing inter-analyst reliability by comparing judgments and modifying techniques until all analysts’ independent determinations matched. Throughout the entire analysis effort, at least one experienced analyst was available at all times to answer any questions or review particular cases as needed. “Spot checks” were performed throughout the data reduction process, with input provided as needed to maintain a high level of consistency. Robust reliability was further assured by ascertaining that each analyst recorded a portion of the data from each participant (i.e., a portion of the data for each of the 36 participants was analyzed by each analyst). As events were completed, a written record was created with the analyst’s initials and date of completion.

Software

This section outlines the data reduction software program developed to analyze digital billboard, conventional billboard, comparison, and baseline events. The software, currently called DART (Data Analysis and Reduction Tools), was originally developed by software engineers at VTTI for a large-scale naturalistic driving study known as the 100 Car Study (Dingus, Klauer, Neale, Petersen, Lee, et al., 2006). This program integrates Microsoft MapPoint 2003 using GPS data for billboard, comparison, and baseline site locations with the data obtained from the multiple sensors in the test vehicle via a graphical interface. A total of 36 files (representing the route driven for each participant) were analyzed. After a file was opened, the software presented the analyst with the relevant windows required for data identification and reduction. The MapPoint application allowed the analyst to view a map of the Cleveland, OH area, showing the relationship between the site and the roads, so that video could be compared with GPS data during site identification and eyeglance analysis. The map illustrated the route and the location of the vehicle, which was represented by a green vehicle icon that moved as the event was played. This map served solely as a visual display and could not be manipulated.

Procedure

Data reduction was performed by the two analysts for each of the 36 data files. This occurred in three steps: software preparation, event identification, and eyeglance analysis. Analysts were blind as to which event type was being analyzed (in other words, they knew the event only by its number, and did not know what type of event was contained in that segment of data). This was done to insure impartiality in this aspect of the data reduction (event identification and eyeglance reduction were the only two aspects of data analysis which had a subjective component; this was compensated for by re-doing 10% of the events and calculating inter-rater reliability).

Event Identification

Analysts first used the DART software to identify the locations of interest. The GPS coordinates for each location were entered into a master map. Each file was then opened and the DART software suggested the correct point for each location of interest based on the master GPS list. The analyst compared the forward view shown in the video with a master file of forward views and adjusted the event timing slightly if necessary to make sure the forward views were the same for every participant (thus providing a common geographic point of reference for each event analyzed). The end of an event was defined as the sync number (time reference) at which the test vehicle passed the site, and the event's beginning was calculated to be eight seconds before the end point. Identification of the end point thus combined two methods: the GPS data was used to align the vehicle directly in conjunction with the site, and then the video was used to visually confirm accurate GPS positioning using comparison to a master file of forward views.

Eyeglance Analysis

Once all of the events were correctly identified and stored in the database, the analysts conducted the eyeglance analysis for each event. The first step in eyeglance analysis was familiarization with the participant's individual glance patterns by means of a glance location calibration video, during which participants looked at specific places according to a set script. Analysts referred often to the calibration file collected for each participant to make sure that the glance locations were being coded correctly.

As described in the procedures section, eye calibration was conducted *after* data collection was complete, in order to serve as a record of how a particular driver's glance to particular location is shown in video. Analysts reviewed these records in order to become familiar with the participant's glance style. The analyst was thus able to conduct the glance analysis according to each participant's glance style. Glances were coded according to the following abbreviations:

F - Forward
RF - Right Forward
LF - Left Forward
RVM - Rear View Mirror
OX - Outer eXterior, including side mirrors, side windows, blind spot, etc.
DIR – glances toward the experimental route DIRections
OINT - Other INTerior, including speedometer, sun visor, cell phone, etc.

Analysts reviewed events from beginning to end, one tenth of a second at a time, determining the direction of glance for every tenth of a second for the eight-second duration of the event. New glances were recorded as the sync number at which the participant's glance *rested* in a new location. Transition time to the new location was included in the glance location the driver was moving *away* from. The DART program automatically calculated the duration of each glance. Summary information for each event included the number of glances, average glance duration, number of glances in each direction, and the average duration of glances in each direction. The final inter-rater reliability for the eyeglance reduction process was 96.5%, which is considered quite good. Approximately 5% of the daytime events were analyzed by both raters independently, resulting in 8,084 individual glance locations, each lasting 0.1 s. The agreement between raters for each location was compared; the 96.5% reliability means that the raters were in agreement for 7,804 glance locations.

Final Reduced Data Set

With 36 participants and 44 sites, there were 1,584 events available for analysis from approximately 63 hours of data collection. A small amount of data was lost due to cell phone use, sensor outages, sun angle, and vehicle stoppages, leaving 1,540 events for eyeglance analyses. Altogether, 124,740 video frames were analyzed (1,540 events x 81 frames/event) and 8,678 individual glances were identified. The speed data was filtered to remove events as described above, and then further filtered to remove events in which the maximum speed failed to read 20 mph or the minimum speed failed to reach 15 mph, leaving 1,494 events in this dataset, with 121,014 data points for speed. The lane position dataset was further filtered to remove events indicating a possible lane change or lane position sensor failure (often due to poor lane markings). After filtering, there were 1,188 events remaining in the lane position dataset, with 96,228 data points.

Statistical Analysis

Descriptive statistics were calculated using Excel. All other statistical analyses were conducted using SAS statistical software. The analysis of variance (ANOVA) statistical technique was used; in SAS this was accomplished by means of the general linear model (GLM) procedure. Where significant differences were found, and there were more than two levels of the independent variable, a post-hoc analysis was run using the Least Squares Difference procedure in SAS to determine which levels were significantly different from which other levels. (For independent variables with just two levels that differ significantly, a simple examination of the means will demonstrate which level is significantly greater than the other.)

Nighttime Study

A smaller exploratory study was also conducted at nighttime using an abbreviated route that avoided some of the downtown streets. Given that the digital signs being studied were intrinsically illuminated, this was felt to be an important first step in determining whether there are driver performance differences in the presence of these signs under different levels of ambient illumination. All of the nighttime drivers had previously driven the route during the daytime and were thus somewhat familiar with the route (so were unlikely to get lost or go off route). The nighttime route directions are shown in Table 6, while the order of participation is shown in Table 7 (12 of the 36 drivers returned for the nighttime experiment). The nighttime route map is shown in Figure 14.

Table 6. Nighttime Driving Directions.

	Directions	Trip Distance	Notes
←	Left out of Residence Inn onto **W. Creek Rd.**	0.0	
←	Left onto **Rockside Rd.**	0.3	
→	Right toward **I-77 North**	0.5	Go under overpass to I-77 N entrance
	Left lane onto **I-480 West /** Toledo	1.1	
EXIT 12A	Right Exit 12A, turn Right onto **W. 150th St.**	9.9	
→	Right onto **Puritas**	10.9	Curves to Left, becomes Bellaire
←	Left onto **W. 117th**	13.1	Just past entrance to I-71
→	Right onto **I-90 East** / Cleveland	14.4	
EXIT 182A	Right Exit 182A, Right onto **E. 185th St.**	30.1	
	Stay in Right Lane and get onto **I-90 West** to Downtown	30.4	Stay on 90 W when splits to left
EXIT 172A	Take Right Exit 172A to **I-77 South**	40.3	
	Follow I-77 South to **Rockside Road** exit	47.3	
EXIT 155	Take Exit 155 Rockside Road and Independence, turn Right onto **Rockside Rd.**	47.9	
→	Turn Right onto **W. Creek Rd.**	48.0	
→	Turn Right into **Residence Inn** parking lot	48.3	

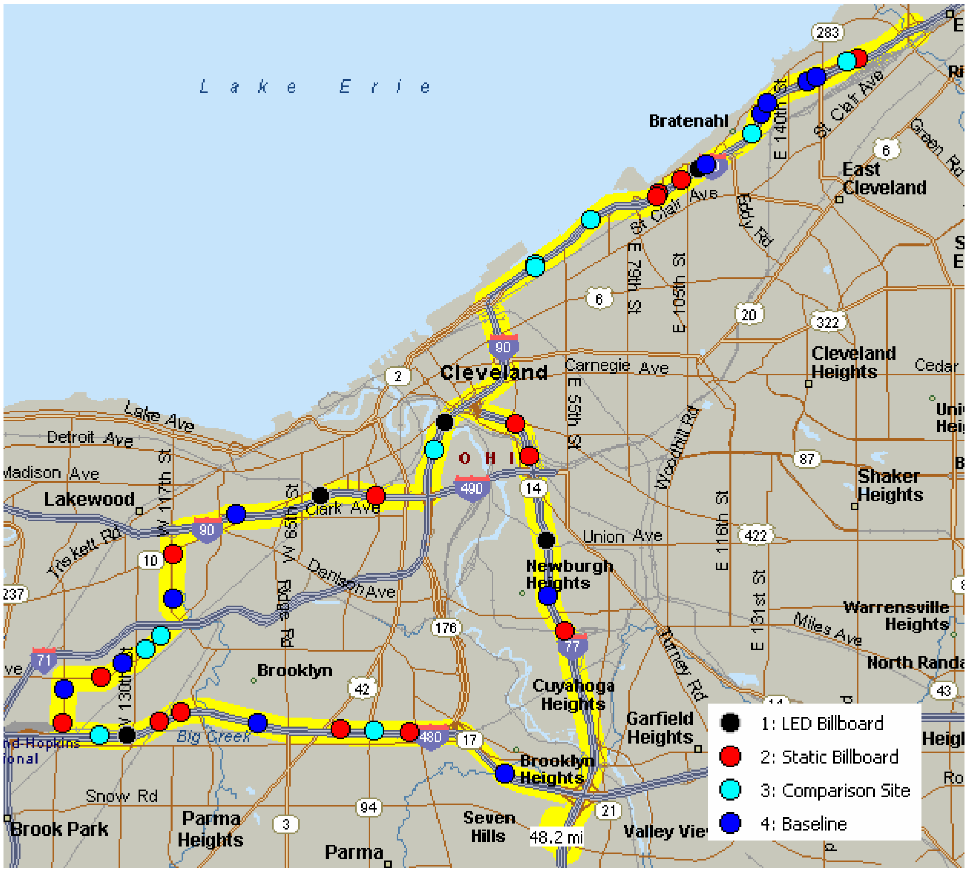

Figure 14. Map Illustrating Nighttime Route with Digital Billboards (black), Conventional Billboards (red), Comparison Sites (aqua blue), and Baseline Sites (blue).

Table 7. Nighttime order of participation.

Number	Age group	Gender
1	Younger	Female
2	Older	Male
3	Older	Female
4	Older	Female
5	Younger	Female
6	Older	Male
7	Younger	Male
8	Younger	Male
9	Older	Female
10	Older	Male
11	Younger	Male
12	Younger	Female

With 12 participants and 40 sites, there were 480 events available for analysis from approximately 42 hours of data collection. A small amount of data was lost due to cell phone use, sensor outages, and vehicle stoppages, leaving 470 events for eyeglance analyses. Altogether, 38,070 video frames were analyzed (470 events x 81 frames/event) and 2,335 individual glances were identified. The speed data was filtered to remove events as described above, and then further filtered to remove events in which the maximum speed failed to read 20 mph or the minimum speed failed to reach 15 mph, leaving 456 events in this dataset, with 36,936 data points for speed. The lane position dataset was further filtered to remove events indicating a possible lane change or lane position sensor failure (often due to poor lane markings). After filtering, there were 411 events remaining in the lane position dataset, with 33,291 data points. Because the nighttime study was exploratory in nature with fewer data points, these data are shown descriptively, but were not analyzed statistically (due to lack of statistical power).

RESULTS

Post-Drive Questionnaire – Daytime Results

Participants completed the post-drive questionnaire (Appendix D) after they returned from driving the daytime driving route as well as the nighttime route. The questionnaire gathered information such as route familiarity and items noticed while driving; it also collected demographic and personal information, including education level, marital status, ethnicity, and income. The questionnaire was the same one used by Lee et al. (2004) in the previous study using similar methods. The following sections summarize all questionnaire results for the daytime drivers, followed by a section describing the results for the nighttime drivers.

Demographics Overview

In terms of demographics, the average age was 28 years for younger drivers and 59 years for older drivers. The sample of drivers was quite diverse in terms of education level, marital status, and income. All drivers lived and worked in the Cleveland, OH area and were familiar with some or most of the route. The following sections provide details for relevant information about the sample of drivers. Table 8 presents these findings as well.

Age. The sample of 36 drivers ranged in age from 18 to 71 years old. The mean age of all participants was 43.3 years (SD = 16.7). The younger drivers ranged in age from 18 to 35 years old, with a mean of 27.9 years (SD = 6.0). The older drivers ranged in age from 50 to 71 years old, with a mean of 58.7 years (SD = 6.1).

Education Level. Participants were surveyed regarding the highest education level they had completed. The number of responses and equivalent number of years were used to calculate the product. This was used to calculate the mean education level for the sample by dividing the total number of years completed by the number of participants (482/36). The average was 13.4 years of education completed (equivalent to high school plus a year and a half of college). Most of the participants had finished high school, but few had attended college.

Marital Status. Half of the participants were married, while 28% reported that they were single and 17% were divorced. Two individuals (5.6%) indicated that they were separated.

Ethnicity. Most participants were European (Caucasian/White) with only one participant identifying herself as African American.

Income. The income level with the most participants was the group earning between $25,000 and $49,000 per year (16 participants or 44%).

Table 8. Summary of Demographic Results for All Daytime Participants.

CATEGORY	**LEVELS**			
Age (mean)	**Younger Drivers**	**Older Drivers**	**All Drivers**	
	27.9 years	58.7 years	43.3 years	
Education Level	**High Sch.**	**2-Yr Deg.**	**B.A./B.S.**	
	52.8%	25.0%	22.2%	
Marital Status	**Single**	**Married**	**Divorced**	**Separated**
	27.8%	50.0%	16.7%	5.6%
Ethnicity	**African American**	**European**		
	2.8%	97.2%		
Income Level	**$0-24K**	**$25-49K**	**$50-74K**	**>$100K**
	33.3%	44.4%	19.4%	2.8%

Route Familiarity

Route familiarity was assessed by three items in the questionnaire. Specific topics addressed were: location of work, location of home, and frequency of driving on roads in the experimental route (defined as familiarity). Table 9 presents the route familiarity findings.

Living and Working Location. All drivers reported that they were familiar with the Cleveland, OH area and had driven on the interstates and surface roads included in the route. All of the participants lived in the Cleveland area, and those who were employed also worked in the area. Cleveland proper, Parma, and Independence were the most common locations where participants lived and worked, with 39% of participants reporting that that they both lived and worked in one of these three areas (Independence and Parma are adjacent suburbs of Cleveland).

Familiarity. Route familiarity was also evaluated in terms of five route segments that represented various types of driving (i.e., various segments of interstate and downtown Cleveland). Drivers were asked to indicate if they were either "familiar" (driven at least once a week) or "not familiar" (driven less than one time a week) with each segment. In some cases, participants inquired about this question item, indicating (verbally) that, although they were quite familiar with certain areas, they may not drive on them every week. Nonetheless, the results indicated that overall, drivers were familiar with the route, particularly I-480 W between I-77 and W150th (83% were familiar with this segment as shown in Table 9).

Table 9. Route Segment Familiarity for All Daytime Participants.

	Route Segment				
	I-480W between I-77 and W150th	W.130th - Bellaire - W.117th	I-90 between 9th and 185th	Carnegie Ave.	I-77 between I-90 and Rockside
% Familiar	83%	42%	64%	67%	72%

Overview of What Drivers Noticed

Drivers primarily noticed items such as traffic and other drivers, road or highway signs, and road construction. Fifteen of 36 drivers (42%) marked "billboards" as one of the top 5 items (out of 18 items) that caught their attention during the drive. Participants engaged in a variety of activities while driving; listening to the radio or CD player and using the cell phone were the most prevalent. At no point was it apparent that any participant knew the specific purpose of the study; all responses indicated that drivers believed the study was related to observing drivers in a natural driving situation, which was also true. The following sub-sections describe findings in more detail, with tables illustrating drivers' responses.

Attention Getters. Participants were asked to indicate "the top five items that most caught your attention during your drive." Over 50% of drivers indicated that they paid attention to traffic, road signs, exit signs, and other drivers. The top 9 items (out of 18 listed) are shown in Figure 15. For those drivers who indicated "billboard" as one of the items that caught their attention, the experimenter asked them to verbally expand upon all items; however, none of these drivers made any additional comments about billboards except that they caught their attention. Three drivers (8%) mentioned billboard under a separate question regarding the single most memorable part of the drive. Their comments were "The lighted billboards," "Ridiculous billboards," and "The light up billboards." A fourth driver mentioned "Markers and signs" but did not elaborate further. Even in the daytime, the digital billboards appeared to have been noticeably different from conventional billboards and appeared to attract a certain amount of attention.

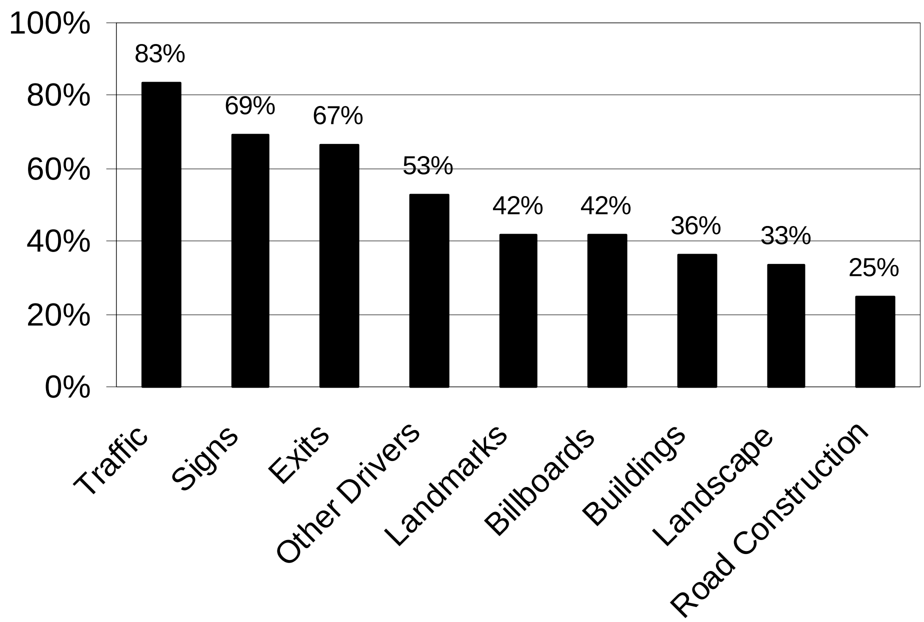

Figure 15. Top Daytime Attention Getters (top nine of eighteen possible).

Most Memorable. Participants were asked "What was most memorable about the drive?" This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. There were 35 comments. Over 68% of the comments were related to construction, weather/view, the experimental vehicle, or traffic, as presented in Table 10.

Table 10. Number and Percent of Comments for Daytime Participants for the Question: "What was most memorable about the drive? For example, were there any objects that stood out?"

Comment Categories	Number of Comments	Percent of Comments
Other Vehicles/Traffic	7	17.5%
New Route/feature about route	6	15.0%
Lake	5	12.5%
Weather/View	4	10.0%
Test Vehicle	3	7.5%
Digital Billboards/Billboards/signs	3	7.5%
Neighborhoods	3	7.5%
Rough Road	3	7.5%
Relaxing/Positive trip	2	5.0%
Construction	1	2.5%
Near accident/Accident	1	2.5%
Sports Arena	1	2.5%

What Bothers You? Participants were asked, "What bothers you about other drivers?" This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. A total of 30 comments were made. The large majority of the comments were related to aggressive maneuvers or questionable driving behavior such as tailgating, being cut off, not using turn signals, or driving slowly in the fast lane (Table 11).

Table 11. Number and Percent of Comments for Daytime Participants in Response to the Question: "Does anything about other drivers bother you? If so, please briefly describe."

Comment Category	Number of Comments	Percent of Comments
Tailgating	7	23.3%
Cut off	6	20.0%
No signal	5	16.7%
Speeding	3	10.0%
Aggressive	3	10.0%
Slow in fast lane	3	10.0%
Cell phone talking	1	3.3%
Drivers who don't pay attention	1	3.3%
Inability to adjust to conditions	1	3.3%

Other Activities. Participants were asked, "What other activities do you engage in while driving?" Again, this was open-ended and the comments varied, but similar comments were grouped where possible. There were 72 comments in all. Listening to the radio or CDs was the largest single activity, making up over 26% of the comments. Using the cell phone was also common (15%). Other activities included singing or talking, drinking, smoking cigarettes, and eating, as presented in Table 12.

Table 12. Number and Percent of Comments for Daytime Participants in Response to the Question: "What other activities do you typically engage in while driving?"

Comment Categories	Number of Comments	Percent of Comments
Listen to radio/CDs	21	38.9%
Cell phone	11	20.4%
Smoking	4	7.4%
Eating	4	7.4%
Drinking	3	5.6%
Talk w/others	3	5.6%
Adjust radio/CDs	2	3.7%
Driving/steering	2	3.7%
Adjust AC/windows	1	1.9%
Look for something	1	1.9%
Homework	1	1.9%
Read directions/map	1	1.9%

Other questions asked participants for additional input about the written directions and the purpose of the study. Substantively relevant participant responses included three separate suggestions relating to conducting a driving study with passengers or children, the effect of video cameras on driving behavior, and the statement that "driving in my own car would be more 'normal.' " While no one reported problems with the directions, three drivers did get off-route at one point during their trip; however, very few data points were missed. Drivers were also queried as to their recollection of the purpose of the study; all responses were within the scope of what they had been told verbally and in the informed consent form.

Post-Drive Questionnaire – Nighttime Results

Age

The sample of 12 nighttime drivers ranged in age from 25 to 62 years old and consisted of drivers who had recently performed the daytime portion of the experiment. As for the main experiment, the participant pool was balanced for age and gender. The mean age of the nighttime participants was 44.5 years (*SD* = 14.0). The younger drivers ranged in age from 25 to 35 years old, with a mean of 31.5 years (*SD* = 4.1). The older drivers ranged in age from 54 to 62 years old, with a mean of 57.5 years (*SD* = 3.3). The demographics for these 12 drivers are summarized in Table 13.

Table 13. Summary of Demographic Results for All Nighttime Participants.

CATEGORY	LEVELS		
Age (mean)	**Younger Drivers**	**Older Drivers**	**All Drivers**
	31.5 years	57.5 years	44.5 years
Education Level	**High Sch.**	**2-Yr Deg.**	**B.A./B.S.**
	58.3%	25.0%	16.7%
Marital Status	**Single**	**Married**	**Divorced**
	8.3%	66.7%	25.0%
Ethnicity	**European**		
	100.0%		
Income Level	**$0-24K**	**$25-49K**	**$50-74K**
	16.7%	41.7%	41.7%

Route Familiarity

Route familiarity was assessed by three items in the questionnaire. Specific topics addressed were: location of work, location of home, and frequency of driving on roads in the experimental route (defined as familiarity). As before, all nighttime drivers lived and worked in the Cleveland, OH area. Route familiarity was also evaluated in terms of five route segments that represented various types of driving (i.e., various segments of interstate). Drivers were asked to indicate if they were either “familiar” (driven at least once a week) or “not familiar” (driven less than one time a week) with each segment. Table 14 presents the route familiarity findings.

Table 14. Route Segment Familiarity for All Nighttime Participants.

	Route Segment				
	I-480W between I-77 and W150th	W.130th - Bellaire - W.117th	I-90 between 9th and 185th	Carnegie Ave.	I-77 between I-90 and Rockside
% Familiar	75%	42%	58%	58%	50%

Attention Getters

Participants were asked to indicate “the top five items that most caught your attention during your drive.” Over 50% of drivers indicated that they paid attention to traffic, road signs, billboards, and exits. Figure 16 shows the top nine nighttime attention getters. For those drivers who indicated “billboard” as one of the items that caught their attention, the experimenter asked them to verbally expand upon all items, but no one made any remarks relevant to billboards. However, 3 of the 12 nighttime drivers (25%) noted billboards as being the single most memorable thing about the drive. One person just said “Billboards,” another said “I saw a billboard that changed and I wished it hadn't because I wanted to read the previous message,” and a third said “One billboard.” This is much higher than the 8% who mentioned billboards as being most memorable during the daytime, and may be a reflection of the nature of the digital billboards.

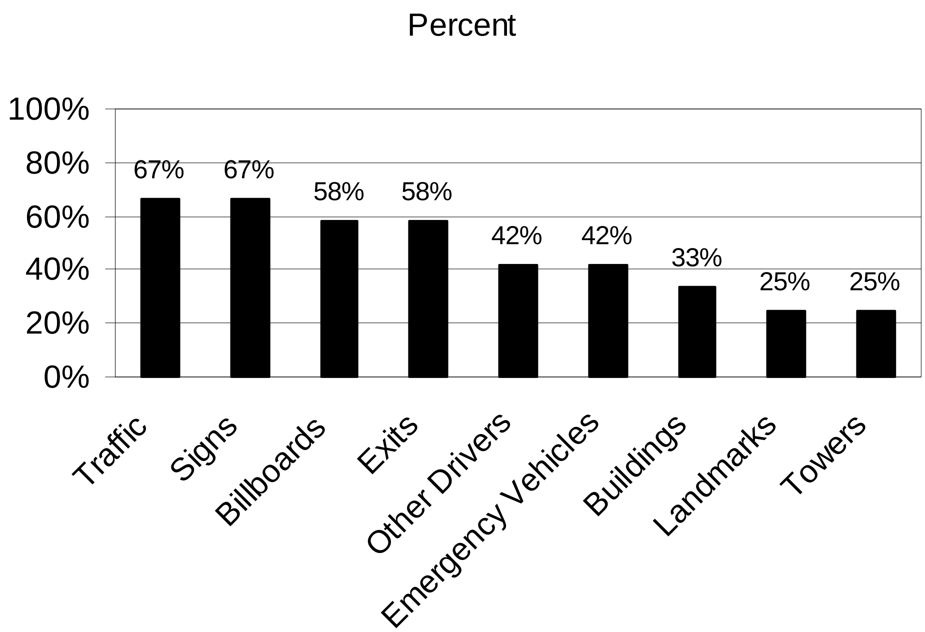

Figure 16. Top Nighttime Attention Getters (top nine of eighteen possible).

Most Memorable

Participants were asked "What was most memorable about the drive?" This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. There were nine comments from the 12 nighttime drivers. As mentioned, three comments concerned billboards, while other common answers included the views and other vehicles and traffic, as presented in Table 15. The drivers had previously answered the general questions regarding "What bothers you about other drivers?" and "What other activities do you engage in while driving?" during their daytime session, so these were not asked again here. Likewise, the responses to "What is the purpose of this study?" were similar to what the same participants had said during the daytime session; all responses were within the scope of what they had been told verbally and in the informed consent form.

Table 15. Number and Percent of Comments for Nighttime Participants in Response to the Question: "What was most memorable about the drive? For example, were there any objects that stood out?"

Comment Categories	Frequency
Digital Billboards/Billboards	3
View	2
Other Vehicles/Traffic	2
Positive trip	1
Personal condition while driving	1

Driving Performance Results – Daytime

Event Type

Eyeglance Results. With regard to eyeglance behavior, there were six questions of interest, each of which will be discussed in turn:

1. Does eyes-on-road percent (looking straight forward) vary in the presence of different event types?
2. Is there a more active glance pattern in the presence of certain event types (as measured by the number of individual glances to any location during the eight seconds of the event)?
3. For events on the left side of the road, are there more glances in the left forward direction for certain event types?
4. For events on the right side of the road, are there more glances in the right forward direction for certain event types?
5. For events on the left side of the road, does the mean single glance time in the left forward direction vary according to event type?
6. For events on the right side of the road, does the mean single glance time in the right forward direction vary according to event type?
7. Are longer glances (longer than 1.6 s) associated more with any of the event types?

Question 1 (Does eyes-on-road percent (looking straight forward) vary in the presence of different event types?) was answered by examining the amount of time spend looking straight forward in the course of an event, and dividing it by 8 s to obtain the percentage of time the driver was looking forward. As shown in Figure 17, this ranged between 70% and 75% for the various event types, with baseline, digital billboard, and conventional billboard being close to equal. Statistical analysis showed that this measure did vary across event types ($F_{3,96} = 11.62$, $p < 0.0001$, using an α of 0.05 as a criterion, as is standard for studies of this type). The comparison events had significantly less eyes-on-road percent than did the other event types, which did not vary from one another.

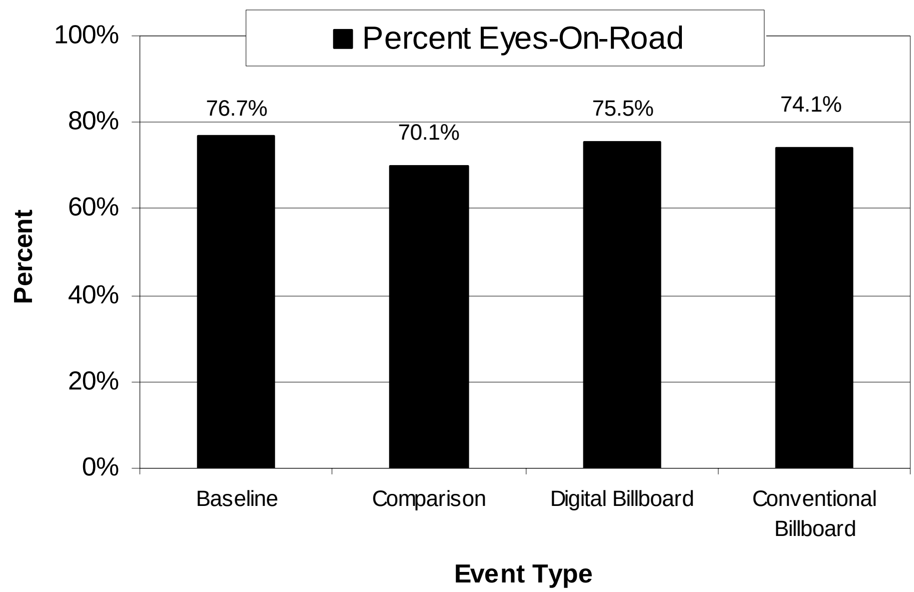

Figure 17. Percent Eyes-on-Road Time for the Four Event Types. (Comparison events were significantly lower than the other three event types, which did not differ from one another).

Question 2 (Is there a more active glance pattern in the presence of certain event types?) was measured by examining the number of individual glances to any location during the eight seconds of the event. A higher mean number of glances during the eight seconds indicated a more active scanning pattern. As shown in Figure 18, there were very few differences in the overall glance activity. The statistical analysis verified this observation, showing no significant differences between event types ($F_{3,96} = 1.78$, $p = 0.1564$).

Questions 1 and 2 were aimed at the larger question of whether overall driver eyeglance behavior changed in the presence of certain event types. In other words, did driver total time looking forward change in the presence of certain event types, and did drivers exhibit a more active glance pattern for certain event types? Except for lower eyes-on-road time for comparison events, there were no observed differences in overall eyeglance patterns. The next four questions are concerned with the specific eyeglance patterns that might be expected to occur if drivers were allocating more visual attention to specific objects located on the side of the road.

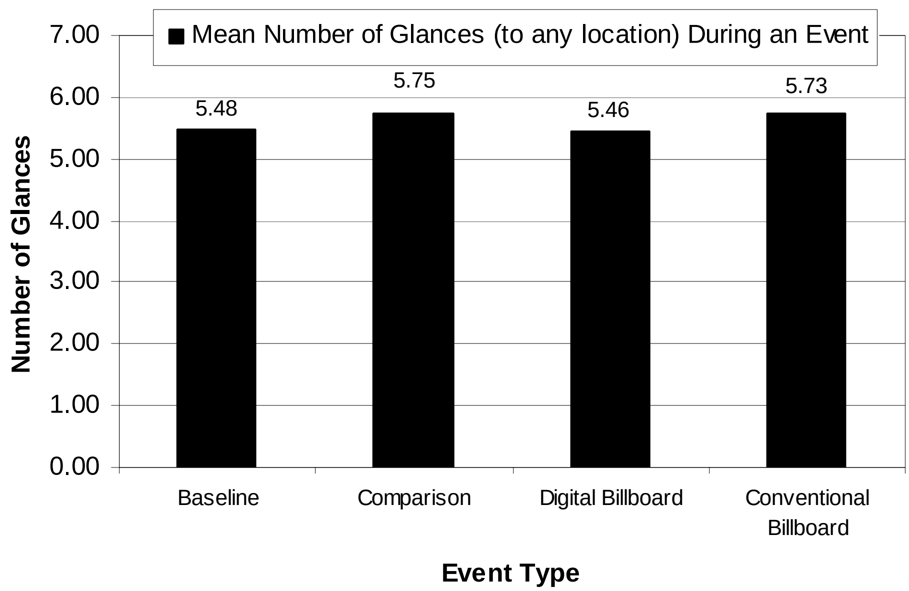

Figure 18. Mean Number of Glances to Any Location During an Event. (There were no significant differences between event types.)

Question 3 (For events on the left side of the road, are there more glances in the left forward direction for certain event types?) was aimed at the question of whether the presence of a site of interest on the side of the road was related to a greater number of glances in that direction. All baseline events were included in this analysis since these events were considered to have been located on both sides of the road. As can be seen in Figure 19, digital billboards to the left side of the road did garner a larger number of left forward glances during the eight seconds than did any of the other event types. However, statistical analysis showed that these differences were not significant ($F_{3, 73} = 1.49$, $p = 0.2244$).

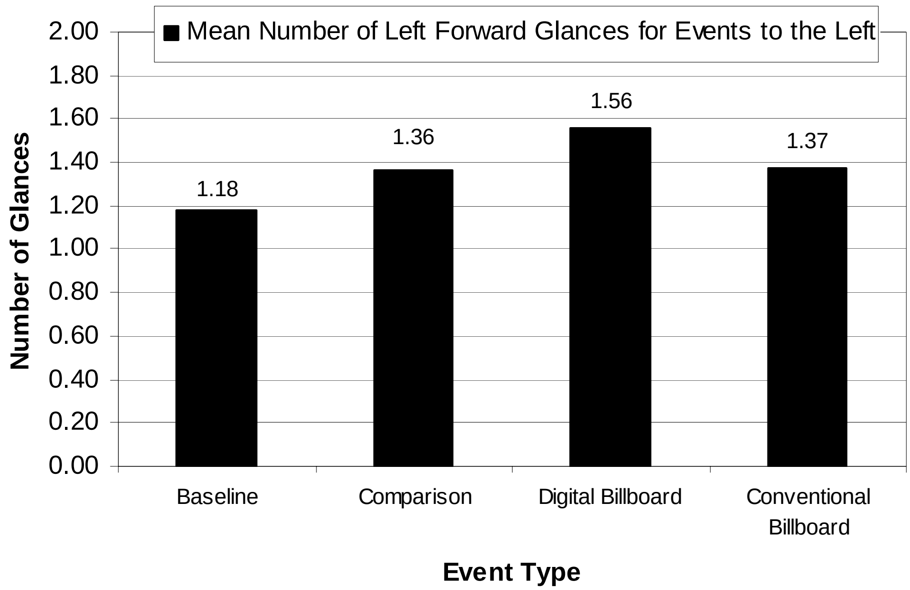

Figure 19. Mean Number of Left Forward Glances for Events on the Left Side of the Road. (There were no significant differences between event types.)

Question 4 (For events on the right side of the road, are there more glances in the right forward direction for certain event types?) was similar in intent, but used events on the right side of the road and right forward glances. Again, all baseline events were included in this analysis since these events were considered to have been located on both sides of the road. As can be seen in Figure 20, there appeared to be little difference in the number of right forward glances across event types. Statistical analysis showed that the observed differences were not significant ($F_{3,77} = 0.29$, $p = 0.8353$).

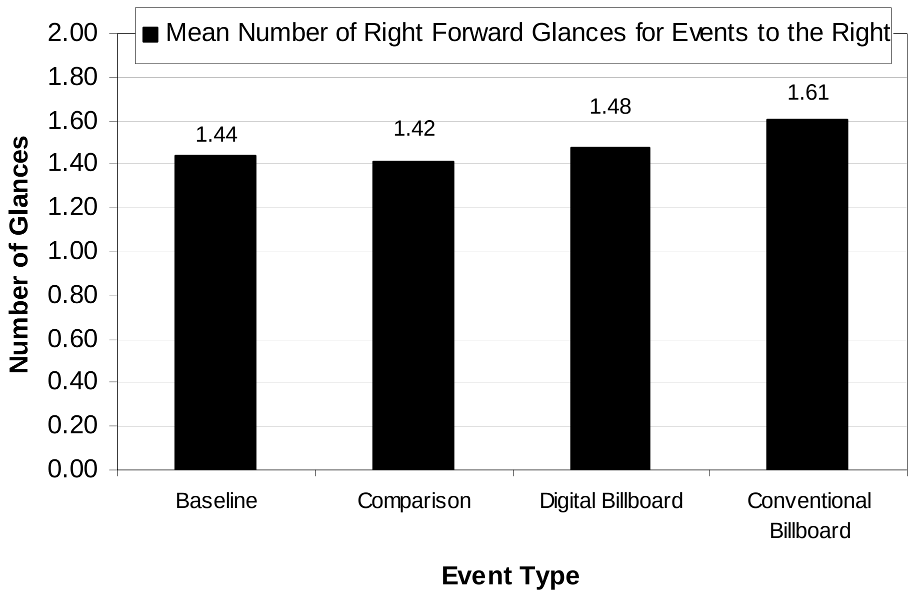

Figure 20. Mean Number of Right Forward Glances for Events on the Right Side of the Road. (None of the observed differences were significant.)

Question 5 (For events on the left side of the road, does the mean single glance time in the left forward direction vary according to event type?) was measured by examining the mean single glance time for left forward glances. Longer glances in the left forward direction for events to the left could indicate that the driver is paying greater visual attention to the event. Figure 21 shows that the digital billboard and comparison event types had longer mean single glance times than did baseline or conventional billboard events. Statistical analysis showed that these differences were significant ($F_{3,73} = 3.59$, $p = 0.0176$). Post hoc analysis showed that the digital billboards to the left had significantly longer left forward glances than did conventional billboards or baseline sites, but that they did not differ from comparison sites. Comparison sites differed from baseline sites, but not from conventional billboard sites, and conventional billboards and baseline sites did not differ from one another.

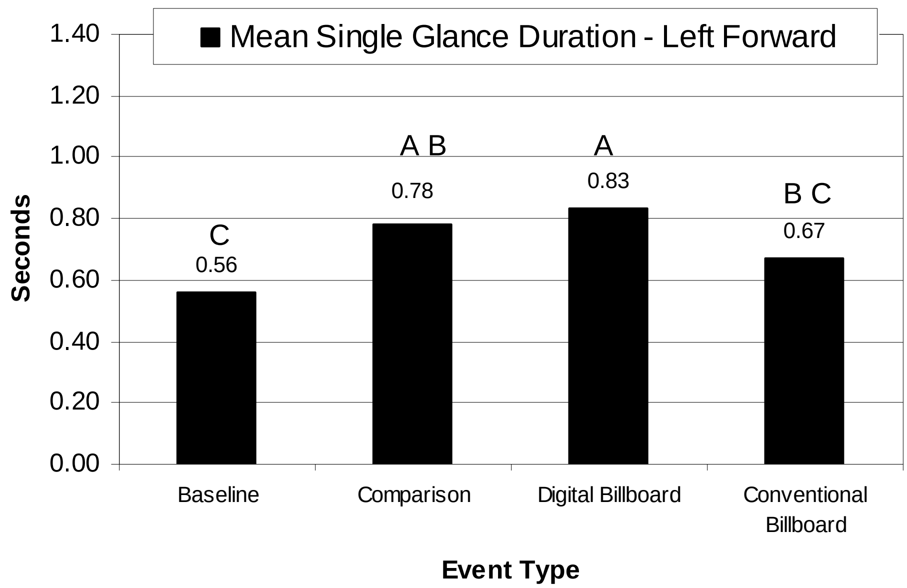

Figure 21. Mean Single Glance Time for Left Forward Glances for Events on the Left Side of the Road. (Data points with a shared letter do not differ significantly from one another.)

Question 6 (For events on the right side of the road, does the mean single glance time in the right forward direction vary according to event type?) was similar to Question 5 in approach, except that it examined right forward glances and events to the right. Statistical analysis showed that the observed differences were significant ($F_{3,77} = 3.73$, $p = 0.0147$). Post-hoc tests showed that digital billboards located on the right had significantly longer glance times to the right than did either baseline events or conventional billboards, but did not differ significantly from comparison events. Comparison events had longer glance times than did baseline events, but did not differ significantly from conventional billboards. Conventional billboards also had significantly longer glances than did baseline events.

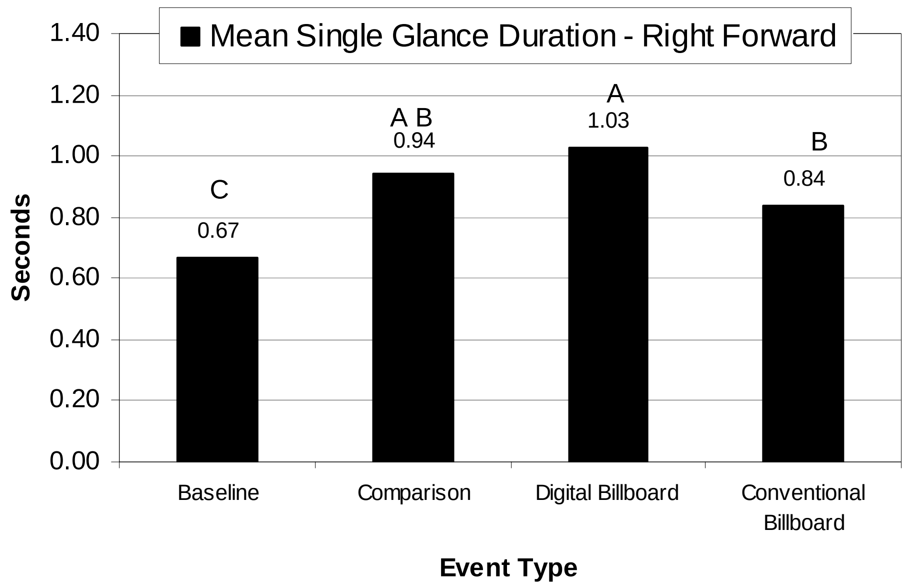

Figure 22. Mean Single Glance Time for Right Forward Glances for Events on the Right Side of the Road. (Data points with a shared letter do not differ significantly from one another.)

Question 7 (Are longer glances (longer than 1.6 s) associated more with any of the event types?) follows an approach provided by Horrey and Wickens (2007), who suggest analyzing the tails of the distributions whenever eyeglance analysis is performed. Various researchers have suggested that longer glances may be associated with poorer driving performance. For example, Wierwille (1993) suggests a 1.6 s criterion as representing a long glance away from the forward roadway. As shown in Figure 23, the distributions of glance duration were similar across all event types, and there was no obvious pattern of longer glances being associated with any of the event types.

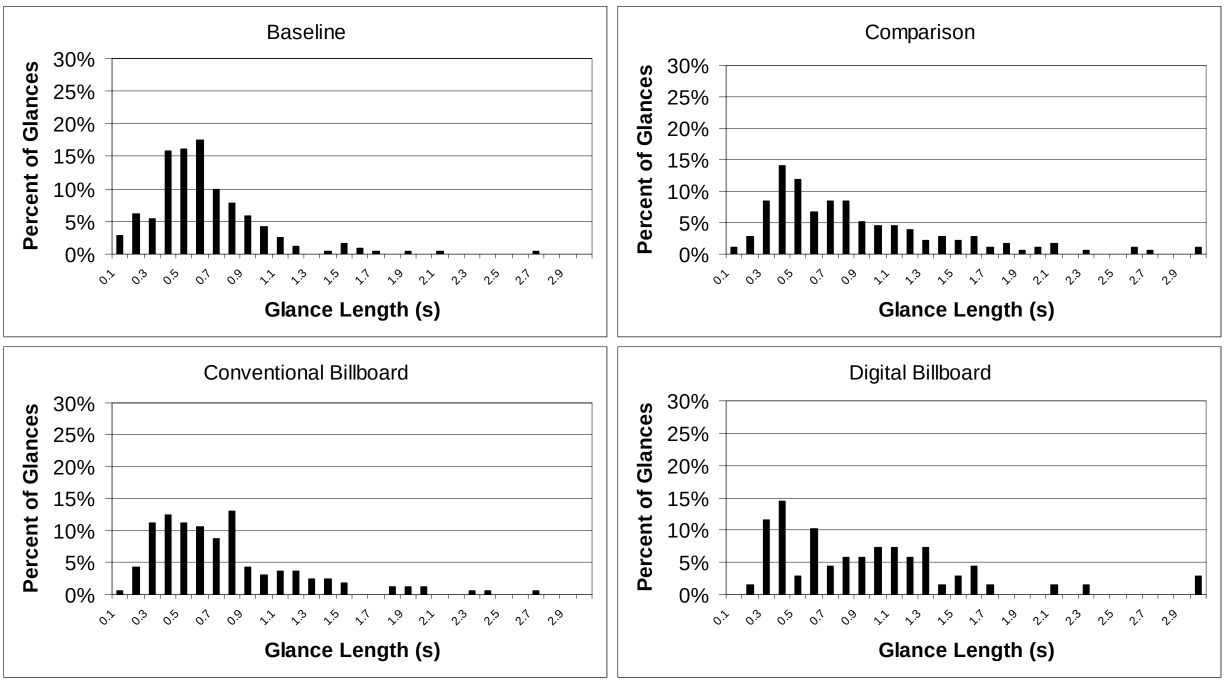

Figure 23. Tails analysis for the distribution of glance duration, (method described in Horrey and Wickens, 2007).

Discussion of Daytime Eyeglance Results. Results showed that digital billboards were not associated with changes in overall glance patterns (overall number of glances or percent eyes-on-road time). Likewise, digital billboards were not associated with more frequent glances towards the direction where the billboard was located. However, digital billboards in both the left and right directions were associated with longer glances in that direction.

There were only five digital billboards along the route (these were all that were available). This led to low statistical power for the digital comparisons, especially when the digital billboards were separated into left and right (two in one direction and three in the other). To increase power and verify the above findings, the data were next aggregated so that all glances in the direction where an event was located were included. For glance frequency, there were still no significant differences in the number of glances depending on event type ($F_{3, 91} = 1.22$, $p = 0.3065$). For glance duration, the findings from above were also confirmed with this combined analysis ($F_{3, 91} = 4.98$, $p = 0.0030$). Digital billboards and comparison sites did not differ from one another, but each differed from conventional billboards and baseline events. Conventional billboards and baseline events did not differ from one another; these results are shown in Figure 24.

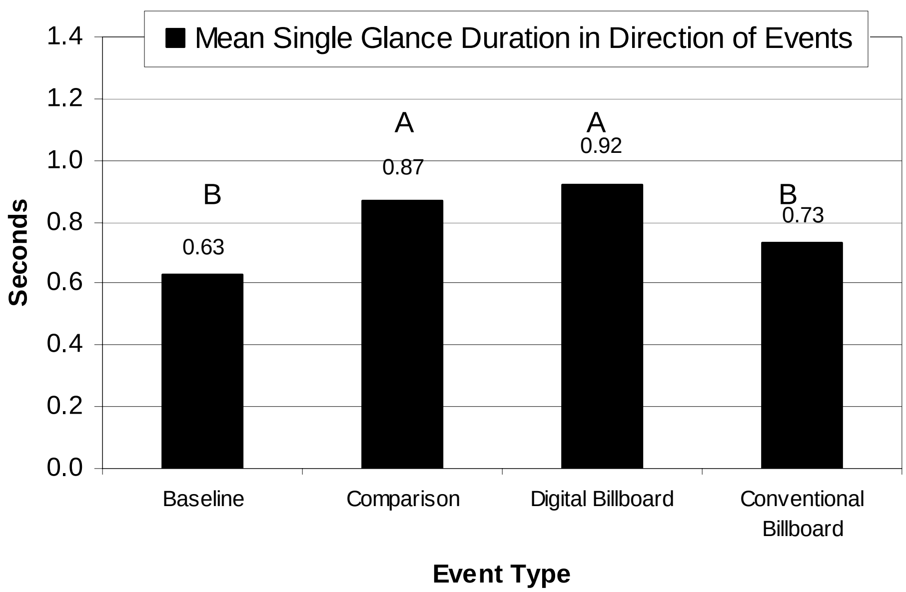

Figure 24. Mean Single Glance Time for Glances in the Direction of Events. (Data points with a shared letter do not differ significantly from one another.)

It should also be noted that digital billboards did not differ in glance duration from comparison events for left side, right side, or the combined comparison. Several of the comparison events had a digital component, but in the form of on-premises signing rather than as billboards. One comparison event used full motion video at times. Thus, it is not surprising that these event types revealed similar glance duration patterns. Finally, it should be noted that the results for conventional billboards were similar to those found in the Charlotte study, with very few differences between conventional billboards and either comparison events or baseline events.

Speed maintenance. As shown in Figure 25, there were differences in the standard deviation of speed for the different event types. These differences were statistically significant ($F_{3, 96} = 5.33$, $p = 0.0019$), with conventional billboards showing a higher speed deviation than baseline and digital billboards, but not different from comparison sites. Baseline events, comparison events, and digital billboards did not differ from one another. Much of this difference may be because there is typically greater speed deviation on surface streets than on interstates, and all of the digital billboards were on interstates. To account for this in the research design, the same analysis was conducted, but using only events occurring on interstates. In this analysis, there were no significant differences in standard deviation of speed ($F_{3, 96} = 1.66$, $p = 0.1819$), as shown in Figure 26.

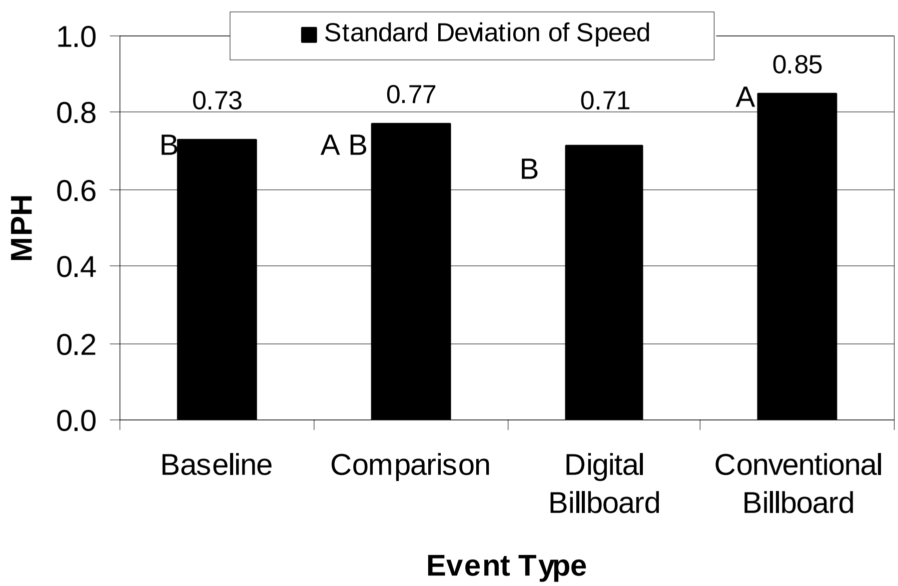

Figure 25. Standard Deviation of Speed by Event, in miles per hour. (Data points with a shared letter do not differ significantly from one another.)

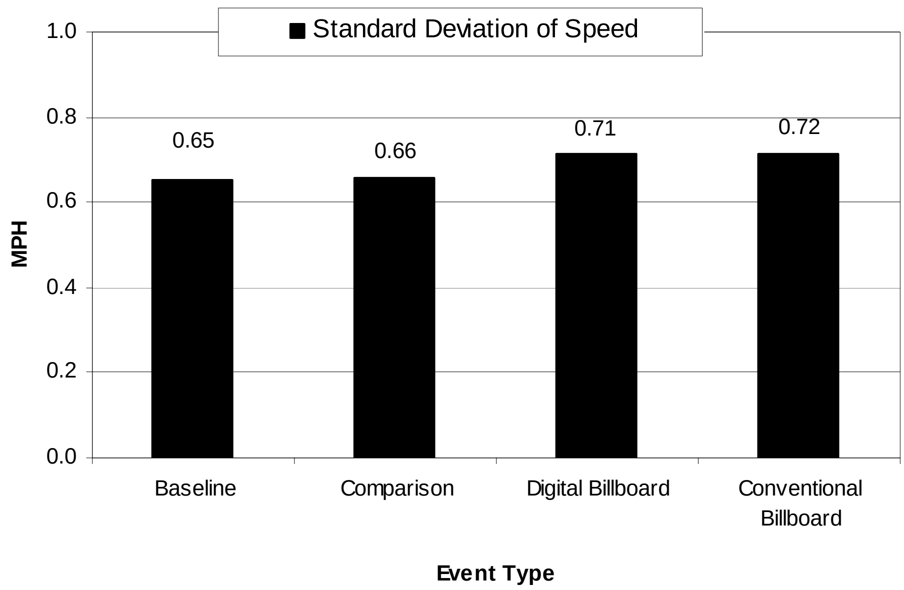

Figure 26. Standard Deviation of Speed by Event for Events Occurring on Interstates, in miles per hour. (None of the observed differences was significant.)

Lane keeping. The standard deviation of lane position was calculated for each event. Standard deviation was used instead of average lane position, because average lane position can be to the right or left, and thus an average would tend to wash out true differences, while standard deviation takes overall deviation into account, regardless of left or right. While there appeared to be differences in lane keeping for the different event types as shown in Figure 27, these differences did not quite reach significance ($F_{3, 91} = 2.46$, $p = 0.0673$). Nevertheless, the trend is that digital billboards and conventional billboards seem to be related to poorer lane keeping, and it is likely that a larger sample would have shown significance for this measure.

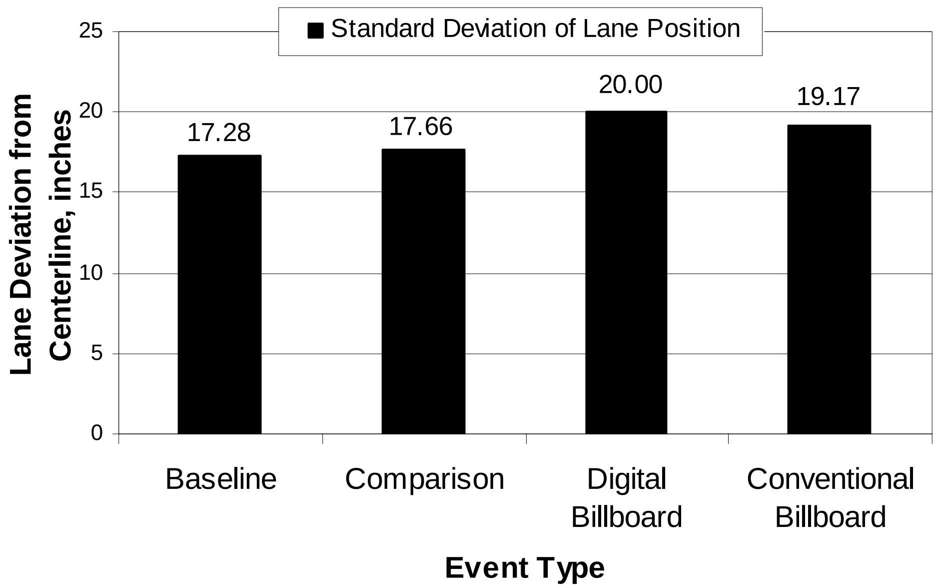

Figure 27. Standard Deviation of Lane Position by Event, in inches. (None of the observed differences was significant.)

Other findings

Road Type. There were significant differences in the two overall eyeglance measures, both of which indicated a more active glance pattern on surface streets. The eyes-on-road percentage was higher for interstate events than for surface street events (71% for interstate vs. 64% for surface streets; $F_{1, 32} = 30.29$, $p < 0.0001$). There were also more total glances during an event on surface streets as opposed to on the interstates (6.3 glances for interstate vs. 7.2 glances for surface streets; $F_{1, 32} = 10.51$, $p < 0.0028$). There were no significant differences for the eyeglance measures associated with the left or right side of the road. These findings are consistent with the findings of the Charlotte study, in that eyeglance patterns tend to be more active while driving on surface streets due to driver monitoring of driveways, intersections, and on-coming traffic.

Familiarity. Drivers spent significantly more time with their eyes on the road while driving on unfamiliar roads (73% for familiar roads and 75% for unfamiliar roads; $F_{1, 22} = 4.81$, $p = 0.0392$). However, this small significant difference likely has no practical implications, especially given that the overall glance frequency was not significant ($F_{1, 22} = 1.38$, $p = 0.2530$).

There were no significant differences for speed maintenance or lane keeping depending on familiarity with the route segment. These results are likely confounded by the fact that most of the road segments that drivers classified as familiar were the interstate portions of the route, while the unfamiliar roads tended to be the surface street sections.

Age. There were two age findings in the eyeglance measures. Older drivers had higher eyes-on-road percentage than did younger drivers (73% for older and 67% for younger; $F_{1, 32} = 4.46$, $p = 0.0426$). Younger drivers also had more frequent right forward glances for events to the right than did older drivers (younger = 1.55 right forward glances per event; older = 1.34 right forward glances per event; $F_{1, 32} = 4.42$, $p = 0.0436$). Younger drivers thus seemed to have a slightly more active glance pattern than older drivers, but this did not show up in very many of the eyeglance measures examined. There were no age differences for speed keeping or lane maintenance.

Gender. There were no significant findings for gender for eyeglance, speed maintenance, or lane keeping measures.

Driving Performance Results – Nighttime

Event Type

Eyeglance results. As mentioned previously, there were about one-third fewer data points for the nighttime portion of the study, which was considered an exploratory study. Thus, the results in this section are presented descriptively, without statistical analysis. Where the differences shown are strong, it is likely that a larger study would show statistical significance, while weak differences may or may not hold up with a larger study. Four eyeglance measures were examined for the nighttime data: eyes-on-road percent, overall glance frequency, mean glance duration in the direction of an event, and mean number of glances in the direction of an event. Eyes-on-road percent is presented in Figure 28, which shows that digital billboards and comparison events tended to have less eyes-on-road time at nighttime than either baseline events or conventional billboards. The overall glance frequency was also higher in the presence of digital billboards and comparison events at nighttime, as shown in Figure 29. These two findings taken together show a more active glance pattern at nighttime in the presence of these two event types, which mirrors some of the daytime findings.

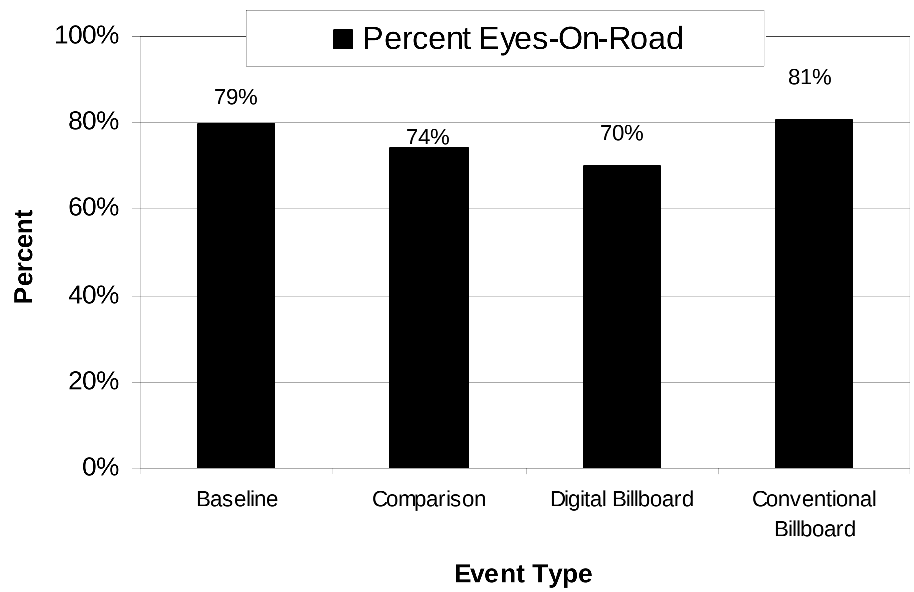

Figure 28. Eyes-on-Road Percent by Event Type for the Nighttime Exploratory Study.

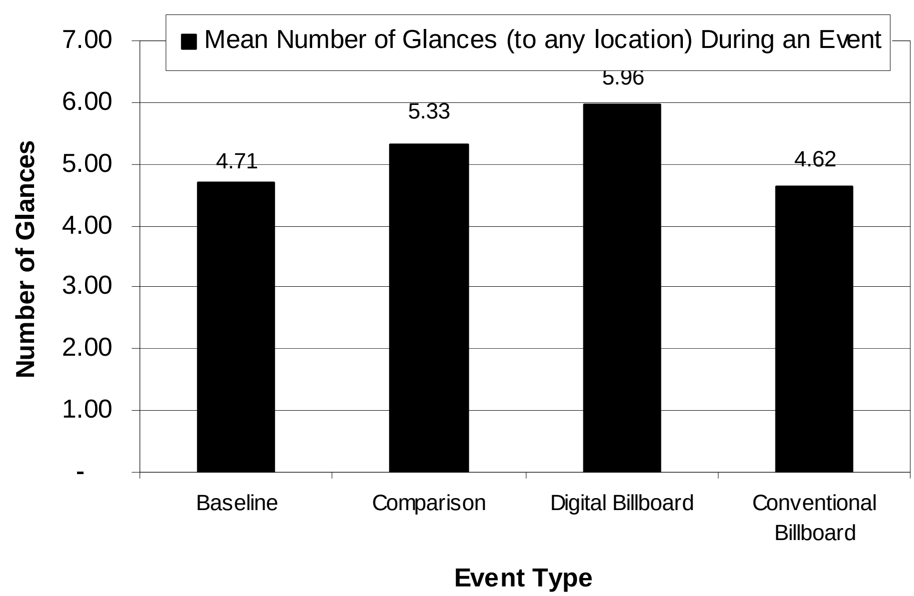

Figure 29. Overall Glance Frequency by Event Type for the Nighttime Exploratory Study.

The mean glance duration for glances in the direction of an event also showed higher values for digital billboards and comparison events; however, in this case, the comparison sites appeared to have longer glance times than did the digital billboards (Figure 30). The mean number of glances in the direction of an event again showed digital billboards and comparison events as having higher values than either baseline events or conventional billboards, as shown in Figure 31. Taken together, these four findings indicate that digital billboards and comparison events may result in more active glance patterns overall, as well as more frequent and longer glances towards the digital billboards and comparison events.

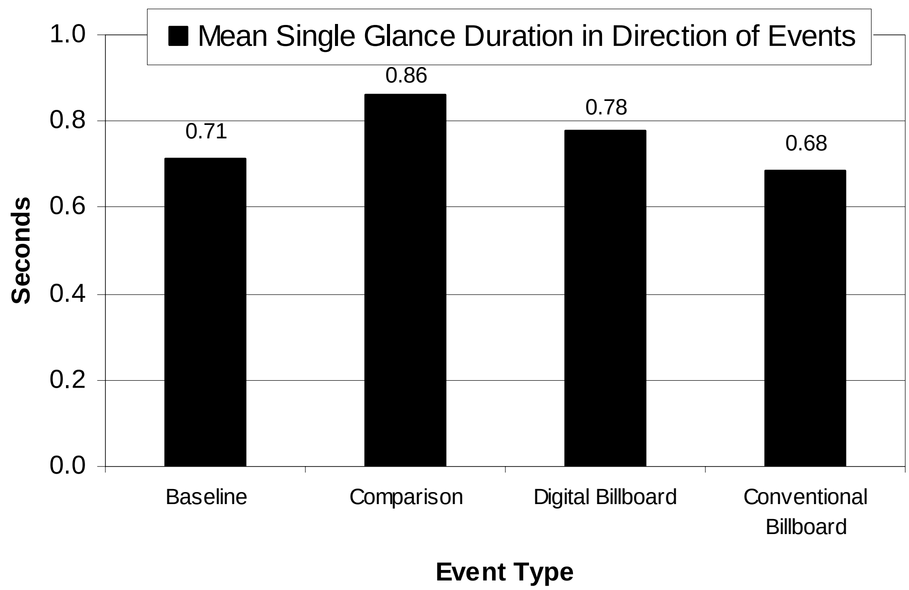

Figure 30. Mean Glance Time for Glances in the Direction of an Event for the Nighttime Exploratory Study.

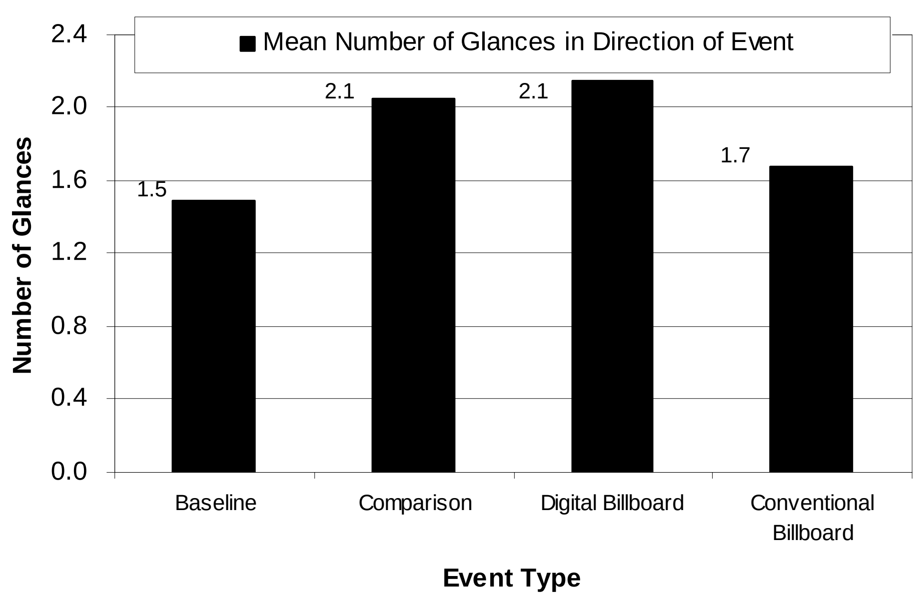

Figure 31. Mean Number of Glances in the Direction of an Event for the Nighttime Exploratory Study.

Speed maintenance. Figure 32 shows that the standard deviation of speed appeared to be higher in the presence of both conventional and digital billboards than for baseline and comparison events. If this effect is related to the event type, it may be due to the attempt to read the copy of these signs at night while driving. If this is true, the higher value shown for conventional billboards may indicate that these signs are more difficult to read at night than are the digital billboards.

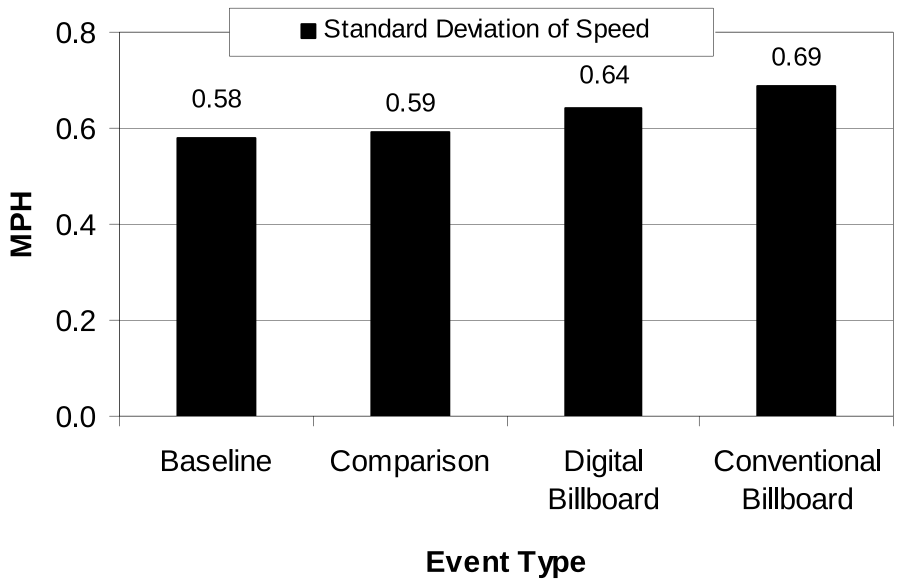

Figure 32. Speed Maintenance as Measured by the Standard Deviation of Speed by Event for the Nighttime Exploratory Study.

Lane keeping. Lane keeping also showed a trend towards greater lane deviations in the presence of both digital billboards and conventional billboards as shown in Figure 33. As was true for speed maintenance, conventional billboards showed higher values than did digital billboards. Again, this may be an indication of the difficulty of reading these signs at night.

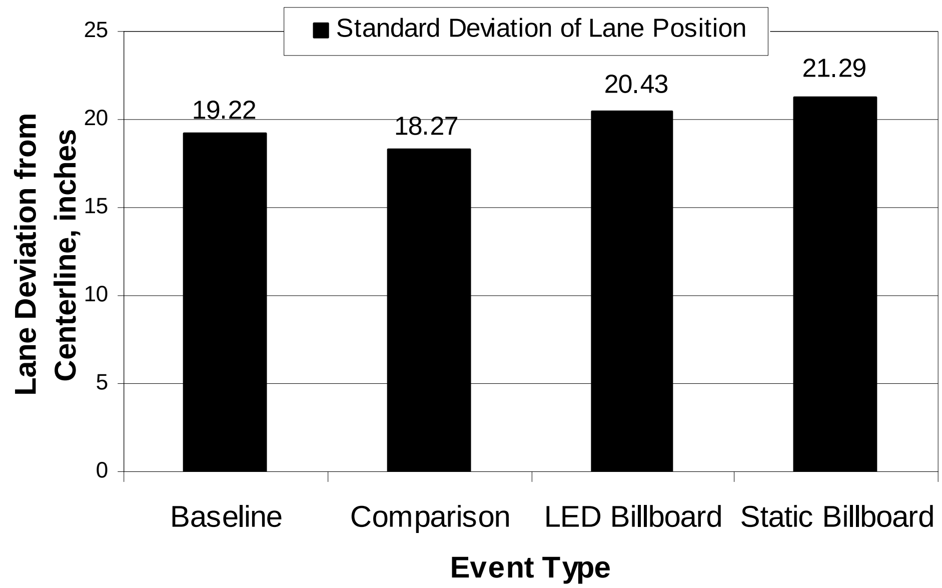

Figure 33. Lane Keeping as Measured by the Standard Deviation of Lane Position by Event for the Nighttime Exploratory Study.

Nighttime Luminance Measures

The luminance was measured with a Radiant Imaging Charge-Coupled Device (CCD) photometer with a 300 mm lens. The CCD photometer provided a method of capturing the luminance of an entire scene at one time. Luminance represents the amount of light that is projected off a surface in a given direction. For this investigation, the direction of interest was towards the driver. Luminance is measured in candelas per meter squared.

The photometer was located in the experimental vehicle as close to the driver's position as possible (Figures 34 and 35). The experimental vehicle was then driven to the sign location and stopped on the side of the road. Images of the sign were then acquired. For multiple face signs such as the digital and the tri-visions signs, each of the presented messages was imaged. Using the software provided with the system, the average luminance of the sign and each message was measured. The photometer was connected to a laptop computer in the back seat that stored the data as the images were acquired. All measurements were taken at night. Figure 36 shows the average luminance measures for each of the four event types measured in candelas per meter squared. Note that the digital billboards had noticeably higher luminance values than any of the other event types, even though their luminance was automatically reduced at night. This probably explains some of the driver performance findings in the presence of the digital billboards. The overall ranking of luminance by event (digital billboards were the highest, followed in order by comparison events, conventional billboards, and baseline events) closely mirrors the rankings of many of the performance measures for both daytime and nighttime, including eyeglance, speed maintenance, and lane keeping. Altogether, there were 74 measurements (17 for comparison events, 36 for digital billboards, 6 for conventional billboards, and 15 for baseline events). More readings were taken for the digital billboards because each message was measured individually.

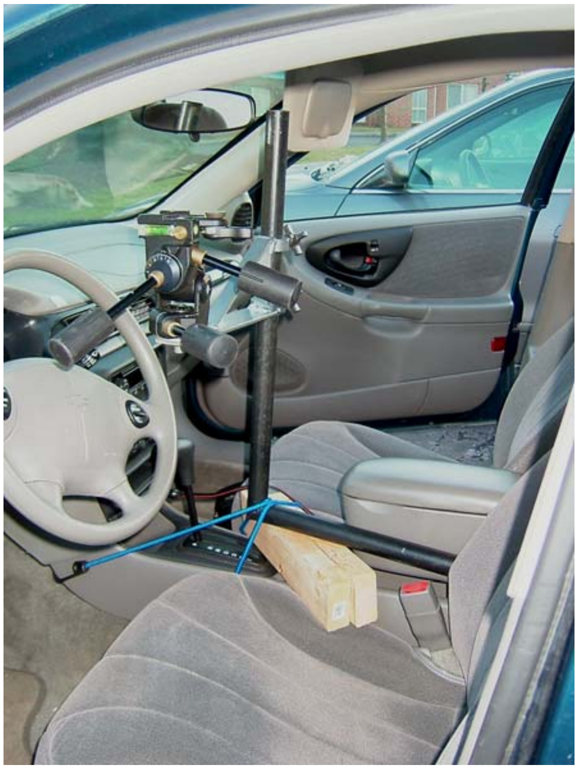

Figure 34. Bracket for Radiant Imaging CCD Photometer.

Figure 35. Radiant Imaging CCD Photometer in Position for Measurements, with Experimenter Making Final Adjustments.

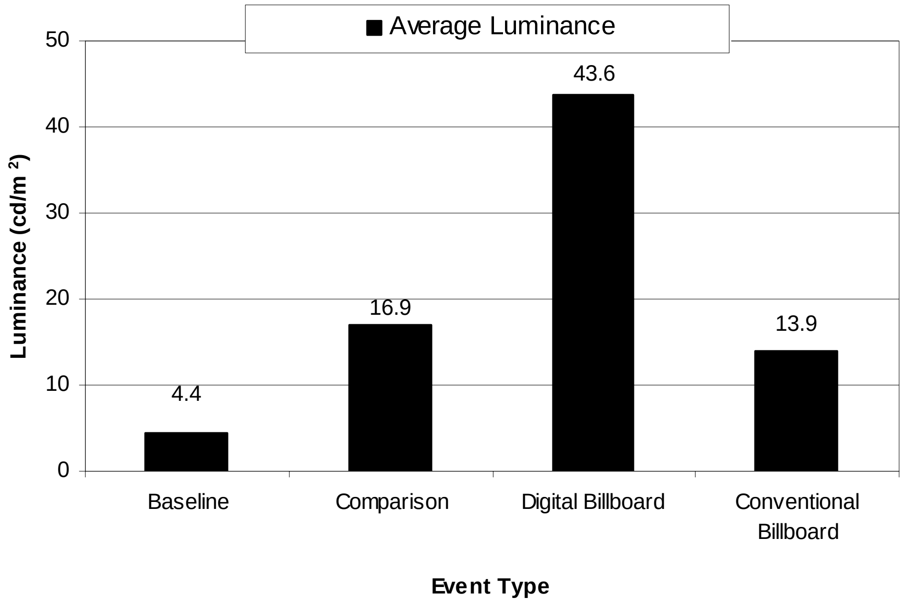

Figure 36. Average Luminance of the Four Event Types, in Candelas per Meter Squared.

COMPARISONS TO THE CHARLOTTE STUDY

There were several similarities and several differences between this study and the study conducted in Charlotte, NC. The original intent was to make the studies as similar as possible, and this was achieved to the degree possible, as demonstrated by the following items:

- Both were conducted in mid-sized cities (Charlotte population: 540,828; Cleveland population: 478,403; both figures taken from US Census 2000).
- Both were conducted in areas with similar terrain (fairly flat, with a few rolling hills; Charlotte elevation: 650 feet; Cleveland elevation: 581 feet).
- Both studies included conventional billboards, comparison events, and baseline events.
- Both studies showed similar results when conventional billboards were compared to baseline and comparison sites (very few differences in eyeglance measures, speed maintenance, or lane keeping for conventional billboards as compared to baseline events and comparison events).
- Both studies used 36 participants who performed the experiment in the daytime, equally divided into four age by gender cells (nine older males, nine older females, nine younger males, and nine younger females).
- Both included participants who lived and worked in the area and were familiar with at least some parts of the route.
- Both studies were conducted during similar times of day (between rush hours, from about 9 a.m. to 4 p.m.).
- Both studies included surface streets and interstates.
- Both studies used the same make and model of vehicle, and similar instrumentation.
- Both studies used the same basic protocols and questionnaires.
- The data were reduced and analyzed in a similar fashion using the same software tools.
- Both studies were sponsored by a foundation with strong ties to the outdoor advertising industry. Thus, in each study every effort was made to remove sources of potential bias. These efforts included:
    - Final selection of route and events were made by VTTI project staff;
    - Data collection and reduction was as automated as possible (speed and lane keeping data were totally automated, and involved no human intervention or interpretation); and
    - In the case of eyeglance data reduction, where human intervention and interpretation were necessary, data reductionists knew very little about the project, its focus, or its sponsor. They evaluated each event according to a number code, with no knowledge about whether the number represented a digital billboard, conventional billboard, comparison event, or baseline event.
    - In addition, the participants themselves did not know the true purpose of the study.

Differences between the two studies included the following items; these were motivated primarily by the difference in focus between the two studies:

- The focus of the Charlotte study was driver performance in relation to conventional billboards, while the focus of the Cleveland study was driver performance in relation to digital billboards.
- The comparison events in each study were chosen to be comparable to the events of interest. In the Charlotte study, the comparison events were chosen prior to data collection and were considered by the experimenters to be visually similar to conventional billboards. In the Cleveland study, the comparison events were again chosen prior to data collection and were considered by the experimenters to be visually similar to digital billboards.
- The Cleveland route was longer (50 miles, versus 35 miles for the Charlotte study; this was due to the need to include as many digital billboards as possible).
- The Cleveland subject pool was not as representative of the demographics of Cleveland as was the Charlotte subject pool (in terms of race and ethnicity). For example, Cleveland is approximately 41% Caucasian, while 97% of the participants were Caucasian. Charlotte is 58% Caucasian and 61% of the participants in that study were Caucasian.
- The Charlotte study examined the 7 seconds preceding each event, while the Cleveland study used 8 seconds (to increase the chances of capturing data for a message change for the digital billboards).
- The Cleveland study included digital billboards, which were not present in the Charlotte study.
- The Cleveland study included an exploratory nighttime study using 12 of the daytime participants.
- Luminance measures were obtained for the Cleveland study as part of the nighttime exploratory study.
- The Charlotte study included some US highway type roads that were not available in the Cleveland study.
- Because the digital billboards were all located on the interstate segments of the route, the road type and event type were confounded, unlike in the Charlotte study. To get around this, some of the analyses examined only events occurring on interstates.
- Because most of the drivers were more familiar with the interstate segments than with the surface streets, road type and familiarity were also confounded to a greater degree than in the Charlotte study. However, this interaction was not a primary focus of the current study.
- The Cleveland study was conducted in late fall and early winter, while the Charlotte study was conducted in late spring.

CONCLUSIONS

As with all studies, especially those conducted in real-world environments, the research design demonstrated both limitations and strengths. The study was designed to be as similar as possible to the study previously conducted in Charlotte, NC, with the major exception of the focus of the study (conventional billboards for Charlotte and digital billboards for Cleveland). The studies were similar in many important aspects with the exception of the location of the digital billboards. In the Charlotte study, billboards were present on all road types, while in Cleveland, all of the digital billboards were located along interstate highways. Thus, no conclusions can be made regarding the potential impact of digital billboards located on surface streets on driver behavior or performance. Despite this one flaw, necessitated by the real-world constraints of the digital billboard locations, the overall findings of this study were consistent and compelling.

The overall conclusion, supported by both the eyeglance results and the questionnaire results, is that the digital billboards seem to attract more attention than the conventional billboards and baseline sites (as shown by a greater number of spontaneous comments regarding the digital billboards and by longer glances in the direction of the billboards). The comparison events, 25% of which included signs with digital components, showed very similar results to the digital billboards. Thus, there appears to be some aspect of the digital billboards and on-premises signs that holds the driver's attention once the driver has glanced in that direction. This is most likely the result of the intrinsic lighting of these signs, which is noticeable even during the daytime. Drivers may also have maintained longer glances towards the digital billboards in the hopes of catching the next message (knowing that the message changed periodically), although an analysis of longer glances did not bear this out.

Although exploratory in nature, the nighttime results were very similar to the daytime results, with degraded eyeglance performance for digital billboards and comparison events. The digital billboards were also found to have much higher luminance at nighttime than any of the other event types.

These particular LED billboards were considered safety-neutral in their design and operation from a human factors perspective: they changed only once every eight seconds, they changed instantaneously with no special effects or video, they looked very much like conventional billboards, and their luminance was attenuated at night. It is thus quite likely that digital signs with video, movement, higher luminance, shorter on-message duration, longer transition times, and special effects would also be related to differences in driver behavior and performance. Because of the lack of crash causation data, no conclusions can be drawn regarding the ultimate safety of digital billboards. Although there are measurable changes in driver performance in the presence of digital billboards, in many cases these differences are on a par with those associated with everyday driving, such as the on-premises signs located at businesses. Conventional billboards were shown both in the current study and in the Charlotte study to be very similar to baseline and comparison events in terms of driver behavior and performance; thus, the design of digital billboards should be kept as similar as possible to conventional billboards.

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APPENDICES

Appendix A: Initial Participant Telephone Screening Form

FOARE Cleveland Participant Screening Script

Note to Researcher:
Initial contact between participants and researchers may take place over the phone. If this is the case, read the following Introductory Statement, followed by the questionnaire. Regardless of how contact is made, this questionnaire must be administered verbally before a decision is made regarding suitability for this study.

Introductory Statement:
After prospective participant calls or you call him/her, use the following script as a guideline in the screening interview.

Hello. My name is Melinda McElheny and I'm a researcher with the Virginia Tech Transportation Institute in Blacksburg, Virginia. The project involves participation in a driving study to help researchers understand how people drive.

This study involves coming to a meeting room at the Residence Inn by Marriott in Independence, OH, just south of Cleveland on I-77 one time for approximately 2 hours. During this session you would help us by driving one of our vehicles along a pre-selected route for about 50 miles. The vehicle will be equipped with data collection equipment. Does this sound interesting to you?

Next, I would like to ask you several questions to see if you are eligible to participate.

Questions

1. Do you have a valid driver's license?

   Yes _____ No _____

2. How often do you drive each week?

   Every day ____ At least 2 times a week___ Less than 2 times a week_____

3. How old are you? ______ (stop if not 18-35 years old or 50-75 years old.)

4. What type of vehicle do you usually drive?__________________________

5. Have you previously participated in any experiments at the Virginia Tech Transportation Institute? If so, can you briefly describe the study?

   Yes _____ ____
   No _____

6. How long have you held your drivers' license? ________________________________

7. Are you able to drive an automatic transmission without assistive devices or special equipment? Yes _____ No _____

8. Do you have a history of any of the following? If yes, please explain.

Stroke	No____	Yes___
Brain tumor	No____	Yes___
Head injury	No____	Yes___
Epileptic seizures	No____	Yes___
Respiratory disorders	No____	Yes___
Motion sickness	No____	Yes___
Inner ear problems	No____	Yes___
Dizziness, vertigo, or other balance problems	No____	Yes___
Diabetes	No____	Yes___
Migraine, tension headaches	No____	Yes___

9. (Females only, of course) Are you currently pregnant?

Yes _____ No _____ (If "yes" then read the following statement to the participant: *"It is not recommended that pregnant women participate in this study. However, female participants who are pregnant and wish to participate must first consult with their personal physician for advice and guidance regarding participation in a study where risks, although minimal, include the possibility of collision and airbag deployment."*)

10. Are you currently taking any medications on a regular basis? If yes, please list them.

Yes _____ ____
No _____

11. Do you have normal or corrected to normal hearing and vision? If no, please explain.
Yes _____
No _____ ____

12. Have you ever had radial keratotomy, LASIK, or other eye surgeries? If yes, please specify.
Yes _____ ____
No _____

I would like to take your name, phone number or phone numbers, and/or email where you can be reached and hours/days when it's best to reach you.

Name ____ Male/Female

Phone Numbers ____ Age: _______

Best Time to Call ____

Email ____________________________

When contacting participants for scheduling purposes, the following statement must be included in the conversation. "*We ask that all participants refrain from drinking alcohol and taking any substances that will impair their ability to drive prior to participating in our study.*"

Criteria for Participation:

1. ***Must hold a valid driver's license.***
2. ***Must be 18-35 or 50-75 years of age.***
3. ***Must drive at least 2 times a week.***
4. ***Must have normal (or corrected to normal) hearing and vision.***
5. ***Must be able to drive an automatic transmission without special equipment.***
6. ***Cannot have lingering effects of brain damage from stroke, tumor, head injury, recent concussion, or infection. Cannot have had epileptic seizures within 12 months, respiratory disorders, motion sickness, inner ear problems, dizziness, vertigo, balance problems, diabetes for which insulin is required, chronic migraine or tension headaches.***
7. ***Cannot currently be taking any substances that may interfere with driving ability (cause drowsiness or impair motor abilities).***
8. ***No history of radial keratotomy, LASIK eye surgery, or any other ophthalmic surgery.***
9. ***Must be willing to drive without sunglasses or tinted lenses.***
10. ***Must live or work in the Cleveland area.***

A total of 2 hours of time will be needed. What days and times would you be able to participate?

Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
9:30	9:30	9:30	9:30	9:30	9:30	9:30
11:45	11:45	11:45	11:45	11:45	11:45	11:45
2:00	2:00	2:00	2:00	2:00	2:00	2:00

Thank you for your time. I will contact you to schedule a session if you are selected as a participant.

Appendix B: Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants
of Investigative Projects

Title of Project: Influence of driver characteristics on driving performance

Investigators: Dr. Suzanne E. Lee, Research Scientist, Virginia Tech Transportation Institute.

Dr. Ronald B. Gibbons, Research Scientist, Virginia Tech Transportation Institute.

Melinda J. McElheny, Senior Research Specialist, Virginia Tech Transportation Institute.

I. The Purpose of this Research Project

This study will collect driver performance data to help understand the way people drive in a natural environment (with no experimenter present). The goal of this study is improve the understanding of how people drive.

II. Procedures

For this study you will be asked to drive on a loop-route on freeways and highways in Cleveland, Ohio. We want you to drive as you normally would on any roadway, following the typical laws and regulations of the road. The session is expected to last about two hours, including this orientation. You will then be paid for your participation.

This vehicle contains sensors and data processing equipment that will capture aspects of your driving behavior. Small video cameras are also mounted in the vehicle. One of these cameras will be directed toward your face while you are driving. The equipment has been installed in such a way that you will hardly be able to notice its presence. It will not interfere with your driving, and there is nothing special that you will need to do in regard to the equipment.

This experiment will consist of five experimental stages:

1. Introductory stage

This stage consists of preliminaries. You will be asked to read the informed consent form. Once you have signed this form, we will also ask to see your driver's license, and an eye exam will be administered. Finally, we will have you complete a medical questionnaire. Once you have completed this stage we will go on to stage 2.

2. Familiarization with the test vehicle

While the instrumented vehicle is parked you will be shown how to operate the vehicle (for example, lights, mirror adjustments, windshield wipers, etc.) as this may be different from your personal vehicle. You will then be asked to set each control to the best level for your comfort and driving performance. You will then take a short drive with the experimenter riding along in the passenger's seat to become familiar with the vehicle. This stage should take approximately 15 minutes.

3. Preparation for loop route
The experimenter will then review the loop-route with you. You will be given a map and written directions that the experimenter will review with you.

4. Driving the loop route
You will then drive the instrumented vehicle for approximately 1.5 hours over the pre-planned loop route of approximately 50 miles. You are expected to follow the posted speed limit and to wear your seatbelt. Also, please stay in the right-hand lane to the extent possible during the drive. The loop route is to be completed in one session if possible.

5. Debriefing and Payment
After completing the experiment, you will return here for a short debriefing session. You will then be paid for your participation. It is expected that the complete session will last approximately 2 hours, including orientation, loop-route, and debriefing.

III. Risks

<u>The experiment is believed to be minimal risk.</u> There are risks or discomforts to which you are exposed in volunteering for this research. The risks in this study are the same as the risks normally associated with driving on public roadways. The risks involved include the following:

1) The risks normally associated with driving on commonly encountered roadway segments at freeway speeds, and if you are participating in the nighttime driving study, the risks include those normally associated with driving on similar roadway segments at night.
2) Possible fatigue due to the length of the experiment. However, the route will be selected to minimize the amount of driving required. You will be instructed to exit the roadway to take a break if you feel the need to do so at any time during the experimental session.
3) Cameras will videotape you as you drive the vehicle; therefore, we will ask you not to wear sunglasses. However, you should feel free to put on your sunglasses if this request at any time impairs your ability to drive the vehicle safely.

The following precautions will be taken to ensure minimal risk to you:

1) The experimenter will monitor you during the orientation drive and help you become familiar with the experimental vehicle. However, as long as the you are driving the research vehicle, it remains your responsibility to drive in a safe, legal manner.
2) You will be required to wear the lap and shoulder belt restraint system while in the car. The vehicle is also equipped with a driver's side airbag supplemental restraint system.
3) If an accident does occur, you will be instructed to call appropriate emergency services via a cell phone in the glove compartment, and then to call the experimenter. If a visit to a medical facility is required, you would be required to undergo examination by medical personnel.

4) A cell phone (stored in the glove compartment) will be made available for you to call the experimenter for any reason. You will be instructed to call only while the vehicle is in a safe location, and while the vehicle is not in motion.
5) All data collection equipment will be mounted such that, to the greatest extent possible, it does not pose a hazard to you in any foreseeable case.
6) None of the data collection equipment or the display technology interferes with any part of your normal field of view present in the automobile.

IV. Benefits of this Research Project
The information collected from this project will provide new information on how people tend to drive in a natural setting. This information will be used to improve roadway and vehicle design, so that roadside and in-vehicle devices can be better designed to fit in with what people expect. While there are no direct benefits of participating in this study, you may find the experiment interesting. No guarantee of benefits has been made to encourage you to participate. However, to avoid biasing other potential participants, you are requested not to discuss this study with anyone for at least 8 months after participation.

V. Extent of Anonymity and Confidentiality
The results obtained from this study will be kept completely anonymous. Your name will not appear on data derived from your session. Only a number will differentiate your data from others who take part in the study. This number, and not your name, will also be used in subsequent data analyses and reports.

As indicated, video will be recorded while you are driving. The video includes an image of your face, so that we can determine where you are normally looking. The video will be treated with confidentiality and kept secure. It will be shared only with other qualified researchers, and not published except as noted in the following paragraph.

If at a later time we wish to use the video information for other than research purposes, say, for public education, or if we wish to publish (for research or for other purposes) your likeness or other information from the study that identifies you either directly or indirectly, we will only do so after we have contacted you again and obtained your explicit permission.

VI. Compensation
You will be paid $20 per hour for the time you actually spend in the experiment. It is estimated that the entire session, including orientation, driving, and debriefing will be 2 hours. Payment will be made in cash immediately after you have finished your participation.

VII. Freedom to Withdraw
You are free to withdraw at any time without penalty. If you choose to withdraw from this study you will be compensated for your time up until that point.

VIII. Medical Treatment and Insurance

If you should become injured in an accident, the medical treatment available to you would be that provided to any driver or passenger by emergency medical services in the vicinity where the accident occurs. The vehicle you will be driving is insured for automobile liability and collision/comprehensive through Virginia Tech and the Commonwealth of Virginia. There is medical coverage for you under this policy. The total policy amount per occurrence is $2,000,000. This coverage would apply in case of an accident, except as noted below.

Under certain circumstances, you may be deemed to be driving in the course of your employment, and your employer's worker's compensation provisions may apply in lieu of the Virginia Tech and Commonwealth of Virginia insurance provisions, in case of an accident. The particular circumstances under which worker's compensation would apply are specified in Virginia law. If worker's compensation provisions do not apply in a particular situation, the Virginia Tech and Commonwealth of Virginia insurance provisions will provide coverage.

Briefly, worker's compensation would apply if your driving for this research can be considered as part of the duties you perform in your regular job. If it is not considered as part of your regular job, then the insurance policy would apply.

IX. Approval of Research

You should know that this research project has been approved, as required by the Institutional Review Board for Research Involving Human Participants at Virginia Polytechnic Institute and State University, and the Virginia Tech Transportation Institution.

X. Participant's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

1) I should not participate in this study if I do not have a valid driver's license or if I am not in good health.

2) I should notify the experimenter if at any time I do not want to continue my participation.

3) I should operate the instrumented vehicle in a safe and responsible manner.

4) I should answer all questions truthfully.

XI. Participant's Permission

Check one of the following:

☐ I have **not** had an eye injury/eye surgery (including, but not limited to, LASIK, Radial Keratotomy, and cataract surgery.)

☐ I **have** had an eye injury/eye surgery and I've have been informed of the possible risks to participants who have had eye surgery. I choose to accept this possible risk to participate in this study.

Participant #________

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

____

Signature **Date**

Should I have any questions about this research project or its conduct, I may contact:

Dr. Suzanne E. Lee, Principal Investigator (540) 231-1511
Melinda J. McElheny, Senior Research Specialist (540) 231-1557
David Moore, Chair of the Virginia Tech Institutional Review Board (540) 231-4991

Participants must be given a complete copy (or duplicate original) of the signed Informed Consent.

Appendix C: Health Screening Questionnaire

Health Screening Questionnaire

1. Are you in good general health? Yes No

   If no, list any health-related conditions you are experiencing or have experienced in the recent past.

   ____
   ____
   ____

2. Have you, in the last 24 hours, experienced any of the following conditions?

Inadequate sleep	Yes	No
Hangover	Yes	No
Headache	Yes	No
Cold symptoms	Yes	No
Depression	Yes	No
Allergies	Yes	No
Emotional upset	Yes	No

3. Do you have a history of any of the following?

   Visual Impairment Yes No

   (If yes, please describe.)

   ____
   ____
   ____

   Seizures or other lapses of consciousness Yes No

   (If yes, please describe.)

   ____
   ____
   ____

   Any disorders similar to the above or that would impair your driving ability Yes No

   (If yes, please describe.)

   ____

____
____

4. List any prescription or non-prescription drugs you are currently taking or have taken in the last 24 hours.

____
____

5. List the approximate amount of alcohol (beer, wine, fortified wine, or liquor) you have consumed in the last 24 hours.

____
____

6. Are you taking any drugs of any kind other than those listed in 4 or 5 above?

Yes No

______________________________________ ______________________

Signature Date

Participant #________

Appendix D: Post Drive-Questionnaire

Thank you for participating in this driving study. We appreciate your responses to the following items. All information will remain confidential.

1. Please check either "Familiar" (driven at least once a week) or "Not Familiar" (driven less than one time a week) for the following roadway sections:

I-480between I-77 and 150th	_____Familiar	_____Not Familiar
W.130th –Bellaire–W.117th	_____Familiar	_____Not Familiar
I-90 between 9th and 185th	_____Familiar	_____Not Familiar
Carnegie St.	_____Familiar	_____Not Familiar
I-77 between I-90 and Rockside	_____Familiar	_____Not Familiar

---

2. For the following systems, please check what you liked or disliked:

Seating	_____like	_____neutral	_____dislike
Air conditioning	_____like	_____neutral	_____dislike
Engine power	_____like	_____neutral	_____dislike
Visibility	_____like	_____neutral	_____dislike
Steering	_____like	_____neutral	_____dislike

---

3. Please check the top five items that most caught your attention during your drive:

_____Surrounding traffic
_____Other drivers
_____Construction areas
_____Road/street signs
_____Emergency vehicles
_____Buildings
_____Landmarks
_____Walls
_____Landscaping/scenery
_____Gas Stations
_____Restaurants
_____Motels/Hotels
_____Billboards
_____Towers
_____Highway/Exit Signs
_____Smoke Stacks
_____Apartments/housing
_____Other________________________

---

4. Did you experience any problems while following the written directions? ___Yes ___No
   If yes, please describe:

---

5. What was most memorable about the drive? For example, where there any objects that stood out?

---

6. What other activities do you typically engage in while driving?

---

7. Does anything about other drivers bother you? If so, please briefly describe:

---

8. Please provide any other input about this study:

---

9. In what city do you live?

---

10. In what city do you work?

---

11. What level of education have you completed?

    _____Elementary/Secondary
    _____Junior High School
    _____High School degree
    _____2-yr Associate degree
    _____Bachelor's degree
    _____Master's degree
    _____Doctoral/Professional degree

---

12. Please indicate your marital status:

    _____single _____married _____widowed _____divorced _____separated

---

13. Which of the following groups best represent your ethnicity?
    _____African American
    _____Hispanic (Latino)
    _____Asian

_____Native American (American Indian)
_____European (Caucasian, White)
_____Multi-racial

---

14. Which of the following best represents your annual household income?
_____$0-$24,999
_____$25,000-$49,999
_____$50,000-$74,999
_____$75,000-$99,999
_____ > $100,000

---

15. What was the purpose of this study?

Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject: **<u>INFORMATION</u>:** Guidance on Off-Premise Changeable Message Signs

Date: September 25, 2007

Original signed by:

From: Gloria M. Shepherd
Associate Administrator for
Planning, Environment, and Realty

In Reply Refer To:
HEPR -20

To: Division Administrators
Attn: Division Realty Professionals

Purpose

The purpose of this memorandum is to provide guidance to Division offices concerning off-premises changeable message signs adjacent to routes subject to requirements for effective control under the Highway Beautification Act (HBA) codified at 23 U.S.C. 131. It clarifies the application of the Federal Highway Administration (FHWA) July 17, 1996 memorandum on this subject. This office may provide further guidance in the future as a result of additional information received through safety research, stakeholder input, and other sources.

Pursuant to 23 CFR 750.705, a State DOT is required to obtain FHWA Division approval of any changes to its laws, regulations, and procedures to implement the requirements of its outdoor advertising control program. A State DOT should request and Division offices should provide a determination as to whether the State should allow off-premises changeable electronic variable message signs (CEVMS) adjacent to controlled routes, as required by our delegation of responsibilities under 23 CFR 750.705(j). Those Divisions that already have formally approved CEVMS use on HBA controlled routes, as well as those that have not yet issued a decision, should re-evaluate their position in light of the following considerations. The decision of the Division should be based upon a review and approval of a State's affirmation and policy that: (1) is consistent with the existing Federal/State Agreement (FSA) for the particular State, and (2) includes but is not limited to consideration of requirements associated with the duration of message, transition time, brightness, spacing, and location, submitted for FHWA approval, that evidence reasonable and safe standards to regulate such signs are in place for the protection of the motoring public. **Proposed laws, regulations, and procedures that would allow permitting CEVMS subject to acceptable criteria (as described below) do not violate a prohibition against "intermittent" or "flashing" or "moving" lights as those terms are used in the various FSAs that have been entered into during the 1960s and 1970s.**

This Guidance is applicable to conforming signs, as applying updated technology to nonconforming signs would be considered a substantial change and inconsistent with the requirements of 23 CFR 750.707(d)(5). As noted below, all of the requirements in the HBA and its implementing regulations, and the specific provisions of the FSAs, continue to apply.

Background

The HBA requires States to maintain effective control of outdoor advertising adjacent to certain controlled routes. The reasonable, orderly and effective display of outdoor advertising is permitted in zoned or unzoned commercial or industrial areas. Signs displays and devices whose size, lighting and spacing are consistent with customary use determined by agreement between the several States and the Secretary, may be erected and maintained in these areas (23 U.S.C. § 131(d)). Most of these agreements between the States and the Secretary that determined the size, lighting and spacing of conforming signs were signed in the late 1960's and the early 1970's.

On July 17, 1996, this Office issued a Memorandum to Regional Administrators to provide guidance on off-premise changeable message signs and confirmed that FHWA has "always applied the Federal law 23 U.S.C. 131 as it is interpreted and implemented under the Federal regulations and individual Federal/State agreements.". It was expressly noted that "in the twenty-odd years since the agreements have been signed, there have been many technological changes in signs, including changes that were unforeseen at the time the agreements were executed. While most of the agreements have not changed, the changes in technology require the State and FHWA to interpret the agreements with those changes in mind". The 1996 Memorandum primarily addressed tri-vision signs, which were the leading technology at the time, but it specifically noted that changeable message signs "regardless of the type of technology used" are permitted if the interpretation of the FSA allowed them. Further advances in technology and affordability of LED and other complex electronic message signs, unanticipated at the time the FSAs were entered into, require the FHWA to confirm and expand on the principles set forth in the 1996 Memorandum.

The policy espoused in the 1996 Memorandum was premised upon the concept that changeable messages that were fixed for a reasonable time period do not constitute a moving sign. If the State set a reasonable time period, the agreed-upon prohibition against moving signs is not violated. Electronic signs that have stationary messages for a reasonably fixed time merit the same considerations.

Discussion

Changeable message signs, including Digital/LED Display CEVMS, are acceptable for conforming off-premise signs, if found to be consistent with the FSA and with acceptable and approved State regulations, policies and procedures.

This Guidance does not prohibit States from adopting more restrictive requirements for permitting CEVMS to the extent those requirements are not inconsistent with the HBA, Federal regulations, and existing FSAs. Similarly, Divisions are not required to concur with State proposed regulations, policies, and procedures if the Division review determines, based upon all relevant information, that the proposed regulations, policies and procedures are not consistent with the FSA or do not include adequate standards to address the safety of the motoring public. If the Division Office has any question that the FSA is being fully complied with, this should be discussed with the State and a process to change the FSA may be considered and completed before such CEVMS may be allowed on HBA controlled routes. The Office of Real Estate Services is available to discuss this process with the Division, if requested.

If the Division accepts the State's assertions that their FSA permits CEVMS, in reviewing State-proposed regulations, policy and procedures for acceptability, Divisions should consider all relevant information, including but not limited to duration of message, transition time, brightness, spacing, and location, to ensure that they are consistent with their FSA and that there are adequate standards to address safety for the motoring public. Divisions should also confirm that the State provided for appropriate public input, consistent with applicable State law and requirements, in its interpretation of the terms of their FSA as allowing CEVMS in accordance with their proposed regulations, policies, and procedures.

Based upon contacts with all Divisions, we have identified certain ranges of acceptability that have been adopted in those States that do allow CEVMS that will be useful in reviewing State proposals on this topic. Available information indicates that State regulations, policy and procedures that have been approved by Divisions to date, contain some or all of the following standards:

- Duration of Message
  - Duration of each display is generally between 4 and 10 seconds – 8 seconds is recommended.
- Transition Time
  - Transition between messages is generally between 1 and 4 seconds – 1-2 seconds is recommended.
- Brightness
  - Adjust brightness in response to changes in light levels so that the signs are not unreasonably bright for the safety of the motoring public.
- Spacing
  - Spacing between such signs not less than minimum spacing requirements for signs under the FSA, or greater if determined appropriate to ensure the safety of the motoring public.
- Locations
  - Locations where allowed for signs under the FSA except such locations where determined inappropriate to ensure safety of the motoring public.

Other standards that States have found helpful to ensure driver safety include a default designed to freeze a display in one still position if a malfunction occurs; a process for modifying displays and lighting levels where directed by the State DOT to assure safety of the motoring public; and requirements that a display contain static messages without movement such as animation, flashing, scrolling, intermittent or full-motion video.

Conclusion

This Memorandum is intended to provide information to assist the Divisions in evaluating proposals and to achieve national consistency given the variations in FSAs, State law, and State regulations, policies and procedures. It is not intended to amend applicable legal requirements. Divisions are strongly encouraged to work with their State in its review of their existing FSAs and, if appropriate, assist in pursuing amendments to address proposed changes relating to CEVMS or other matters. In this regard, our Office is currently reviewing the process for amending FSAs, as established in 1980, to determine appropriate revisions to streamline requirements while continuing to ensure there is adequate opportunity for public involvement.

For further information, please contact your Office of Real Estate Point of Contact or Catherine O'Hara (Catherine.O'Hara@dot.gov).

Connecticut General Statutes §8-2

KeyCite Yellow Flag - Negative Treatment
Proposed Legislation

Connecticut General Statutes Annotated
Title 8. Zoning, Planning, Housing and Economic and Community Development (Refs & Annos)
Chapter 124. Zoning (Refs & Annos)

C.G.S.A. § 8-2

§ 8-2. Regulations

Effective: July 1, 2018

Currentness

(a) The zoning commission of each city, town or borough is authorized to regulate, within the limits of such municipality, the height, number of stories and size of buildings and other structures; the percentage of the area of the lot that may be occupied; the size of yards, courts and other open spaces; the density of population and the location and use of buildings, structures and land for trade, industry, residence or other purposes, including water-dependent uses, as defined in section 22a-93, and the height, size, location, brightness and illumination of advertising signs and billboards. Such bulk regulations may allow for cluster development, as defined in section 8-18. Such zoning commission may divide the municipality into districts of such number, shape and area as may be best suited to carry out the purposes of this chapter; and, within such districts, it may regulate the erection, construction, reconstruction, alteration or use of buildings or structures and the use of land. All such regulations shall be uniform for each class or kind of buildings, structures or use of land throughout each district, but the regulations in one district may differ from those in another district, and may provide that certain classes or kinds of buildings, structures or uses of land are permitted only after obtaining a special permit or special exception from a zoning commission, planning commission, combined planning and zoning commission or zoning board of appeals, whichever commission or board the regulations may, notwithstanding any special act to the contrary, designate, subject to standards set forth in the regulations and to conditions necessary to protect the public health, safety, convenience and property values. Such regulations shall be made in accordance with a comprehensive plan and in adopting such regulations the commission shall consider the plan of conservation and development prepared under section 8-23. Such regulations shall be designed to lessen congestion in the streets; to secure safety from fire, panic, flood and other dangers; to promote health and the general welfare; to provide adequate light and air; to prevent the overcrowding of land; to avoid undue concentration of population and to facilitate the adequate provision for transportation, water, sewerage, schools, parks and other public requirements. Such regulations shall be made with reasonable consideration as to the character of the district and its peculiar suitability for particular uses and with a view to conserving the value of buildings and encouraging the most appropriate use of land throughout such municipality. Such regulations may, to the extent consistent with soil types, terrain, infrastructure capacity and the plan of conservation and development for the community, provide for cluster development, as defined in section 8-18, in residential zones. Such regulations shall also encourage the development of housing opportunities, including opportunities for multifamily dwellings, consistent with soil types, terrain and infrastructure capacity, for all residents of the municipality and the planning region in which the municipality is located, as designated by the Secretary of the Office of Policy and Management under section 16a-4a. Such regulations shall also promote housing choice and economic diversity in housing, including housing for both low and moderate income households, and shall encourage the development of housing which will meet the housing needs identified in the state's consolidated plan for housing and community development prepared pursuant to section 8-37t and in the housing component and the other components of the state plan of conservation and development prepared pursuant to section 16a-26. Zoning regulations shall be made with reasonable consideration for their impact on agriculture, as defined in subsection (q) of section 1-1. Zoning regulations may be made with reasonable consideration for the protection of historic factors and shall be made with reasonable consideration for the protection of existing and potential public surface and ground drinking water supplies. On and after July 1, 1985, the regulations shall provide that proper provision be made for soil erosion and sediment control pursuant to section 22a-329. Such regulations may also encourage energy-efficient patterns of development, the use of solar and other renewable forms of energy, and energy conservation. The regulations may also provide for incentives for developers who use passive solar energy techniques, as defined in subsection (b) of section 8-25, in planning a residential subdivision development. The incentives may include, but not be limited to, cluster development, higher density development and performance standards for roads, sidewalks and underground facilities in the subdivision. Such regulations may provide for a municipal system for the creation of development rights and the permanent transfer of such development rights, which may include a system for the variance of density limits in connection with any such transfer. Such regulations may also provide for notice requirements in addition to those required by this chapter. Such regulations may provide for conditions on operations to collect spring water or well water, as defined in section 21a-150, including the time, place and manner of such operations. No such regulations shall prohibit the operation of any family child care home or group child care home in a residential zone. No such regulations shall prohibit the use of receptacles for the storage of items designated for recycling in accordance with section 22a-241b or require that such receptacles comply with provisions for bulk or lot area, or similar provisions, except provisions for side yards, rear yards and front yards. No such regulations shall unreasonably restrict access to or the size of such receptacles for businesses, given the nature of the business and the volume of items designated for recycling in accordance with section 22a-241b, that such business produces in its normal course of business, provided nothing in this section shall be construed to prohibit such regulations from requiring the screening or buffering of such receptacles for aesthetic reasons. Such regulations shall not impose conditions and requirements on manufactured homes having as their narrowest dimension twenty-two feet or more and built in accordance with federal manufactured home construction and safety standards or on lots containing such manufactured homes which are substantially different from conditions and requirements imposed on single-family dwellings and lots containing single-family dwellings. Such regulations shall not impose conditions and requirements on developments to be occupied by manufactured homes having as their narrowest dimension twenty-two feet or more and built in accordance with federal manufactured home construction and safety standards which are substantially different from conditions and requirements imposed on multifamily dwellings, lots containing multifamily dwellings, cluster developments or planned unit developments. Such regulations shall not prohibit the continuance of any nonconforming use, building or structure existing at the time of the adoption of such regulations or require a special permit or special exception for any such continuance. Such regulations shall not provide for the termination of any nonconforming use solely as a result of nonuse for a specified period of time without regard to the intent of the property owner to maintain that use. Such regulations shall not terminate or deem abandoned a nonconforming use, building or structure unless the property owner of such use, building or structure voluntarily discontinues such use, building or structure and such discontinuance is accompanied by an intent to not reestablish such use, building or structure. The demolition or deconstruction of a nonconforming use, building or structure shall not by itself be evidence of such property owner's intent to not reestablish such use, building or structure. Unless such town opts out, in accordance with the provisions of subsection (j) of section 8-1bb, such regulations shall not prohibit the installation of temporary health care structures for use by mentally or physically impaired persons in accordance with the provisions of section 8-1bb if such structures comply with the provisions of said section. Any city, town or borough which adopts the provisions of this chapter may, by vote of its legislative body, exempt municipal property from the regulations prescribed by the zoning commission of such city, town or borough; but unless it is so voted municipal property shall be subject to such regulations.

(b) In any municipality that is contiguous to Long Island Sound the regulations adopted under this section shall be made with reasonable consideration for restoration and protection of the ecosystem and habitat of Long Island Sound and shall be designed to reduce hypoxia, pathogens, toxic contaminants and floatable debris in Long Island Sound. Such regulations shall provide that the commission consider the environmental impact on Long Island Sound of any proposal for development.

(c) In any municipality where a traprock ridge, as defined in section 8-1aa, or an amphibolite ridge, as defined in section 8-1aa, is located the regulations may provide for development restrictions in ridgeline setback areas, as defined in said section. The regulations may restrict quarrying and clear cutting, except that the following operations and uses shall be permitted in ridgeline setback areas, as of right: (1) Emergency work necessary to protect life and property; (2) any nonconforming uses that were in existence and that were approved on or before the effective date of regulations adopted under this section; and (3) selective timbering, grazing of domesticated animals and passive recreation.

(d) Any advertising sign or billboard that is not equipped with the ability to calibrate brightness or illumination shall be exempt from any municipal ordinance or regulation regulating such brightness or illumination that is adopted by a city, town or borough after the date of installation of such advertising sign or billboard pursuant to subsection (a) of this section.

Credits

(1949 Rev., § 837; Nov., 1955, Supp. § N 10; 1959, P.A. 614, § 2; 1959, P.A. 661; 1961, P.A. 569, § 1; 1963, P.A. 133; 1967, P.A. 801; 1977, P.A. 77-509, § 1; 1978, P.A. 78-314, § 1; 1980, P.A. 80-327, § 1; 1981, P.A. 81-334, § 2; 1983, P.A. 83-388, § 6, eff. July 1, 1985; 1984, P.A. 84-263; 1985, P.A. 85-91, § 2, eff. May 1, 1985; 1985, P.A. 85-279, § 3; 1987, P.A. 87-215, § 1, eff. July 1, 1987; 1987, P.A. 87-232; 1987, P.A. 87-474, § 1; 1987, P.A. 87-490, § 1; 1988, P.A. 88-105, § 2; 1988, P.A. 88-203, § 1; 1989, P.A. 89-277, § 1, eff. Oct. 1, 1989; 1991, P.A. 91-170, § 1; 1991, P.A. 91-392, § 1; 1991, P.A. 91-395, § 1, eff. July 1, 1991; 1992, P.A. 92-50; 1993, P.A. 93-385, § 3; 1995, P.A. 95-239, § 2; 1995, P.A. 95-335, § 14, eff. July 1, 1995; 1997, P.A. 97-296, § 2, eff. July 8, 1997; 1998, P.A. 98-105, § 3; 2010, P.A. 10-87, § 4; 2011, P.A. 11-124, § 2; 2011, P.A. 11-188, § 3; 2015, P.A. 15-227, § 25, eff. July 1, 2015; 2017, P.A. 17-39, § 1, eff. July 1, 2017; 2017, P.A. 17-155, § 2; 2018, P.A. 18-28, §§ 1, 2, eff. July 1, 2018; 2018, P.A. 18-132, § 1, eff. July 1, 2018.)

Notes of Decisions (846)

C. G. S. A. § 8-2, CT ST § 8-2
The statutes and Constitution are current through the 2019 January Regular Session and the 2019 July Special Session.

End of Document

Memorandum
Re: Uniformity Requirement

MEMORANDUM
CONNECTICUT GENERAL STATUTES §8-2 UNIFORMITY

TO: City of Milford Planning and Zoning Board

FROM: Kevin J. Curseaden, Esq., Attorney for the Applicant

DATE: November 27, 2019

SUBJECT: C.G.S. §8-2 and Uniformity of Proposed Regulations

BACKGROUND:

During public comment at the 11/19/19 hearing, Ms. Donna Dutko speaking in opposition, raised the issue of the proposed regulation either not complying with C.G.S. §8-2, or that C.G.S. §8-2 would require the City to issue permits to allow digital billboards in other locations not adjacent to I-95 but within the same zones that are proposed in the zone text amendment.

RULE:

Connecticut General Statutes §8-2 requires uniformity of zoning regulations, "regulations shall be uniform for each class or kind of buildings, structures or use of land throughout each district." C.G.S. §8-2.

> The obvious purpose of the requirement of uniformity in the regulations is to assure property owners that there shall be no improper discrimination, all owners of the same class in the same district being treated alike, with provisions for relief, in cases of exceptional difficulty or an unusual hardship, by action of the zoning board of appeals. General Statutes §8-6; Florentine v. Darien, 142 Conn. 415, 424, 425 (1955).

(Veseskis v. Bristol Zoning Commission, 168 Conn. 358 at 360 (1975)).

> As long as the zoning regulations provide a standard that can be applied to all cases of a like nature so as to reduce the likelihood of allowing a zoning agency to act in a capricious manner, the regulations will not be deemed to contain meaningless standards that can lead to unpredictable

> results. Smith-Groh, Inc. v. Planning and Zoning Com'n of Town of Greenwich 78 Conn. App. 216 (2003).
>
> Town planning and zoning commission's "waiver" of the landscaped buffer requirement and varying the parking setback requirements, through its purported regulatory authority to vary the application of zoning regulations on a case-by-case basis in acting on a special exception request for properties located in a design business district, violated the uniformity requirement of zoning statute governing municipal zoning regulations. MacKenzie v. Planning and Zoning Com'n of Town of Monroe, 146 Conn. App. 406 (2013).

Unequal treatment violates General Statutes § 8-2 (a) which requires "[a]ll such regulations shall be uniform for each class or kind of buildings, structures or use of land throughout each district, but the regulations in one district may differ from those in another district..." "The thrust of the statutory requirement of uniformity is equal treatment." Harris v. Zoning Commission, 259 Conn. 402, 431, (2002). A regulation does not violate the uniformity requirement when the regulation is applied to standard and substandard lots equally. Id. "We conclude, however, that the fact that the amendment has this differing ***effect*** on parcels of land throughout the town does not render its application inconsistent or unequal." Id. ***It is undisputed that, although the amendment ultimately has a differing effect on parcels of land depending on the presence and amount of wetlands, watercourses and slopes greater than 25 percent, it is applied to every parcel within its purview consistently and equally***. Id. at 431 [Citation ***emphasis*** in original and ***added***.]; see also Schefer v. City Council, 279 Va. 588, 595, 691 S.E.2d 778, 782 (2010).

ANALYSIS:

Uniformity of Milford Zoning Regulations. There is no dispute that the City of Milford uniformly applies its regulations.

Here, as in Harris, the proposed text amendment may have a different ***effect*** on parcels of land in the same zone throughout town, but "the amendment applies to all parcels of land that contain the features set forth in the amendment." Harris at 430. Specifically, it applies to those parcels in those zones with existing billboards that abut the I-95 Corridor as defined in the amendment.

Further, C.G.S. §8-2 would not require a zoning officer to issue a permit for a Digital Billboard on a parcel in one of the states zoned that did not also meet all of the listed requirements, i.e. proximity to I-95 Corridor, etc. A permit could only issue to a parcel that met *all* of the requirements.

In summary, under the proposed regulation text change the Digital Billboard regulations are applied identically to each parcel in the stated zone. Therefore, the proposed regulation text change does not violate the uniformity requirement.

Current Zoning Regs. for Sign and Light

SECTION 5.2 EXTERIOR LIGHTING REGULATIONS

5.2.1 General Purpose: This regulation of outdoor lighting applies to both permanently installed outdoor light fixtures and temporary installation of lighting for special events (i.e. carnivals, grand openings), and is necessary to prevent misdirected or excessive artificial light, caused by inappropriate or misarranged light fixtures that produce direct glare, light trespass, and also that such regulation is necessary to improve or maintain nighttime public safety, utility and security.

5.2.2 Design Standard

5.2.2.1 Where used for security purposes or to illuminate walkways, and parking lots, only shielded light fixtures shall be used and mounted no higher than 20 feet.

5.2.2.2 Where used for commercial and industrial purposes such as in merchandise display area, work areas, platforms, signs, architectural, landscape, or sports or recreational facilities, all light fixtures shall be equipped with automatic timing devices and comply with the following:

(1) Indirect uplighting of signs shall be limited to two (2) seventy-five (75) watt incandescent bulbs per sign. If the sign is double-faced, the same type and amount of lighting may be used on each side. The seventy-five (75) watt incandescent bulbs shall be limited to seven hundred fifty (750) lumens per bulb, and shall be completely shielded from view at the nearest property line or street line. All lighting must be shielded to prevent direct glare and/or light trespass. The lighting must also be, as much as physically possible, contained to the target area. Internally lighted signs are acceptable. Indirect uplighting may be included as part of landscaping, walls or other architectural features.

(2) Recreational and sports facility lighting shall comply with IES recommendations and shall be shielded.

(3) All other outdoor light fixtures shall be shielded to prevent misdirected or excessive artificial light.

(4) Merchandise display area lighting shall be turned off within 30 minutes after closing of the business. Under no circumstances shall the full illumination of the display area be permitted after 11:00 p.m. Any lighting used after 11:00 p.m. shall be used for security purposes only.

(5) All outdoor lighting fixtures necessary for security purposes shall be activated by motion sensor devices, or turned off during non-operating hours. Illuminated signs are excluded from this requirement.

5.2.2.3 Foundations supporting lighting poles shall not be less than 24 inches above grade.

5.2.2.4 Light fixtures shall not be mounted on the lighting pole higher than 20 feet from grade

5.2.3 **Light Trespass:** All light fixtures shall be designed, installed, and maintained to prevent light trespass, as specified in Section 5.2.3.1 and 5.2.3.2 below.

5.2.3.1 At the property line of the originating property (light source), illumination from light fixtures shall not exceed 0.1 foot-candle on residentially zoned property or 0.5 foot-candle on business zoned property, measured in a vertical plane.

5.2.3.2 Exterior light fixtures properly installed and thereafter maintained shall be directed so that there will be no direct glare light emissions.

Exterior light fixtures in close proximity to adjacent property may require special shielding devices to prevent light trespass.

5.2.4 **Submission of Lighting Plans:** All applications for subdivisions and Site Plan reviews shall include a lighting plan. The lighting plan shall include the following items:

5.2.4.1 Location, size, height, orientation, design, and plans for all illuminated signs and outdoor lighting. A detail drawing showing type of fixture and level of wattage shall be provided. For Site Plans showing a high level of illumination the board shall require an Iso-Lux plan indicating the levels of illumination in foot-candles, at ground level.

5.2.4.2 Show location of all security lighting on the site.

5.2.4.3 Show foundation details and location of poles when applicable.

5.2.4.4 The hours of operation for the business at the site location shall be indicated.

SECTION 5.3 SIGN REGULATIONS

5.3.1 General Procedure:

It is the intention of these sign regulations to promote the public safety, protect property values, create an attractive business climate and enhance the physical appearance of the community. No sign, except as provided in Section 5.3.3 hereof, shall be erected or structurally altered unless an application for a Zoning Permit has been approved by the Zoning Enforcement Officer, in accordance with ARTICLE VIII, herein. The Zoning Enforcement Officer shall act on all sign permit applications within 30 days after receipt exclusive of weekends and holidays. Failure of the Zoning Enforcement Officer to approve or deny the application within said period shall constitute approval of the application.

5.3.2 General Requirements:

5.3.2.1 Maintenance: All signs together with their supports, braces, guys, and anchors shall be kept in good repair and in safe condition. The owner of the premises on which a sign is erected shall be directly responsible for keeping such sign and premises around it in a safe, sanitary, neat and clean condition.

5.3.2.2 Any commercial sign now or hereafter existing which no longer identifies or advertises a bonafide business conducted, product sold, or activity or campaign being conducted shall be taken down and removed by the owner, agent or person having beneficial use of the building, structure, or lot upon which sign is located within 65 days of such cessation.

5.3.2.3 Illumination: Any illuminated sign or lighting device shall employ only lights emitting a light of constant intensity and shall be designed, located, erected and maintained only for the purposes of illuminating the subject sign and/or premises.

5.3.2.4 Any non-residential building or use that requires Site Plan review subject to Section 7.1 herein shall include a freestanding sign displaying the street address number or numbers of the building or use placed perpendicular to the roadway on which the building or use has its primary frontage. Such freestanding sign shall have a minimum size of 0.5 square feet and a maximum size of 2 square feet, shall be clearly visible from the roadway and shall have street address numbers that are a minimum of 5 inches in height. The area of such freestanding sign shall not count toward the total allowed signage area for the property.

5.3.3 Signs Exempted from these Regulations:

Subject to the conditions applicable in each instance and provided they are maintained in a safe, sanitary, neat and clean condition, the following signs shall not be subject to Section 5.3.1 and 5.3.2.1 hereof.

5.3.3.1 Purpose and Findings:

The City of Milford Planning & Zoning Board is enacting this Regulation to establish reasonable regulations for the posting of temporary signs on public and private property. The Board finds that temporary signs provide an important medium through which individuals may convey a variety of noncommercial and commercial messages. However, left completely unregulated, temporary signs can become a threat to public safety as a traffic hazard and detriment to property values and the City's overall public welfare as an aesthetic nuisance. By enacting this Regulation the Board intends to:

(1) balance the rights of individuals to convey their messages through temporary signs and the right of the public to be protected against the unrestricted proliferation of signs;

(2) further the objectives of the City's Plan of Conservation and Development;

(3) protect the public health, safety, and welfare;

(4) reduce traffic and pedestrian hazards;

(5) protect property values by minimizing the possible adverse effects and visual blight caused by temporary signs;

(6) promote economic development; and

(7) ensure the fair and consistent enforcement of the temporary sign regulations specified below.

5.3.3.2 Definitions. For the purposes of this Regulation, the following words have the meanings respectively ascribed to them in this Section only, except where the context clearly indicates a different meaning:

(1) BUILDING LOT means any piece or parcel of land or a portion of a subdivision, the boundaries of which have been established by some legal instrument of record, that is recognized and intended as a unit for the purposes of transfer of ownership.

(2) COMMERCIAL SIGN means a sign which identifies, advertises, or directs attention to a business, or is intended to induce the purchase of goods, property, or service, including, without limitation, any sign naming a brand of goods or service and real estate signs, as further defined below.

(3) POST means to erect, attach, or affix in any manner, including without limitation nailing, tacking, tying, gluing, pasting, painting, staking, marking or writing.

(4) PUBLIC RIGHT-OF-WAY means the entire area between property boundaries; which is owned by a government, dedicated to public use, or impressed with an easement for public use; which is primarily used for pedestrian or vehicular travel; and which is publicly maintained, in whole or in part, for such use; and includes without limitation the street, gutter, curb, shoulder, sidewalk, sidewalk area, parking or parking strip, planting strip, and any public way.

(5) REAL ESTATE SIGN means a sign indicating the availability for sale, rent, or lease of the specific lot, building, or portion of a building upon which the sign is posted.

(6) CONSTRUCTION SIGN means a sign identifying the development of land or construction or alteration of buildings. Such signs must be set back at least 10 feet from any street line and may not exceed 32 square feet in area.

(7) SIGN means any writing, pictorial representation, illustration, decoration (including any material used to differentiate sign copy from its background), landscaping form, emblem, symbol, design, trademark, banner, flag, pennant, captive balloon, streamer, spinner, ribbon, sculpture, statue, or any other figure or character that:

(a) Is a structure or any part thereof (including the roof or wall of a building); or
(b) Is written, printed, projected, painted, constructed, or otherwise placed or displayed upon or designed into landscaping or a structure or a board, plate, canopy, awning, marquee, or vehicle, or upon any material object or device whatsoever; and
(c) By reason of its form, color, wording, symbol, design, illumination, or motion attracts or is designed to attract attention to the subject thereof or is used as a means of identification, advertisement, or announcement or political or artistic expression or decoration; but
(d) Landscaping constitutes a sign only to the extent that it is planted, trimmed, graded, arranged or installed in such a manner as to convey an explicit commercial message.

(8) TEMPORARY SIGN means a sign that is:

(a) Intended for a temporary period of posting on public or private property;

(b) Typically constructed from nondurable materials, including paper, cardboard, cloth, plastic, and/or wallboard.

5.3.3.3 Temporary Signs Permitted in All Zones. Temporary signs may be posted on property in all zones, subject to the following requirements and those applicable provisions stated elsewhere in the Regulations.

(1) A permit shall be required for all temporary signs posted in the City of Milford, with the exception of temporary political and real estate signs. Each individual temporary sign proposed for posting shall require its own temporary sign permit. Permitted temporary signs may be posted for a period of 14 days from the date of the temporary sign permit. No owner or leaseholder of a commercial establishment shall be granted more than one temporary sign per allowed time period and no more than six (6) temporary sign permits in a single calendar year.

(2) The total square footage for temporary signs posted on a building lot in a residential zone, in the aggregate, shall not exceed 16 square feet, with no individual sign exceeding 8 square feet. The total square footage for temporary signs posted on a building lot in all other zones, in the

aggregate, shall not exceed 32 square feet, with no individual sign exceeding 8 square feet. The total square footage of a sign is measured to include all of the visible display area of one side of the sign.

(3) No temporary sign shall obstruct or impair access to a public sidewalk, public or private street or driveway, traffic control sign, bus stop, fire hydrant or any other type of street furniture, or otherwise create a hazard, including a tripping hazard.

(4) A temporary sign shall be designed to be stable under all weather conditions, including high winds.

(5) No temporary sign shall be illuminated or painted with light reflecting paint.

(6) A temporary sign shall only be posted with the consent of the property owner or occupant.

(7) Temporary signs shall not be subject to the provisions of Section 5.3.2.1.

5.3.3.4 Temporary Signs. Time period for posting.

(1) Temporary political signs shall be posted no earlier than 90 days prior to the voting day to which the political party, election issue or candidate for public office identified on said sign pertains. Such signs shall be removed within five (5) days following said voting day.

(2) Temporary signs advertising a cultural, civic, charitable, educational or entertainment event, or any event operated by a non-profit, social service, educational or religious organization, shall be posted no earlier than 30 days prior to the day of any such event, or the first day of a multiple day event. Such signs shall be removed within three (3) days following the day of the event, or the last day of a multiple day event.

(3) Temporary signs advertising a commercial sales event or promotion, or any function or event conducted and operated by a commercial enterprise, shall be posted no earlier than fourteen (14) days prior to the day of any such event, promotion or function, or the first day of a multiple day event, promotion or function. Such signs shall be removed

within two (2) days following the day of the event, promotion or function, or the last day of a multiple day event, promotion or function.

(4) Temporary signs advertising the grand opening of a commercial enterprise shall be posted for a maximum of 45 days. Such signs shall be posted no earlier than 30 days prior to the date of the grand opening, and shall be removed within 21 days following the day of the grand opening, with the aggregate of the two time periods not to exceed 45 days.

(5) Temporary signs advertising a temporary commercial activity or event on a residential property, including, but not limited to, yard sales and tag sales, shall be posted no earlier than five (5) days prior to the day of the activity or event, or the first day of a multiple day event. Such signs shall be removed within two (2) days following the day of the activity or event, or the last day of a multiple day activity or event.

5.3.3.5 Temporary signs, real estate.

In addition to the requirements of this Section, real estate signs shall also conform to the following standards:

(1) Individual lots. On lots that are for sale or for rent, not more than two temporary signs may be erected. These signs may advertise the land or premises and the sale or rental agent. Such signs shall be removed within fourteen (14) days following the sale or rental of such property. The foregoing signs shall not exceed the following sizes:

(a) A single residential lot: six square feet; an approved subdivision of three or more lots: 10 square feet; and an approved subdivision of six or more lots: 20 square feet.

(b) Commercial or industrial lots: six square feet in area per acre (or fractional acre), not exceeding 20 square feet in area in any commercial district or 30 square feet each in any industrial district.

(c) Directional signs indicating the location of private real properties or facilities for sale or rent may be erected for open houses, provided that each sign shall not exceed four square feet in area. The sign locations shall not obstruct traffic or traffic visibility and shall be maintained by the applicant for the duration of the activity. Not more than four such temporary signs shall be allowed for a single lot or facility for sale or rent or for subdivision lots or homes for sale.

5.3.3.6 Removal of Signs.

(1) The person who has posted or directed the posting of a temporary sign is responsible for the removal of that sign in accordance with this Regulation.

(2) If that person does not remove the temporary sign in accordance with this Regulation then the property owner or occupant of the building lot where the sign is posted is responsible for the sign's removal.

(3) The Zoning Enforcement Officer is authorized to physically remove any temporary signs posted in violation of this Regulation that are not removed in accordance with the provisions above. Temporary signs posted on private property in violation of this Regulation shall be deemed a public nuisance.

5.3.3.7 Severability.

This Regulation or any portion shall be severable from all or any portion of the City of Milford Zoning Regulations if any portion of these regulations shall be adjudged invalid by a court of competent jurisdiction.

5.3.4 Signs Allowable in Residential, Residential-Multiple Family, Residential-Office.

In addition and subject to all other applicable provisions and limitations contained in these regulations, the following signs shall be allowable in One and Two Family Residential, Medium Density Multiple-Family Residential, and Residential-Office.

5.3.4.1 One non-illuminated or indirectly illuminated identification sign for each separate street line not to exceed 9 square feet in area nor 8 feet in height; and further limited as follows: said sign shall be located not less than 10 feet from the front property line; the height of such sign shall not be greater than the distance it is located from any lot line. Noncommercial speech may be placed on any sign permitted by this portion of the Regulations.

5.3.4.2 Other signs shall be limited to directional signs necessary for public safety or convenience and shall be designed and approved only as an integral part of the Site Plan.

5.3.5 Signs Allowable in Office, Business and Industrial Districts:

In addition and subject to all other applicable provisions and limitations contained in these Regulations, the following on-premise signs shall be allowable in Office, Limited Industrial, Industrial, Business, Corridor Design Districts, Interchange Commercial, Design Office, *Milford Center Design District* and Housatonic Design District in accordance with Section 8.3 herein, and shall be allowable in Shopping Center Design and Waterfront Design Districts. On-premise signs shall be allowable along each separate street frontage, but no such sign shall be allowed within required side or rear yards adjoining a residential district, nor within the part of any front yard within 35 feet of a residential district.

5.3.5.1 Ground Signs: There shall be only one sign along any front property line.

(1) Minimum setback shall be 10 feet except as follows: DO, BD, LI, ID, HDD, ICD, SCD, WDD, 15 feet.

(2) Maximum Sign Area shall be 40 square feet except as follows: MCDD, 20 square feet; CDD-1, CDD-3, CDD-5, ID, HDD, ICD, 100 square feet; SCD and WDD, identification of shopping center, 75 square feet, tenant identification, 16 square feet.

(3) Maximum height shall be 18 feet except as follows: MCDD, 12 feet; ID, LI, CDD-1, CDD-3, CDD-5 and HDD, 25 feet; SCD and WDD, 20 feet.

5.3.5.2 Wall Signs: The total sign area on each building façade viewable from a public street or way, or from a parking area, shall not exceed 10 percent of the gross area of said wall, except as follows: ID, CDD-1, CDD-3, CDD-5 and HDD, 15 percent. The Board may, as deemed appropriate in its judgment, allow additional wall signs in the same manner as above on a building wall which faces and adjoins an accessory off-street parking structure or lot.

5.3.5.3 Canopy Signs: One sign along any building façade viewable from a public street or way, or from a parking area, shall be allowable for each separate use of the building provided that the sign area is included as part of the total allowable sign area for wall signs and provided it is located under a roof over a walkway. No such sign shall exceed 16 square feet.

5.3.5.4 Other signs shall be limited to those necessary for directional or safety purposes and shall be approved only as an integral part of a Site Plan.

5.3.5.5 Window Signs: Window signs shall not exceed 35% of the total window display area for each building façade viewable from a public street or way, or from a parking area; with the exception of the Milford Center Design Development District, where window signs shall not exceed 25% of the total window display area for each building façade viewable from a public street or way, or from a parking area. Any internal wall sign that is clearly visible from the public right-of-way through any window shall count towards the 35% of the total window display area, or the 25% of the total window display area in the Milford Center Design Development District.

5.3.5.6 Directional Signs: No more than two traffic, directional or warning signs with no advertising thereon and not exceeding 4 square feet in area, may be located at each driveway entrance or exit, or anticipated hazard area, providing access to any parking, loading or building area.

5.3.5.7 Directory Signs: Directory signs shall be located internal to the site so as to require users to drive in off the main street to view the sign copy. Directory signs shall not exceed 32 square feet. However, more than one directory sign may be allowed if the number of tenants or number of company departments/divisions exceed 10. In general, such signs shall be located on internal site road or pedestrian intersections as necessary.

5.3.5.8 Clocks and Thermometers: The square footage of clocks and/or thermometers shall count as part of the total allowed sign square footage per establishment.

5.3.5.9 Blade Signs: A sign projecting or cantilevered from the face of a building or structure for identification of a tenant or tenancy with writing and/or graphics on one or both sides. Blade shall be allowed when meeting the following conditions:

(1) No larger than 4 square feet.

(2) No internal illumination.

(3) The bottom of the sign must be a minimum of 7’ from the adjacent ground.

(4) The top of the sign shall not be more than 12’ from the adjacent ground.

(5) There can be 1 (one) projecting sign for each ground floor tenant.

(6) A blade sign can project no more than 36” from the face of the building façade and can be no wider than 36” if hung from the canopy.

(7) Any blade sign may overhang the public right of way provided the applicant provides written permission by the owner of the right of way (the City of Milford or the State of Connecticut), whoever is the owner of the sidewalk or street right of way.

(8) In no case shall a blade sign extend beyond the existing curb line that divides the pedestrian side of the sidewalk from the vehicular portion of the right of way.

5.3.6 Commercial Advertising Signs in CDD-1, CDD-3, CDD-5, ICD & ID Zoning Districts:

Subject to all other provisions and limitations of these regulations, indirectly illuminated commercial advertising signs shall be allowed in CDD-1, CDD-3, CDD-5, Interchange Commercial and Industrial Districts, subject to Special Permit and Site Plan Approval and the following additional conditions and safeguards.

5.3.6.1 SIGN, COMMERCIAL ADVERTISING - Any sign owned or operated by any person, firm or corporation engaged in the business of outdoor advertising for compensation for the use of such signs.

5.3.6.2 Not more than one commercial advertising signs shall be permitted on any lot and the sign area of such sign shall not exceed an area of 672 square feet. All such commercial advertising signs shall be ground signs.

5.3.6.3 Such signs shall be located only where the applicable zoning districts extend at least 150 feet in all directions from the proposed sign and shall not be placed closer than 300 feet apart measured along the center line of the street or streets to any other such sign.

5.3.6.4 Such signs shall comply with all yard requirements for principal buildings in the applicable zoning district, but in no case shall such yard setback be less than 20 feet from any lot line and 50 feet from any intersection abutting the lot.

5.3.6.5 The maximum height of the structure shall not exceed the maximum height for principal buildings in the applicable zoning district nor shall it exceed a height of 40 feet above the ground level nor 24 feet above the pavement level of the street to which it is oriented.

5.3.6.6 When such signs are visible from the main traveled way of a limited access highway and are located within 150 feet of such highway, they shall not be placed closer than 50 feet from the right-of-way and shall be a minimum of 1,500 feet apart as measured on the same side of the road (along the center line of the road).

5.3.6.7 Where a non-conforming commercial advertising sign exists, the owner may apply to the Planning and Zoning Board to remove such sign and replace it with a new relocated commercial advertising sign which conforms to this section in all respects; except that such relocated sign may be 50% closer to other commercial signs than is otherwise required.

5.3.7 General Prohibitions:

The prohibitions contained in this Section shall apply to all signs in all zoning districts, regardless of designation, within the City of Milford.

5.3.7.1 Except where allowed by these regulations, no allowable sign, including canopy signs, shall be located in or project over, any street right-of-way.

5.3.7.2 No sign or advertising device shall be erected, used or maintained which in any way simulates official directional or warning signs erected or maintained by the Federal, State and City Governments for the protection of the public health and safety.

5.3.7.3 No sign or advertising device shall be erected or maintained in such a manner as to obstruct or interfere with the free and clear vision on any street, sidewalk, driveway or navigable channel.

5.3.7.4 No sign or advertising device shall be erected or maintained with any lighting or control mechanism which may cause radio or television interference.

5.3.7.5 No illuminated sign or lighting device shall be placed or directed on any property in a manner that would permit the light beams and illumination there from to be directed or beamed onto a public street or walkway, or onto adjoining properties so as to cause glare or reflection that might constitute a traffic hazard or public nuisance.

5.3.7.6 No animated sign or advertising device shall be allowed.

5.3.7.7 No advertising banner shall be attached to any on-premise light pole, utility pole, tree, or other free-standing vertical site element. Advertising banners shall only be permitted to be attached to building façades, at a minimum height of twelve (12) feet above grade.

5.3.7.8 No advertising balloon, inflatable sign or advertising streamer shall be allowed.

5.3.7.9 No flashing sign or advertising device which creates intermittent or varying light intensity shall be allowed.

5.3.7.10 No projecting sign shall extend more than 15 inches beyond the building walls or parts thereof, except as otherwise provided in these sign regulations.

5.3.7.11 No roof sign shall be erected, except that signs on architecturally detailed facades such as mansard roofs shall not be construed to be roof signs. Such signs shall not extend above the parapet of the structural roof.

5.3.7.12 No sign shall be painted or erected on any fence or retaining wall.

5.3.7.13 No building or part thereof, such as a gable, roof or wall shall be outlined by direct illumination for the purpose of commercial advertising.

5.3.7.14 No sign shall be attached to or be erected or maintained in such a manner as to obstruct any fire escape, windows, door or other building opening used for egress and ingress, ventilation or other fire fighting purposes.

5.3.7.15 No temporary pennants or A-frame signs shall be allowed as permanent signs.

5.3.7.16 Electronic message signs are prohibited. An electronic message sign shall not be defined to include clocks and/or thermometer displays.

5.3.7.17 Signs. Vehicle fueling stations may utilize one digital numeric price sign as part of their ground sign to display the price of fuel. The square footage of such signage shall be included in the allowable ground sign size for such zone in which it is located. The numeric digits shall be a constant display and shall not vary in color, intensity, brightness and shall not flash, blink or otherwise be animated.

Letters in Support

ShopRite, Garafalo Markets
935 Boston Post Road
Milford, CT 06460

City of Milford
Planning & Zoning Commission
70 West River Street
Milford, CT 06460

Dear City of Milford Planning & Zoning Commission:

I am writing this letter in strong support of the application before you to allow electronic billboards in our city.

Billboards have always been a great form of advertising for Shop Rite supermarkets. As a family owned business, it is extremely important for us to be able to communicate our message to the public in a cost effective manner with the ability to reach as many people as possible; billboard highway signs accomplish this. Now with the capabilities of digital billboards, it has become an even more cost effective advertising medium which all businesses can afford due to rental periods ranging from 1 day to 1 year. There are many small businesses in Milford who will now be able to enjoy the ability for their message to be seen to the traveling public.

Furthermore, the applicant is businessmen I have know and worked with for over 15 years. Dominick Demartino has always been a tremendous asset to the Shop Rite family but also to the communities in which he operates. His philanthropic ways and his ability to buy dilapidated properties and transform them into revitalized tax producing pieces of real estate is welcoming to any local community. As you are aware, he has already transformed 45 Banner Drive into a NAPA superstore and Force 3 ProGear warehouse/distribution center where the existing board is located.

Thank you for your consideration of this application which I am in strong support!

Sincerely,

Harry Garafalo
Shop Rite Supermarkets