

EUGENE CITY COUNCIL AGENDA

September 21, 2020

7:30 p.m. EUGENE CITY COUNCIL PUBLIC HEARING

Due to Governor Kate Brown's Stay Home, Save Lives Executive Order to combat the spread of Covid-19, this meeting will be held remotely using virtual meeting technology. Information about online or other options for access and participation will be available at https://www.eugene-or.gov/3360/Webcasts-and-Meeting-Materials

Meeting of September 21, 2020; Her Honor Mayor Lucy Vinis Presiding

Councilors

Emily Semple, President Jennifer Yeh, Vice President

Mike Clark Greg Evans
Chris Pryor Claire Syrett
Betty Taylor Alan Zelenka

7:30 p.m. EUGENE CITY COUNCIL PUBLIC HEARING

- 1. PUBLIC HEARING: An Ordinance Concerning Digital Sign Code, Amending Sections 9.0500, 9.6610, 9.6615, 9.6620, 9.6630, 9.6635, 9.6640, 9.6645, 9.6650, 9.6655, 9.6660, 9.6665, 9.6670, 9.6675, and 9.6680 of the Eugene Code, 1971, and Providing an Effective Date. (City File CA 20-2)
- 2. PUBLIC HEARING: An Ordinance Amending the Eugene-Springfield Metropolitan Area General Plan Diagram and the Willakenzie Area Plan Diagram to Redesignate the Property Identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 And 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800 from Campus Industrial to Light Medium Industrial and Rezone the Property from E-1 Campus Employment to E-2 Mixed Use Employment
- 3. PUBLIC HEARING: 1059 Willamette Street Redevelopment
- 4. PUBLIC HEARING: An Ordinance Extending the Term of Ordinance No. 20170 Granting to Northwest Natural Gas Company, a Corporation, a Non-Exclusive Natural Gas Franchise, to May 11, 2021

Adjourn.

The Eugene City Council welcomes your interest in these agenda items. This meeting location is wheelchair-accessible. For the hearing impaired, an interpreter can be provided with 48 hours' notice prior to the meeting. Spanish-language interpretation will also be provided with 48 hours' notice. To arrange for these services, contact the receptionist at 541-682-5010. City Council meetings are telecast live on Metro Television, Comcast channel 21, and rebroadcast later in the week.

El consejo de la Ciudad de Eugene agradece su interés en estos asuntos de la agenda. El lugar de la reunión tiene acceso para sillas de ruedas. Se puede proveer a un intérprete para las personas con discapacidad auditiva si avisa con 48 horas de anticipación. También se puede proveer interpretación para español si avisa con 48 horas de anticipación. Para reservar estos servicios llame al 541-682-5010. Las reuniones del consejo de la ciudad se transmiten en vivo por Metro Television, Canal 21 de Comcast y son retransmitidas durante la semana.

For more information, contact the Council Coordinator at 541-682-5010, or visit us online at www.eugene-or.gov.

EUGENE CITY COUNCIL AGENDA ITEM SUMMARY



Public Hearing: An Ordinance Concerning Digital Sign Code, Amending Sections 9.0500, 9.6610, 9.6615, 9.6620, 9.6630, 9.6635, 9.6640, 9.6645, 9.6650, 9.6665, 9.6660, 9.6665, 9.6670, 9.6675, and 9.6680 of the Eugene Code, 1971, and Providing an Effective Date. (City File CA 20-2)

Meeting Date: September 21, 2020

Department: Planning & Development

www.eugene-or.gov

Agenda Item Number: 1

Staff Contact: Jenessa Dragovich

Contact Telephone Number: 541-682-8385

ISSUE STATEMENT

The City Council will hold a public hearing on a city-wide land use code amendment to modify existing sign standards to allow various digital signs.

BACKGROUND

Eugene's Sign Code (which is part of the Eugene land use code, Chapter 9) was originally adopted in 1968. The last major change to the sign code occurred in the late 1980's and minor amendments were passed in 2001 and 2013. Electronic sign technology has changed significantly in that period and the sign code has not been changed to accommodate the new technology. Digital signs use an electronic display system, such as a light-emitting diode (LED) screen, to deliver multiple messages at a single location. Images are often static and held for a specified amount of time.

Eugene's current sign code prohibits flashing signs and most digital or electronic signs except for electronic message centers, which are limited in size and location. Most existing electronic message centers in Eugene are digital time and temperature displays (three square feet in area and five display characters) except for a few cases where variances were approved to allow larger digital signs.

Eugene has few examples of existing digital signs. They include signs for the Lane County Fairgrounds, the Hult Center, Matthew Knight Arena, and The Shedd, which were allowed either as public signs or through approved sign variances as mentioned above.

Project Initiation

Billboard industry representatives contacted City Councilor Chris Pryor to request a modification to the sign code standards to allow for electronic (digital) billboards. Councilor Pryor polled the council and in response, a work session to discuss the proposal was held on <u>September 18, 2019</u>. For additional background, the agenda item summary for that Council meeting is provided as

Attachment A. Please note that the original date of the work session was September 9, 2019; however, due to time constraints, the work session was bumped to the following week. After staff presented information about what would be needed to allow digital signs, the City Council initiated the current code amendment process with the following motion:

MOTION AND VOTE: Move to initiate land use code amendments to allow digital billboards and digital reader boards within the city and to implement changes to the sign regulations identified by staff that are legally required or necessary to clarify the current regulations. (The motion passed 4:2, with Councilors Taylor and Semple voting in opposition.)

The proposed modifications to the existing sign code are primarily focused on allowing digital billboards as well as limited digital signage for drive-through signs, service stations and institutional uses. The other proposed changes in the draft code are clarifications recommended by staff. The following is a summary of the proposed changes:

- Provides new definitions for digital billboards, cutouts and digital signs and modifies existing definitions for electronic message centers and flashing signs.
- Provides an allowance for digital billboards when proposed standards are met:
 - Minimum spacing of 1,200 feet (3 blocks) between digital billboards facing the same direction
 - o Minimum 10 seconds between messages with instantaneous transition
 - o No video, animations, scrolling, or other similar distracting effects.
 - o Auto-dimming requirement to prevent glare, especially at night
- Allows one digital sign (maximum 20 square feet) for each institutional use such as schools, religious institutions and community centers.
- Allows up to six small digital sign components (totaling not more than 20 square feet) for each service station use.
- Allows up to two digital signs (maximum 7-foot high and not more than 40 square feet) for each lane for drive-through uses.

Procedural Summary

This proposed code amendment is subject to Type V application procedures (EC <u>9.7500</u> through EC <u>9.7560</u>) for the upcoming public hearing, as well as the applicable approval criteria from EC <u>9.8065</u>. Type V applications provide for a legislative review of changes to the land use code. The Type V process includes public notice and hearing before the Planning commission, which forwards a recommendation to the City Council for a final public hearing and action.

Planning Commission Process

Consistent with Type V procedures, notice of the Planning Commission public hearing was provided to all neighborhood organizations in Eugene, the Oregon Department of Land Conservation and Development, Lane County, City of Springfield, and community groups and individuals who have requested notice. Notice of the public hearing was published in the Register Guard. In addition to the notices required by the land use code, current information regarding this and other land use code updates is available on the City's Land Use Code Amendments web page.

The Planning Commission held a public hearing on <u>July 28, 2020</u> to consider the proposed land use code amendment. Two people testified at the public hearing and spoke in favor of the proposed amendments. Following the public hearing, the Planning Commission deliberated on <u>August 11, 2020</u> and <u>August 24, 2020</u>. After a protracted discussion, the commission struggled with recommending adoption of the proposed amendments that would specifically allow digital billboards. This was primarily due to remaining concerns about whether conversion to digital displays will cause an unreasonable risk to traffic safety. Over the course of the process, Commissioners were provided conflicting testimony pertaining to the safety issue. Studies were provided in testimony from industry representatives that conclude little to no direct correlation to crashes; whereas, <u>Vision Zero</u> staff presented a <u>memo</u> with study references that found they contribute to driver distraction.

The first suggested motion was to split the recommendation into two parts, one for digital billboards and the other for the remaining changes. The motion didn't receive a second. A second motion recommended moving the proposed amendments forward while elevating specific concerns for Council's consideration. A technical glitch led the commissioner who made the motion losing connection to the virtual meeting just before the vote took place and the result was a tie with three commissioners in favor and three commissioners against. The commission then voted on a third motion to recommend adoption of the proposed amendments, excepting out the changes related to allowing digital billboards. This motion passed 4:2, with the commissioner who missed the previous vote (due to being disconnected) abstaining.

The proposed Ordinance (Attachment B) includes recommended language to implement Council's original direction to "allow digital billboards and digital reader boards..." and does not yet reflect the recommendation from Planning Commission to remove the allowance for digital billboards. Should Council choose to proceed based on this recommendation, the draft Ordinance will need to be revised to reflect that direction. Draft findings are provided in Attachment C.

Given the amount of discussion and challenging circumstances at the deliberation meeting, staff felt it important to convey the concerns expressed by the commissioners in coming to their recommendation. If Council moves forward on allowing digital billboards, there were a few specific concerns that Council might further consider.

The first area of concern relates to the proposed dwell time minimum of 10 seconds. Testimony submitted by industry representatives asked that the proposed 10-second dwell time requirement be reduced to 8 seconds consistent with the State minimum and industry standard. However, input from Public Works staff suggested that longer dwell times were preferred from the perspective of traffic safety. A specific longer alternative amount was not suggested, and discussion ranged from supporting 8 seconds, 10 seconds, or longer without landing on a clear recommendation.

The next area of concern relates to the allowed locations for digital billboards. Staff drafted the proposal to allow digital billboards along portions of major arterial streets that currently allow traditional billboards. Staff focused only on long stretches of roadway and, therefore, three short portions of these major arterial street segments were not included (portions of Garfield Street, Mill Street, and East Broadway – see Attachment D). The omission was not due to a specific

reason and industry representative testimony requested that the three omitted sections be included. Discussion on this topic was complicated when considering input from Public Works staff regarding safety concerns and insufficient information on the actual impact of digital conversion of traditional billboards. Commissioners struggled with the prospect of adding distractions to drivers, especially if the impacts could be counterproductive to Vision Zero goals. Some commissioners were open to including the three street segments and others expressed that they would not support including them.

Another area of concern relates to the proposed spacing requirement. While no specific change from the draft standard was ever suggested, this topic did come up several times as this standard would indirectly limit the overall number of digital billboards ultimately allowed in Eugene. As proposed, staff estimates that there could be approximately 60 suitable digital billboard locations. Increasing the spacing would reduce the projected number. To reduce by half would require about four times the spacing. Stakeholders with existing billboards in Eugene identified 10 locations that they would like to convert to digital within the next five years. If proliferation is a concern, the proposed spacing may not be the best approach. One suggestion that received some traction with commissioners in deliberations was the possibility of starting with a pilot program. This would need to be explored further but could be an effective way to slow down the roll out of digital billboards and provide an opportunity to gather Eugene-specific data on their impacts to traffic safety. There was significant support from commissioners to recommend that Council direct staff to explore other options and mechanisms to slow down conversion of digital billboards to allow further study of potential traffic impacts with options that could include a pilot program, limited duration approvals, or limited roll out. Some suggested using the list of 10 preferred sites as the pilot. Public Works staff is currently looking more closely at those 10 locations with respect to the concerns they flagged. It is worth noting that the busiest and best locations from the industry standpoint are likely to also be locations where existing crash data are high. Both aspects relate to higher traffic volumes.

The final area of concern is around green energy. The proposed standards do not address energy consumption; however, several commissioners supported recommending that Council include a requirement that digital billboards be powered by green energy. Staff reached out to our sustainability program previously to get their input on the environmental impact of allowing digital billboards. Comparing impacts between digital and traditional billboards is difficult. Feedback indicated that energy consumption is probably not a significant issue, in part due to Eugene's electricity being close to carbon neutral. Traditional billboards generate petroleumbased vinyl waste each time an ad is changed; however, digital billboard displays create e-waste with a 10 to 13-year lifespan. The difference between lifecycle impacts is understudied, making it hard to determine the net effect.

All testimony received as of September 14, 2020, including the internal memo on Digital Billboards and Traffic Safety, are included in Attachment E. Any additional testimony received will be forwarded to Council in addition to being made available on the Land Use Code Amendment website here: https://www.eugene-or.gov/764/Land-Use-Code-Amendments.

PREVIOUS COUNCIL DIRECTION

September 18, 2019 Work Session

Move to initiate land use code amendments to allow digital billboards and digital reader boards within the city and to implement changes to the sign regulations identified by staff that are legally required or necessary to clarify the current regulations. (*Motion Passed*)

COUNCIL OPTIONS

No action is required at this time; however, options will be provided at the time of City Council deliberations and action scheduled for October 12, 2020.

CITY MANAGER'S RECOMMENDATION

This item is scheduled for a public hearing only. Following the public hearing and City's receipt of any testimony, the City Manager will make a recommendation to be included in the council packet for action on October 12, 2020.

ATTACHMENTS

- A. City Council Work Session Agenda Item Summary, September 9, 2019
- B. Draft Ordinance
- C. Draft Findings
- D. Billboard Inventory Map
- E. Testimony Received as of September 14, 2020

FOR MORE INFORMATION

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EUGENE CITY COUNCIL AGENDA ITEM SUMMARY



Work Session: Digital Signs

Meeting Date: September 9, 2019

Department: Planning and Development

www.eugene-or.gov

Agenda Item Number: 3

Staff Contact: Jenessa Dragovich

Contact Telephone Number: 541-682-8385

ISSUE STATEMENT

At this work session, City Council will be provided with an overview of Eugene sign code regulations pertaining to digital signs. This work session is in response to Councilor Pryor's request and was initiated through a poll, provided as Attachment A. This is an informational item and no council action is requested.

BACKGROUND

Eugene's sign code (which is part of the Eugene land use code) was originally adopted in 1968. Minor amendments to the sign code were passed in 2001 and 2013, however, the last major change occurred in the late 1980s. Electronic sign technology has changed significantly in that period. Digital signs use an electronic display system, such as an LED screen, to deliver multiple signs at a single location. Images are often static and held for a specified amount of time; however, the technology is capable of slide presentation effects, including frame transitions, scrolling, animation and videos. With a push to convert traditional billboards to digital, many communities are being asked to allow electronic signage.

At this work session, council will be presented with an overview of:

- Eugene's existing sign code pertaining to digital signs
- Digital sign information
- Common concerns related to digital signs
- Examples of how other communities regulate digital signage

Eugene's current sign code prohibits flashing signs, except electronic message centers (which are considered digital signs). However, because electronic message centers are limited to three square feet in area and five display characters, they are effectively prohibited with the exception of small displays that show time and temperature. A 2007 Land Use Board of Appeals decision affirmed the City's interpretation that LED displays meet the City's definition of electronic message centers and are subject to the size, character and message interval limits prescribed by the sign code. To allow digital signage in Eugene, the sign code would need to be amended to remove prohibitive language and add specific regulations to address common concerns associated with digital signage. Excerpts from the sign code are provided as Attachment B.

There are only a few existing examples of digital signs in Eugene—the Lane County Fairgrounds, the Hult Center, Matthew Knight Arena, and The Shedd. The Eugene land use code generally does not allow digital signs. The examples listed were allowed because two are public signs that are exempt from sign standards and two, Matthew Knight Arena and The Shedd's electronic message centers, received a variance to the sign code standards.

Proponents of digital signage assert several benefits from the technology, including reduced waste compared with traditional copy materials, lower energy consumption, the ability to serve the advertising needs of more businesses, and usage by law enforcement agencies to push public warnings such as Amber alerts.

Concerns over the use of digital signage are primarily focused on driver distraction and visual pollution. Several factors that contribute to these concerns include: flashing effects, moving images, or videos; frequency of image changes; size and location; and brightness/glare.

Digital sign technology has been operating in Portland, Salem, and Springfield for several years. At the work session, staff will provide some examples of how these cities and others regulate such signage.

Allowing digital signs in Eugene would require an amendment to Eugene's land use code. Such changes would require the City Council to initiate the process. The formal adoption process for an amendment to the land use code includes notice to the state and interested parties, a public hearing before the Planning Commission who provides a recommendation to City Council, a public hearing before the City Council, and action by the City Council. In some cases, notice must also be sent to affected property owners. Prior to the formal adoption process, the Building Permit Services Division would engage stakeholders in a public process to identify key issues and possible solutions, and to review draft code language.

In addition to the work session request regarding digital signs, there have been two other questions asked by councilors related to sign standards. One question was about signs that advertise off-premise businesses and whether the City can require that signs be for on-premise, or "proximate" businesses, or limited to businesses located within the city. The City cannot require that signs only advertise proximate businesses or businesses located in the city. Such a requirement would violate the Oregon Constitution because it would prohibit certain speech based on the content of that speech. *See Outdoor Media Dimensions, Inc. v. Department of Transportation*, 340 Or 275 (2006).

The second question is related to mobile advertising signs (e.g., a sign on the flat bed of a truck that is driven around town). The current sign code already prohibits any sign placed on a motor vehicle with the primary purpose of providing a sign not otherwise allowed by the sign standards. See land use code section 9.6615(2) on page 1 of Attachment B.

PREVIOUS COUNCIL DIRECTION

This is the first work session on this topic.

COUNCIL OPTIONS

Informational item. No action requested.

CITY MANAGER'S RECOMMENDATION

No recommended action.

SUGGESTED MOTION

No recommended action.

ATTACHMENTS

A. Work Session Request

B. Eugene Sign Standards Excerpts

FOR MORE INFORMATION

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Staff E-Mail: <u>IDragovich@eugene-or.gov</u>

Councilor:	Chris P	ryor			Date:	1-31-19			
WORK SESSION TOPIC									
Update the Eugene Sign Code to accommodate new digital display technologies.									
ISSUES AND QUESTIONS TO BE ADDRESSED									
The Eugene Sign Code has not been updated for over 15 years and the pace of electronic sign technology has changed significantly in that period. Digital billboards now offer better capability to reduce energy consumption over traditionally illuminated signs, save overhead and labor costs, and reduce "upstream" carbon impacts by eliminating the need to manufacture and ship petroleum-based vinyl fabric signs which might be replaced every month. Digital signage can also aid local agencies with emergency messages, warnings, Amber Alerts, and other public interest content. Digital sign technology has already been operating in Portland, Salem, and Springfield for years.									
OUTCOMES									
Review and update the Eugene Sign Code to allow for the regulated use of electronic and digital sign and billboard technology.									
POLL									
I want to hol	ld a work se	ssion to discuss the issue	outlined above						
Yes	No		Yes	No					
		Ward 1: Emily Semple			Ward 5: I	Mike Clark			
		Ward 2: Betty Taylor			Ward 6:	Greg Evans			
		Ward 3: Alan Zelenka			Ward 7:	Claire Syrett			
		Ward 4: Jennifer Yeh			Ward 8: 0	Chris Pryor			
RESPONSE	DUE BY: F	February 14, 2019							
Please inc	dicate you ze over othe ensitive; sc	ur preference for timi	ı.	session					

COMMENTS

A few years back Churchill High School had a problem using its digital reader board because of conflicts with the sign code. While a makeshift administrative solution was found, it pointed out the need to make updates to the sign code.

Excerpts from the Eugene Land Use Code

Definitions

Billboard. Any sign with a sign face of 200 square feet or greater in surface area.

Electronic Message Center. A sign, or portion of a sign, that conveys information through a periodic automatic change of message on a lampbank, through the use of fiber optics, or through mechanical means. A sign on which any portion less than an entire sign rotates shall be considered an electronic message center.

Flashing Sign. A sign or sign structure where some part of the display is provided by light-emitting elements which abruptly change color or intensity of illumination, including intermittent periods of illumination and non-illumination, or where the effect of flashing is achieved through mechanical means, including rotation.

Sign. Any device, fixture, placard, or structure that is not entirely within an enclosed building, when its message is visible from a public or private way or another development site, and which uses any word, letter, or logo to advertise or to communicate information of any kind. For purposes of the Eugene sign regulations, searchlights, beacons, strings of lights, banners, flags, pennants, and inflated devices shall be considered signs.

Sign Standards

9.6610 Exemptions to Sign Standards.

* * *

<u>Public Signs</u>. 1) Signs constructed or placed in a public right-of-way by or with the approval of a governmental agency having legal control or ownership over the right-of-way; 2) Signs owned or constructed under the direction or authorization of the city, including, but not limited to, signs installed within parks and at natural resource areas within the NR Natural Resource Zone and PRO Parks, Recreation and Open Space Zone to account for entrances, trail signs, and markers; and 3) Signs placed by a public utility for the purpose of providing information concerning a pole, line, pipe or other facility belonging to the public utility.

9.6615 Prohibited Signs. Except where qualified as a nonconforming sign, the following signs are unlawful and are declared to be nuisances:

* * *

* * *

- (2) Any sign written or placed upon or within a motor vehicle with the primary purpose of providing a sign not otherwise allowed by the sign standards.
- (5) Decorative laser signs, search lights, and flashing signs, except electronic message centers;

9.6640 General Provisions.

* * *

(6) Illumination Standards.

- (a) <u>Maximum Exposed Illumination</u>. No single light source element which exceeds 15 watts shall be used in connection with a sign or to illuminate a sign in a way which exposes the face of the bulb, light or lamp when viewed from a public street.
- (b) Glare Reduction. No sign shall be illuminated or use lighting where such lighting is directed at any portion of a traveled street or will otherwise cause glare or impair the vision of the driver of a motor vehicle or otherwise interfere with the operation thereof. Exterior illumination shall be top mounted and shielded to aim light downward only.
- (c) <u>Illumination From Signs on Nonresidential Property</u>. Illumination resulting from all signs and lighting on any property in a non-residential zone shall not exceed 2 foot candles at a height of 5 feet when measured at any point on property in a residential zone. External illumination shall be shielded so that the light source elements are not directly visible from property in a residential zone which is adjacent to or across a street from the property in the non-residential zone.
- (d) <u>Illumination From Signs on Residentially Zoned Property</u>. No internally illuminated sign shall be allowed on property in a residential zone. Lighting from all light sources operated for the purposes of sign illumination on property in a residential zone shall be shielded from other property in the residential zone and shall not be more than 2 foot candles at the closest street or property line.

* * *

(9) Electronic Message Centers. Except electronic message centers operated as public signs by governmental agencies, no electronic message center, or portion of a sign used as an electronic message center, shall be larger than 3 square feet in area, display a message containing more than 5 characters, or change the displayed message at intervals of less than once every 3 seconds. No electronic message center, except for temporary construction use, shall exceed a maximum one-hour equivalent A-weighted sound pressure level of 50 dBa at the receiving property line when the receiving property is occupied by a dwelling, hospital, school, library or assisted care center.

If you would like to see all of Eugene's Sign Standards (beginning at section 9.6600), the entire land use code is available online at: https://www.eugene-or.gov/chapter9.

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AN ORDINANCE CONCERNING DIGITAL SIGN CODE, AMENDING SECTIONS 9.0500, 9.6610, 9.6615, 9.6620, 9.6630, 9.6635, 9.6640, 9.6645, 9.6650, 9.6655, 9.6660, 9.6665, 9.6670, 9.6675, AND 9.6680 OF THE EUGENE CODE, 1971, AND PROVIDING AN EFFECTIVE DATE.

THE CITY OF EUGENE DOES ORDAIN AS FOLLOWS:

Section 1. Section 9.0500 of the Eugene Code, 1971, is amended to add the definitions of "Cutout," "Digital Billboard," and "Digital Sign," and amend the definitions of "Electronic Message Center" and "Flashing Sign" as follows:

Definitions. As used in this land use code, unless the context requires otherwise, the following words and phrases mean:

Cutout. A supplemental design element attached to or superimposed upon a billboard.

Digital Billboard. Any billboard that changes messages by any electronic process.

Digital Sign. Any sign with a sign face of 20 or fewer square feet in surface area that changes messages by any electronic process.

Electronic Message Center. A sign, or portion of a sign, that conveys information through a periodic automatic change of message on a lampbank, through the use of fiber optics, or through mechanical means. A sign on which any portion less than an entire sign rotates shall be considered an electronic message center. A sign component that utilizes a computer or other electronic means to change the digital message displayed.

Flashing Sign. A sign or sign structure *that is not a digital billboard, digital sign, or electronic message center,* where some part of the display is provided by light-emitting elements which abruptly change color or intensity of illumination, including intermittent periods of illumination and non-illumination, or where the effect of flashing is achieved through mechanical means, including rotation.

Section 2. Subsection (2) of Section 9.6610 of the Eugene Code, 1971, is amended to add the "Building Directories" entry, and amend the "Message Boards" entry including renaming it to "Drive-through Signs," and amend the "Residential Signs" entry as follows:

9.6610 Exemptions to Sign Standards.

(2) Except as provided in subsection (3) of this section, the following signs are exempt from the requirements of EC 9.6600 through 9.6680, and are exempt from the requirement to obtain a sign permit if they are located on private

property outside of vision clearance areas:

<u>Building Directories</u>. For buildings with multiple tenants, one wall-mounted sign up to 12 square feet in area for the purpose of communicating to persons already on the development site.

Message Boards Drive-through Signs. One sign per business for the purpose of communicating to persons on the development site, such as a drive through menu sign or building directory. Such a sign may be up to 6 feet in height and up to 40 square feet in area.

Two drive-through signs for each drive-through lane. Each drive-through sign may be up to 7 feet in height and up to 40 square feet in area. Drive-through signs may be digital signs if the sign display is static and the display copy is not changed more than once per hour, except for a portion of the digital display not to exceed 2 square feet may change the display copy more frequently.

Residential Property Signs. Two signs for each development site used primarily for a single family dwelling or duplex. The signs are limited to the following types: freestanding sign or banner. A freestanding sign may not exceed 12 square feet in size per face, with a maximum of two faces; a banner may not exceed 15 square feet in size. The maximum height of a freestanding sign under this exemption is 6 5 feet (from grade), and it must be separated by at least 8 feet from any other freestanding sign on the same development site.

Section 3. Subsection (5) of Section 9.6615 of the Eugene Code, 1971, is amended to provide as follows:

- **9.6615** Prohibited Signs. Except where qualified as a nonconforming sign, the following signs are unlawful and are declared to be nuisances:
 - (5) Decorative laser signs, search lights, and flashing signs, except electronic message centers;

Section 4. Subsections (3) and (5) of Section 9.6620 of the Eugene Code, 1971, are amended to provide as follows, and subsection (6) is deleted.

9.6620 Nonconforming Signs.

- (3) Except as provided in EC 9.6675(7) and EC 9.6680(7) or where only a change in display copy is made, any nonconforming sign which is structurally altered or has illumination installed shall be brought into compliance with all applicable provisions of the sign standards within 90 days and shall thereafter be kept in compliance with the sign standards.
- (5) The provisions of subsection (6) of this section and subsection (2) of EC 9.6635 Approval of Permit Application do not apply to signs in existence pursuant to a validly issued sign permit as of July 1, 1990, along Goodpasture Island Road from a point 300 feet north of the intersection with Valley River

- Way to a point 1400 feet north of the intersection. The provisions of subsection (2) of this section shall apply except that restoration of a damaged sign shall be allowed where a sign is damaged to the extent of 100 percent of its value. All other provisions of this section shall apply.
- (6) All signs with a surface area of 200 square feet or greater shall be removed or brought into compliance with this land use code by April 1, 2003.

<u>Section 5</u>. Subsection (1) of Section 9.6630 of the Eugene Code, 1971, is amended to provide as follows:

9.6630 Permit Application.

(1) An application and related information shall be submitted by the applicant, in a manner prescribed by the city, together with a fee established by the city manager as provided by EC 2.020 City Manager - Authority to Set Fees and Charges. When a person begins construction of a sign requiring a sign permit before the permit is issued, the permit fee shall be doubled. Payment of a double permit fee shall not otherwise exempt the person from liability for other penalties prescribed for a violation of the sign standards.

Section 6. Subsection (8) of Section 9.6635 of the Eugene Code, 1971, is amended to provide as follows:

9.6635 Approval of Permit Application.

(8) A decision granting or denying a sign permit may be appealed to a hearings official. Appeals are processed according to other Type II applications beginning at EC 9.7200 General Overview of Type II Application Procedures. The decision of the hearings official is final.

Section 7. Subsections (4)(a), (4)(c), (5)(f), (6)(d), and (9) of Section 9.6640 of the Eugene Code, 1971, are amended, and subsection (10) is added to provide as follows:

9.6640 General Provisions.

- (4) Location Standards.
 - (a) <u>Setbacks</u>. All signs shall comply with the setback requirements beginning at EC 9.2000 through EC 9.3980 and EC 9.6745 <u>Setbacks Intrusions Permitted</u>. Signs may be installed up to 5 feet into the required front yard setback except that freestanding signs up to 5 feet in height in the E-1 zone may be installed at least 5 feet from the front property line.
 - (c) Projecting Over the Public Right-of-Way. Except as specified in EC 9.6670 Central Commercial Sign Standards, no privately owned sign may project over any public right-of-way.
- (5) Construction Standards.
 - (f) Wall Signs. Wall signs shall may project a maximum of up to 12 inches when the wall sign is more than 8 feet above grade and a maximum of 4

inches when the wall sign is less than 8 feet above grade from the wall, except that wall signs shall project no more than 4 inches from the wall when the sign is less than 8 feet above a sidewalk or public way.

- (6) Illumination Standards.
 - (d) Illumination From Signs on Residentially Zoned Property. No internally illuminated sign shall be allowed on property in a residential zone. Lighting from all light sources operated for the purposes of sign illumination on property in a residential zone shall be shielded from other property in the residential zone and shall not be more than 2 foot candles at the closest street or property line any point along the boundary of the development site. Externally illuminated signs shall be shielded.
- (9) Electronic Message Centers. Except electronic message centers operated as public signs by governmental agencies, no electronic message center, or centers are subject to the following limitations:
 - (a) Except as provided in subsection (b) of this section, that portion of any sign used as an electronic message center, shall be larger than limited to 3 square feet in area, may display a message containing no more than 5 characters, er and must not change the displayed message at intervals of less than once every 3 seconds. No electronic message center, except for temporary construction use, shall exceed a maximum one-hour equivalent A-weighted sound pressure level of 50 dBa at the receiving property line when the receiving property is occupied by a dwelling, hospital, school, library or assisted care center.
 - (b) Each service station may include up to 6 rectangular digital signs, constructed a minimum of 3 inches from each other, limited to 20 square feet in area cumulatively, and must not change the displayed message at intervals of less than once every 24 hours.
- (10) Digital Signs. One digital sign up to 20 square feet in area is permitted per institutional use on a development site. Digital signs must be located a minimum of 50 feet from the property line of any residentially zoned property. All digital signs shall be subject to the following standards:
 - (a) The change from one message to another message shall be no more frequent than once every 10 seconds.
 - (b) The change from one message to another message shall be instantaneous.
 - (c) Animation, scrolling or other perceived movement is not allowed.
 - (d) The digital sign shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 45 feet perpendicular to the sign face
 - (e) The digital sign shall be equipped with a light sensor that automatically adjusts the intensity of the digital display according to the amount of ambient light.

<u>Section 8</u>. Subsections (1) and (2) of Section 9.6645 of the Eugene Code, 1971, are amended to provide as follows:

9.6645 Applicability of Sign Standards.

(1) No sign permit shall be issued for any sign unless specifically identified as an

- allowed sign use under the terms of the applicable sign standards or otherwise allowed a permit under EC 9.6620 Nonconforming Signs or **exempted from the requirement for a permit under EC** 9.6610 Exemptions to Sign Standards.
- (2) Except as otherwise specified, signs located on property zoned S Special Zone shall be subject to the provisions of:
 - (a) EC 9.6650 <u>Residential Sign Standards</u>, if the use thereon is primarily characterized as residential,
 - (b) EC 9.6680 Employment and Industrial Sign Standards, if employment or industrial, or
 - (c) EC 9.6660 General Commercial Sign Standards-, or
 - (d) EC 9.3970(11) if the property is zoned S-WS Walnut Station Special Area Zone.

Section 9. Subsection (2) of Section 9.6650 of the Eugene Code, 1971, is amended to provide as follows:

- **Residential Sign Standards.** The residential sign standards are hereby created and applied to all land zoned as set forth below. Signage is limited to preserve the character of the area by allowing signs only for residential purposes and for non-residential uses allowed in the applicable zone.
 - (2) **Permitted Sign Types.** Signs allowed under residential sign standards are limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Freestanding signs;
 - (ed) Readerboards; and
 - (de) Wall signs.

<u>Section 10</u>. Subsection (2) of Section 9.6655 of the Eugene Code, 1971, is amended to provide as follows:

- **General Office Sign Standards.** The general office sign standards are hereby created and applied to all land as set forth below. Signs are regulated to accommodate the office buildings and other public uses that are commonly located within these zones and because of the proximity of residential areas.
 - (2) **Permitted Sign Types.** Signs allowed under general office sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Under-marquee signs; and
 - (gh) Wall signs.

Section 11. Subsection (2) of Section 9.6660 of the Eugene Code, 1971, is amended to provide as follows:

- **9.6660** General Commercial Sign Standards. The general commercial sign standards are hereby created and applied to all land as set forth below. Sign limitations reflect the commercial nature of the area and the amount of vehicular traffic.
 - (2) **Permitted Sign Types.** Signs allowed under these standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Roof signs;
 - (gh) Under-marquee signs; and
 - (hi) Wall signs.

Section 12. Subsection (2) of Section 9.6665 of the Eugene Code, 1971, is amended to provide as follows:

- 9.665 Shopping Center Sign Standards. The shopping center sign standards are hereby created and applied to all land as set forth below. Sign limitations in these standards accommodate the special commercial character of these areas and the residential areas which are close to most shopping centers.
 - (2) Permitted Sign Types. Signs allowed under the shopping center sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Roof signs;
 - (gh) Under-marquee signs; and
 - (hi) Wall signs.

Section 13. Subsections (2) and (3) of Section 9.6670 of the Eugene Code, 1971, are amended to provide as follows:

9.6670 <u>Central Commercial Sign Standards</u>. The central commercial sign standards are hereby created and applied to all property within the central commercial zones as set forth below. Signs are restricted in recognition of the high density usage of these areas, where pedestrian traffic is heavy and vehicular traffic is commonly limited.

- (2) Permitted Sign Types. Signs allowed under the central commercial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (e**d**) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Projecting signs;
 - (fg) Readerboards;
 - (gh) Roof signs;
 - (hi) Under-marquee signs; and
 - (ii) Wall signs.
- (3) Maximum Number of Signs. The number of signs central commercial sign standards allow shall be limited to no more than 1 electronic message center, freestanding, projecting sign, readerboard, or roof sign per development site street frontage and 1 projecting sign per business occupant. The number of allowed awning, marque, under-marque and wall signs is not limited.

Section 14. Subsections (1), (2), (6)(a) and (6)(b) of Section 9.6675 of the Eugene Code,

1971, are amended, and subsection (7) is added to provide as follows:

- **9.6675**Highway Commercial Sign Standards. The highway commercial sign standards are hereby created and applied to all land as set forth below. Signs in this area are regulated to accommodate the mixed uses of the areas and the presence of major streets with high traffic volumes.
 - (1) Corresponding Zones. The provisions of this section apply to that property within the S-RP Riverfront Park Special Zone located within 200 feet of the Franklin Boulevard center line and to property within the C-1, C-2, C-3, or any employment and industrial zone with frontage along the following named streets:
 - (a) Beltline Road from 11th Avenue to Roosevelt Boulevard:
 - (b) Broadway from Mill Street to Franklin Boulevard;
 - (c) Coburg Road from 6th Avenue to 200 feet north of Frontier Drive;
 - (d) Franklin Boulevard east from Broadway, including the north-south segment;
 - (e) Garfield Street from 11th Avenue to 5th Avenue;
 - (f) Goodpasture Island Road from Valley River Drive to 1,700 feet north;
 - (g) Highway 99 North;
 - (h) I-5 **on the south side only** from Henderson Avenue to 300 feet north of Laurel Hill Drive;
 - (i) I-5 on the north side only, from 720 feet east of Henderson Avenue to 1,330 feet east of Henderson Avenue;
 - (ji) I-105 from the Coburg interchange to Scout Access Road;
 - (kj) Mill Street from Broadway to Coburg Road;
 - (1k) Railroad Boulevard;
 - (m/) 6th Avenue east of conjunction with Highway 99 North;
 - (Am) 7th Avenue east of conjunction with Highway 99 North; and
 - (en) 11th Avenue from 200 feet east of the centerline of Chambers Street to Terry Street.

- **(2) Permitted Sign Types.** Signs allowed under the highway commercial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Billboards;
 - (c) Digital Billboards;
 - (d) Digital Signs;
 - (ee) Electronic message centers;
 - (df) Freestanding signs;
 - (eg) Marquee signs;
 - (fh) Projecting signs;
 - (ei) Readerboards:
 - (hj) Roof signs;
 - (ik) Under-marquee signs; and
 - (j/) Wall signs.
- **(6) Billboards.** Billboards shall be subject to the following standards:
 - (a) Billboards located along the streets named in subsection (1)(b) through (1)(g) and (1)(kj) through 1(en) of this section shall not exceed 250 square feet in surface area.
 - (b) Billboards located on developed property along streets named in subsection 1(a), and (1)(h) through **and** (1)(ji) of this section shall not exceed 300 square feet in surface area.
- (7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:
 - (a) Minimum spacing between digital billboards facing the same direction shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards.
 - (b) The change from one message to another message shall be no more frequent than once every 10 seconds.
 - (c) The change from one message to another message shall be instantaneous.
 - (d) Animation is not allowed.
 - (e) The digital billboard shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 150 feet perpendicular to the sign face.
 - (f) The digital billboard shall be equipped with a light sensor that automatically adjusts the intensity of the billboard according to the amount of ambient light.
 - (g) The digital billboard shall be designed to either freeze the display in one static position, display a full black screen or turn off in the event of a malfunction.
 - (h) Cutouts are not allowed.
 - (i) Notwithstanding EC 9.1230, legal nonconforming billboards may be removed and replaced by digital billboards if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet and all other standards in this section must be met.

(j) Digital billboards are allowed at the locations identified at EC 9.6675(1) except for (b), (e), (f), (j) and (k).

Section 15. Subsections (2) and (5) of Section 9.6680 of the Eugene Code, 1971, are amended, and subsection (7) is added to provide as follows:

- **Employment and Industrial Sign Standards.** The employment and industrial sign standards are hereby created and applied to all property zoned for employment and industrial use as set forth below. Signs are regulated to accommodate the minimal street frontage of most parcels and the general proximity to highways and arterial streets.
 - **(2) Permitted Sign Types.** Signs allowed under the industrial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Billboards;
 - (c) Digital Billboards;
 - (d) Digital signs;
 - (ee) Electronic message centers;
 - (df) Freestanding signs;
 - (eg) Marquee signs;
 - (fh) Projecting signs;
 - (gi) Readerboards;
 - (hj) Roof signs;
 - (ik) Under-marquee signs; and
 - (jl) Wall signs.
 - (5) Maximum Height. All billboards, freestanding signs and roof signs shall be no more than 30 feet in height except freestanding signsup to 5 feet in height are allowed in the E-1 zone at a minimum of 5 feet from the front property line.
 - (7) Digital Billboards. In addition to the standards in EC 9.6680(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:
 - (a) Minimum spacing between digital billboards facing the same direction shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards.
 - (b) The change from one message to another message shall be no more frequent than once every 10 seconds.
 - (c) The change from one message to another message shall be instantaneous.
 - (d) Animation is not allowed.
 - (e) The digital billboard shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 150 feet perpendicular to the sign face.
 - (f) The digital billboard shall be equipped with a light sensor that automatically adjusts the intensity of the billboard according to the amount of ambient light.
 - (g) The digital billboard shall be designed to either freeze the display in

- one static position, display a full black screen or turn off in the event of a malfunction.
- (h) Cutouts are not allowed.
- (i) Notwithstanding EC 9.1230, legal nonconforming billboards may be removed and replaced by digital billboards if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet and all other standards in this section must be met.
- (j) Digital billboards are only allowed at the location described in EC 9.6680(6)(a)5.

Section 16. The findings set forth in Exhibit A attached to this Ordinance are adopted as findings in support of this Ordinance.

Section 17. The City Recorder, at the request of, or with the concurrence of the City Attorney, is authorized to administratively correct any reference errors contained herein or in other provisions of the Eugene Code, 1971, to the provisions added, amended or repealed herein.

Section 18. If any section, subsection, sentence, clause, phrase or portion of this Ordinance is for any reason held invalid or unconstitutional by a court of competent jurisdiction, such portion shall be deemed a separate, distinct and independent provision and such holding shall not affect the validity of the remaining portions hereof.

Section 19. This Ordinance shall take effect pursuant to Section 32 of the Eugene Charter 2002, or on the date of its acknowledgement as provided in ORS 197.625, whichever is later.

Passed by the City Coun	icil this	Approved by the Mayor this			
day of	, 2020	day of	, 2020		
City Recorder		Mayor	Mayor		

Exhibit A Findings: Digital Sign Code Amendments (City File # CA 20-2)

Overview

These land use code amendments modify existing sign code standards to allow and regulate digital billboards and digital reader boards. The amendments focus on how best to allow conversion of existing billboards to new digital technology with specific standards for maximum size, message change intervals, brightness, location and separation. The amendments also include digital allowances for institutional uses and gas stations and minor changes to the existing sign code to add clarity.

Findings

Eugene Code Section 9.8065 requires that the following approval criteria (in **bold italics**) be applied to a code amendment:

(1) The amendment is consistent with applicable statewide planning goals adopted by the Land Conservation and Development Commission.

<u>Goal 1 - Citizen Involvement</u>. To develop a citizen involvement program that insures the opportunity for citizens to be involved in all phases of the planning process.

The City has acknowledged provisions for community involvement which insure the opportunity for citizens to be involved in all phases of the planning process and set out requirements for such involvement. This code amendment does not amend the City's citizen involvement program. The process for adopting this amendment complied with Goal 1 because it is consistent with the City's acknowledged citizen involvement provisions.

A Notice of Proposed Amendment was filed with the Oregon Department of Land Conservation and Development on June 15, 2020. A public hearing was held by the Planning Commission on July 28, 2020. A public hearing was held by the City Council on September 21, 2020. Consistent with land use code requirements, the Planning Commission public hearing on the proposal was duly noticed to all neighborhood organizations in Eugene, as well as community groups and individuals who requested notice. In addition, notice of the Planning Commission public hearing was published in the Register Guard, a newspaper of general circulation in the city, on July 6, 2020. Also consistent with land use code requirements, the City Council public hearing on the proposal was duly noticed to all persons who provided oral or written testimony during the planning commission hearing procedure and those who requested notice on September 3, 2020. Information concerning the amendment, including the dates of the public hearings was posted on the City of Eugene website.

These processes afford ample opportunity for citizen involvement consistent with Goal 1. Therefore, the ordinance is consistent with Statewide Planning Goal 1.

<u>Goal 2 - Land Use Planning</u>. To establish a land use planning process and policy framework as a basis for all decisions and actions related to use of land and to assure an adequate factual basis for such

decisions and actions.

Eugene's land use code specifies the procedure and criteria that were used in considering this amendment. The record shows that there is an adequate factual basis for the amendment. The Goal 2 coordination requirement is met when the City engages in an exchange, or invites an exchange, between the City and any affected governmental unit and when the City uses the information obtained in the exchange to balance the needs of the citizens.

To comply with the Goal 2 coordination requirement, the City engaged in an exchange about the subject of this amendment with affected governmental units. Specifically, the City provided notice of the proposed amendment and opportunity to comment to the Oregon Department of Land Conservation and Development, as well as to Lane County and the City of Springfield. There are no exceptions to Statewide Planning Goal 2 required for this amendment. Therefore, the amendment is consistent with Statewide Planning Goal 2.

Goal 3 - Agricultural Lands. To preserve agricultural lands.

The amendment affects property located within the City of Eugene and does not affect any land designated for agricultural use. Therefore, Statewide Planning Goal 3 does not apply.

Goal 4 - Forest Lands. To conserve forest lands.

The amendment is for property located within the City of Eugene and does not affect any land designated for forest use. Therefore, Statewide Planning Goal 4 does not apply.

<u>Goal 5 - Open Spaces, Scenic and Historic Areas, and Natural Resources.</u> To conserve open space and protect natural and scenic resources.

OAR 660-023-0250(3) provides: Local governments are not required to apply Goal 5 in consideration of a PAPA unless the PAPA affects a Goal 5 resource. For purposes of this section, a PAPA would affect a Goal 5 resource only if:

- (a) The PAPA creates or amends a resource list or a portion of an acknowledged plan or land use regulation adopted in order to protect a significant Goal 5 resource or to address specific requirements of Goal 5;
- (b) The PAPA allows new uses that could be conflicting uses with a particular significant Goal 5 resource site on an acknowledged resource list; or
- (c) The PAPA amends an acknowledged UGB and factual information is submitted demonstrating that a resource site, or the impact areas of such a site, is included in the amended UGB area.

This amendment does not create or amend the City's list of Goal 5 resources, does not amend a code provision adopted in order to protect a significant Goal 5 resource or to address specific requirements of Goal 5, does not allow new uses that could be conflicting uses with a significant Goal 5 resource site, and does not amend the acknowledged urban growth boundary. Therefore, Statewide Planning Goal 5 does not apply.

Goal 6 - Air, Water and land Resource Quality. To maintain and improve the quality of the air, water

and land resources of the state.

Goal 6 addresses waste and process discharges from development, and is aimed at protecting air, water and land from impacts of those discharges. The amendment does not affect the City's ability to provide for clean air, water or land resources. Therefore, Statewide Planning Goal 6 does not apply.

<u>Goal 7 - Areas Subject to Natural Disasters and Hazards</u>. To protect life and property from natural disasters and hazards.

Goal 7 requires that local government planning programs include provisions to protect people and property from natural hazards such as floods, landslides, earthquakes and related hazards, tsunamis, and wildfires. The Goal prohibits development in natural hazard areas without appropriate safeguards. The amendment does not affect the City's restrictions on development in areas subject to natural disasters and hazards. Further, the amendment does not allow for new development that could result in a natural hazard. Therefore, Statewide Planning Goal 7 does not apply.

<u>Goal 8 - Recreational Needs</u>. To satisfy the recreational needs of the citizens of the state and visitors, and where appropriate, to provide for the siting of necessary recreational facilities including destination resorts.

Goal 8 ensures the provision of recreational facilities for Oregon citizens and is primarily concerned with the provision of those facilities in non-urban areas of the state. The amendment does not affect the City's provisions for or access to recreation areas, facilities, or recreational opportunities. Therefore, Statewide Planning Goal 8 does not apply.

<u>Goal 9 - Economic Development</u>. To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.

Goal 9 requires cities to evaluate the supply and demand of commercial land relative to community economic objectives. The amendment does not impact the supply of industrial or commercial lands. Therefore, the amendment is consistent with Statewide Planning Goal 9.

Goal 10 - Housing. To provide for the housing needs of citizens of the state.

Goal 10 requires communities to provide an adequate supply of residential buildable land to accommodate estimated housing needs for a 20-year planning period. The amendment does not impact the supply of residential lands. Therefore, the amendment is consistent with Statewide Planning Goal 10.

<u>Goal 11- Public Facilities and Services</u>. To plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development.

The amendment does not affect the City's provision of public facilities and services. Therefore, Statewide Planning Goal 11 does not apply.

<u>Goal 12- Transportation</u>. To provide and encourage a safe, convenient and economic transportation system.

The Transportation Planning Rule (OAR 660-012-0060) contains the following requirement:

- (1) If an amendment to a functional plan, an acknowledged comprehensive plan, or a land use regulation (including a zoning map) would significantly affect an existing or planned transportation facility, then the local government must put in place measures as provided in section (2) of this rule, unless the amendment is allowed under section (3), (9) or (10) of this rule. A plan or land use regulation amendment significantly affects a transportation facility if it would:
 - (a) Change the functional classification of an existing or planned transportation facility (exclusive of correction of map errors in an adopted plan);
 - (b) Change standards implementing a functional classification system; or
 - (c) Result in any of the effects listed in paragraphs (A) through (C) of this subsection based on projected conditions measured at the end of the planning period identified in the adopted TSP. As part of evaluating projected conditions, the amount of traffic projected to be generated within the area of the amendment may be reduced if the amendment includes an enforceable, ongoing requirement that would demonstrably limit traffic generation, including, but not limited to, transportation demand management. This reduction may diminish or completely eliminate the significant effect of the amendment.
 - (A) Types or levels of travel or access that are inconsistent with the functional classification of an existing or planned transportation facility;
 - (B) Degrade the performance of an existing or planned transportation facility such that it would not meet the performance standards identified in the TSP or comprehensive plan; or
 - (C) Degrade the performance of an existing or planned transportation facility that is otherwise projected to not meet the performance standards identified in the TSP or comprehensive plan.

The amendment does not: change the functional classification of a transportation facility; change the standards implementing a functional classification system; or degrade the performance of a facility otherwise projected to not meet performance standards. Therefore, the amendment does not significantly affect any existing or future transportation facilities. Based on the above findings, the amendment is consistent with Statewide Planning Goal 12.

<u>Goal 13 - Energy Conservation</u>. To conserve energy.

The amendment does not impact energy conservation. Therefore, Statewide Planning Goal 13 does not apply.

<u>Goal 14 - Urbanization</u>. To provide for an orderly and efficient transition from rural to urban land use.

The amendment does not affect the City's provisions regarding the transition of land from rural to urban uses. Therefore, Statewide Planning Goal 14 does not apply.

<u>Goal 15 - Willamette River Greenway.</u> To protect, conserve, enhance and maintain the natural, scenic, historical, agricultural, economic and recreational qualities of lands along the Willamette River as the Willamette River Greenway.

The amendment does not contain any changes that affect the Willamette River Greenway regulations; therefore, Statewide Planning Goal 15 does not apply.

<u>Goal 16 through 19 - Estuarine Resources, Coastal Shorelands, Beaches and Dunes, and Ocean Resources.</u>

There are no coastal, ocean, estuarine, or beach and dune resources related to the property affected by this amendment. Therefore, Statewide Planning Goals 16 through 19 do not apply.

(2) The amendment is consistent with applicable provisions of the comprehensive plan and applicable adopted refinement plans.

Metro Plan

The Metro Plan does not contain any policies relevant to this amendment.

Envision Eugene Comprehensive Plan

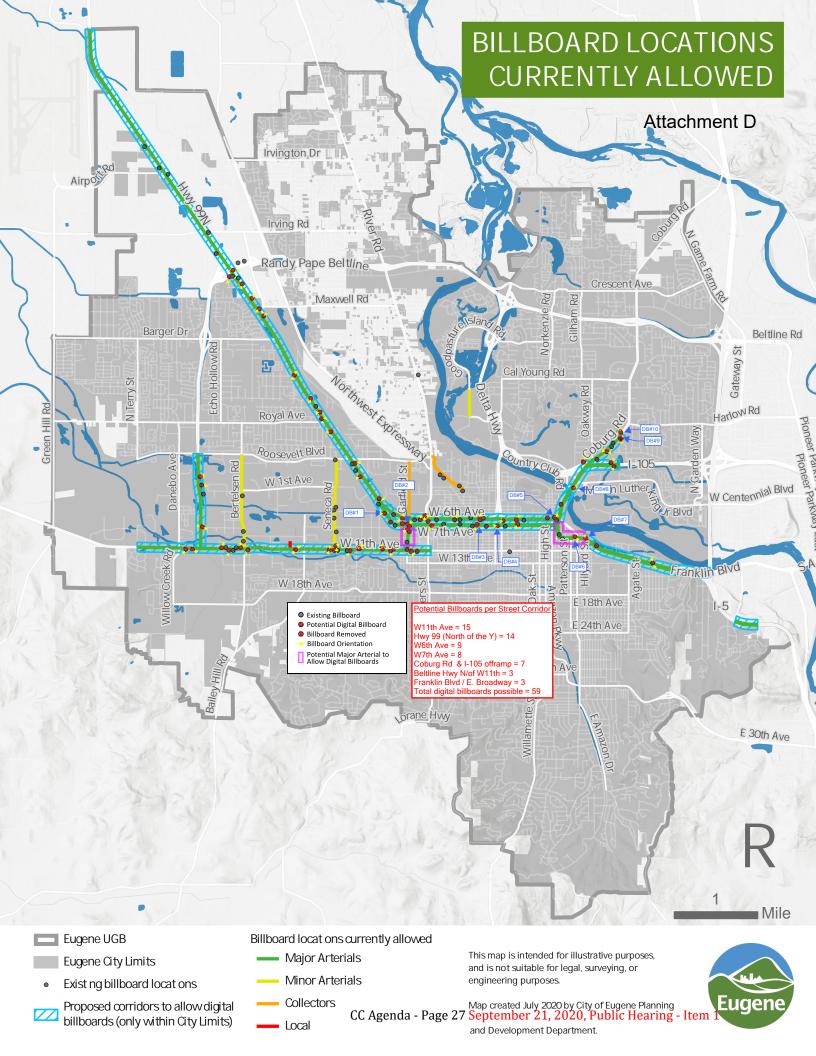
The Envision Eugene Comprehensive Plan does not contain any policies relevant to this amendment.

Applicable Refinement Plans

The City's adopted refinement plans do not contain policies relevant to this amendment.

(3) The amendment is consistent with EC 9.3020 Criteria for Establishment of an S Special Area Zone, in the case of establishment of a special area zone.

The amendments do not establish a special area zone. Therefore, this criterion does not apply.



Attachment E

From: Mike Reeder <mreeder@oregonlanduse.com>

Sent: Thursday, July 9, 2020 3:51 PM

To: MCKERROW Mike J < MMcKerrow@eugene-or.gov >

Cc: Hoobler, Rob < <u>rob.hoobler@outfrontmedia.com</u>>; Valencia, Mary

<<u>mary.valencia@outfrontmedia.com</u>>; Aaron Noteboom <<u>aaron@noteboomlaw.com</u>>; Chris Zukin <<u>czukin@meadowoutdoor.com</u>>; <u>tjtorrey@comcast.net</u>; John Fitzmaurice <<u>jfitzmaurice@lamar.com</u>>; John Lehman <<u>jlehman@meadowoutdoor.com</u>>; Mike Zukin <<u>MZukin@meadowoutdoor.com</u>>; Hill,

Christie D < christie D < christie D < christie D < christie.hill@outfrontmedia.com>
Subject: RE: Eugene Sign Code - Digital

Importance: High

[EXTERNAL ⚠]

Mike:

Please see the attached. We appreciate all of you work on this matter. I hope all is well with you.

Best,

Mike



Office: (458) 210-2845 | <u>oregonlanduse.com</u> 375 W. 4th Ave., Suite 205, Eugene, OR 97401

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Digital Sign Amendments Ordinance

Proposed Land Use Code Changes
DRAFT – June 9, 2020 (Including MMR Edits 7/9/2020)

Language to be added is shown in **bold italics**. Language to be removed is show by strikeout.

Definitions:

Cutout. A supplemental design element attached to or superimposed upon a billboard.

Digital Billboard. Any billboard that changes messages by any electronic process.

Digital Sign. Any sign with a sign face of 20 or fewer square feet in surface area that changes messages by any electronic process.

Electronic Message Center. A sign, or portion of a sign, that conveys information through a periodic automatic change of message on a lampbank, through the use of fiber optics, or through mechanical means. A sign on which any portion less than an entire sign rotates shall be considered an electronic message center. A sign component that utilizes a computer or other electronic means to change the digital message displayed.

Flashing Sign. A sign or sign structure *that is not a digital billboard, digital sign, or electronic message center,* where some part of the display is provided by light-emitting elements which abruptly change color or intensity of illumination, including intermittent periods of illumination and non-illumination, or where the effect of flashing is achieved through mechanical means, including rotation.

Sign Standards:

9.6610 <u>Exemptions to Sign Standards</u>.

(2) Except as provided in subsection (3) of this section, the following signs are exempt from the requirements of EC 9.6600 through 9.6680, and are exempt from the requirement to obtain a sign permit if they are located on private property outside of vision clearance areas:

* * *

<u>Building Directories</u>. For buildings with multiple tenants, one wall-mounted sign up to 12 square feet in area for the purpose of communicating to persons already on the development site.

* * *

Message Boards Drive-through Signs. One sign per business for the purpose of communicating to persons on the development site, such as a drive through menu sign or building directory. Such a sign may be up to 6 feet in height and up to 40 square feet in area.

Two drive-through signs for each drive-through lane. Each drive-through sign may be up to 7 feet in height and up to 40 square feet in area. Drive-through signs may be digital signs if the sign display is static and the copy is not changed more than once per hour, except for a portion of the digital display not to exceed 2 square feet may change copy more frequently.

* * *

Residential Property Signs. Two signs for each development site used primarily for a single family dwelling or duplex. The signs are limited to the following types: freestanding sign or banner. A freestanding sign may not exceed 12 square feet in size per face, with a maximum of two faces; a banner may not exceed 15 square feet in size. The maximum height of a freestanding sign under this exemption is 6 5 feet (from grade), and it must be separated by at least 8 feet from any other freestanding sign on the same development site.

* * *

9.6615 Prohibited Signs. Except where qualified as a nonconforming sign, the following signs are unlawful and are declared to be nuisances:

* * *

- (5) Decorative laser signs, search lights, and flashing signs, except electronic message centers;
- 9.6620 Nonconforming Signs.

* * *

(3) Except as provided in EC 9.6675(7) and EC 9.6680(7) or Except where only a change in display copy is made, any nonconforming sign which is structurally altered or has illumination installed shall be brought into compliance with all applicable provisions of the sign standards within 90 days and shall thereafter be kept in compliance with the sign standards.

* * *

(5) The provisions of subsection (6) of this section and subsection (2) of EC 9.6635 Approval of Permit Application do not apply to signs in existence pursuant to a validly issued sign permit as of July 1, 1990, along Goodpasture Island Road from a point 300 feet north of the intersection with Valley River Way to a point 1400 feet north of the intersection. The provisions of subsection (2) of this section shall apply except that restoration of a damaged

- sign shall be allowed where a sign is damaged to the extent of 100 percent of its value. All other provisions of this section shall apply.
- (6) All signs with a surface area of 200 square feet or greater shall be removed or brought into compliance with this land use code by April 1, 2003.

9.6630 Permit Application.

(1) An application and related information shall be submitted by the applicant, in a manner prescribed by the city, together with a fee established by the city manager as provided by EC 2.020 <u>City Manager - Authority to Set Fees and Charges</u>. When a person begins construction of a sign requiring a sign permit before the permit is issued, the permit fee shall be doubled. Payment of a double permit fee shall not otherwise exempt the person from liability for other penalties prescribed for a violation of the sign standards.

* * *

9.6635 Approval of Permit Application.

* * *

(8) A decision granting or denying a sign permit may be appealed to a hearings official. Appeals are processed according to other Type II applications beginning at EC 9.7200 General Overview of Type II Application Procedures. The decision of the hearings official is final.

9.6640 General Provisions.

* * *

(4) Location Standards.

(a) <u>Setbacks</u>. All signs shall comply with the setback requirements beginning at EC 9.2000 through EC 9.3980 and EC 9.6745 <u>Setbacks - Intrusions Permitted</u>. Signs may be installed up to 5 feet into the required front yard setback except that freestanding signs up to 5 feet in height in the E-1 zone may be installed at least 5 feet from the front property line.

* * *

<u>Projecting Over the Public *Right-of-*Way</u>. Except as specified in EC 9.6670 <u>Central Commercial Sign Standards</u>, no privately owned sign may project over any public right-of-way.

* * *

(5) Construction Standards.

* * *

(f) Wall Signs. Wall signs shall may project up to a maximum of 12 inches from the wall, except that wall signs shall project no more than 4 inches from the wall when the sign is less than 8 feet above a sidewalk or public way. when the wall sign is more than 8 feet above

grade and a maximum of 4 inches when the wall sign is less than 8 feet above grade.

(6) Illumination Standards.

* * *

(d) Illumination From Signs on Residentially Zoned Property. No internally illuminated sign shall be allowed on property in a residential zone. Lighting from all light sources operated for the purposes of sign illumination on property in a residential zone shall be shielded from other property in the residential zone and shall not be more than 2 foot candles at any point along the boundary of the development site closest street or property line. Externally illuminated signs shall be shielded.

* * *

- (9) Electronic Message Centers. Except electronic message centers operated as public signs by governmental agencies, no electronic message centers are subject to the following limitations:, or
 - (a) Except as provided in subsection (b) of this section, that portion of any sign used as an electronic message center shall be larger than limited to 3 square feet in area, may display-a message containing no more than 5 characters, orand must not change the displayed message at intervals of less than once every 3 seconds. No electronic message center, except for temporary construction use, shall exceed a maximum one-hour equivalent A-weighted sound pressure level of 50 dBa at the receiving property line when the receiving property is occupied by a dwelling, hospital, school, library or assisted care center.
 - (b) Each service station may include up to 6 rectangular digital signs, constructed a minimum of 3 inches from each other, limited to 20 square feet in area cumulatively, and must not change the displayed message at intervals of less than once every 24 hours.
- (10) Digital Signs. One digital sign up to 20 square feet in area is permitted per institutional use on a development site. Digital signs must be located a minimum of 50 feet from the property line of any residentially zoned property.

All digital signs shall be subject to the following standards:

- (a) The change from one message to another message shall be no more frequent than once every 10 seconds.
- (b) The change from one message to another message shall be instantaneous.
- (c) Animation, scrolling or other perceived movement is not allowed.
- (d) The digital sign shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 45 feet perpendicular to the sign face
- (e) The digital sign shall be equipped with a light sensor that automatically adjusts the intensity of the digital display according to the amount of ambient light.

9.6645 Applicability of Sign Standards.

- (1) No sign permit shall be issued for any sign unless specifically identified as an allowed sign use under the terms of the applicable sign standards or otherwise allowed a permit under EC 9.6620 Nonconforming Signs or exempted from the requirement for a permit under EC 9.6610 Exemptions to Sign Standards.
- (2) Except as otherwise specified, signs located on property zoned S Special Zone shall be subject to the provisions of:

* * *

- (b) EC 9.6680 Employment and Industrial Sign Standards, if employment or industrial, er
- (c) EC 9.6660 General Commercial Sign Standards., or
- (d) EC 9.3970(11) if the property is zoned S-WS Walnut Station Special Area Zone.

* * *

Residential Sign Standards. The residential sign standards are hereby created and applied to all land zoned as set forth below. Signage is limited to preserve the character of the area by allowing signs only for residential purposes and for non-residential uses allowed in the applicable zone.

* * *

- (2) **Permitted Sign Types.** Signs allowed under residential sign standards are limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Freestanding signs:
 - (ed) Readerboards; and
 - (de) Wall signs.

* * *

General Office Sign Standards. The general office sign standards are hereby created and applied to all land as set forth below. Signs are regulated to accommodate the office buildings and other public uses that are commonly located within these zones and because of the proximity of residential areas.

* * *

- (2) **Permitted Sign Types.** Signs allowed under general office sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs:
 - (de) Marquee signs;
 - (ef) Readerboards;

- (fg) Under-marquee signs; and
- (gh) Wall signs.

* * *

9.6660 General Commercial Sign Standards. The general commercial sign standards are hereby created and applied to all land as set forth below. Sign limitations reflect the commercial nature of the area and the amount of vehicular traffic.

* * *

- (2) **Permitted Sign Types.** Signs allowed under these standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Roof signs;
 - (gh) Under-marquee signs; and
 - (hi) Wall signs.

* * *

Shopping Center Sign Standards. The shopping center sign standards are hereby created and applied to all land as set forth below. Sign limitations in these standards accommodate the special commercial character of these areas and the residential areas which are close to most shopping centers.

* * *

- (2) **Permitted Sign Types.** Signs allowed under the shopping center sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Roof signs;
 - (gh) Under-marquee signs; and
 - (hi) Wall signs.

* * *

9.6670 Central Commercial Sign Standards. The central commercial sign standards are hereby created and applied to all property within the central commercial zones as set forth below. Signs are restricted in recognition of the high density usage of these areas, where pedestrian traffic is heavy and vehicular traffic is commonly limited.

* * *

- (2) **Permitted Sign Types.** Signs allowed under the central commercial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Projecting signs:
 - (fg) Readerboards;
 - (gh) Roof signs;
 - (hi) Under-marquee signs; and
 - (ij) Wall signs.
- (3) Maximum Number of Signs. The number of signs central commercial sign standards allow shall be limited to no more than 1 electronic message center, freestanding, projecting sign, readerboard, or roof sign per development site street frontage and 1 projecting sign per business occupant. The number of allowed awning, marque, under-marque and wall signs is not limited.

* * *

- **9.6675**Highway Commercial Sign Standards. The highway commercial sign standards are hereby created and applied to all land as set forth below. Signs in this area are regulated to accommodate the mixed uses of the areas and the presence of major streets with high traffic volumes.
 - (1) Corresponding Zones. The provisions of this section apply to that property within the S-RP Riverfront Park Special Zone located within 200 feet of the Franklin Boulevard center line and to property within the C-1, C-2, C-3, or any employment and industrial zone with frontage along the following named streets:
 - (a) Beltline Road from 11th Avenue to Roosevelt Boulevard;
 - (b) Broadway from Mill Street to Franklin Boulevard;
 - (c) Coburg Road from 6th Avenue to 200 feet north of Frontier Drive;
 - (d) Franklin Boulevard east from Broadway, including the north-south segment;
 - (e) Garfield Street from 11th Avenue to 5th Avenue;
 - (f) Goodpasture Island Road from Valley River Drive to 1,700 feet north;
 - (g) Highway 99 North;
 - (h) I-5 **on the south side only** from Henderson Avenue to 300 feet north of Laurel Hill Drive;
 - (i) I-5 on the north side only, from 720 feet east of Henderson Avenue to 1,330 feet east of Henderson Avenue;
 - (ji) I-105 from the Coburg interchange to Scout Access Road;
 - (kj) Mill Street from Broadway to Coburg Road;
 - (lk) Railroad Boulevard;
 - (ml) 6th Avenue east of conjunction with Highway 99 North;
 - (nm) 7th Avenue east of conjunction with Highway 99 North; and
 - (en) 11th Avenue from 200 feet east of the centerline of Chambers Street to Terry Street.

- (2) **Permitted Sign Types.** Signs allowed under the highway commercial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Billboards;
 - (c) Digital Billboards;
 - (d) Digital Signs;
 - (ee) Electronic message centers;
 - (df) Freestanding signs;
 - (eg) Marquee signs;
 - (fh) Projecting signs;
 - (qi) Readerboards;
 - (hj) Roof signs;
 - (ik) Under-marquee signs; and
 - (il) Wall signs.

* * *

- (6) Billboards. Billboards shall be subject to the following standards:
 - (a) Billboards located along the streets named in subsection (1)(b) through (1)(g) and (1)(jk) through 1(ne) of this section shall not exceed 250 square feet in surface area.
 - (b) Billboards located on developed property along streets named in subsection 1(a), and (1)(h) and through (1)(ij) of this section shall not exceed 300 square feet in surface area.

* * *

- (7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:
 - (a) Minimum spacing between digital billboards facing the same direction shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards.
 - (b) The change from one message to another message shall be no more frequent than once every 108 seconds.
 - (c) The change from one message to another message shall be instantaneous.
 - (d) Animation is not allowed.
 - (e) The digital billboard shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 150 feet perpendicular to the sign face.
 - (f) The digital billboard shall be equipped with a light sensor that automatically adjusts the intensity of the billboard according to the amount of ambient light.
 - (g) The digital billboard shall be designed to either freeze the display in one static position, display a full black screen or turn off in the event of a malfunction.
 - (h) Cutouts are not allowed.

- (i) Notwithstanding EC 9.1230, legal nonconforming billboards may be removed and replaced by digital billboards if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet and all other standards in this section must be met.
- (j) Digital billboards <u>must have a permit from the Oregon Department</u> of Transportation issued pursuant to ORS 377.725 are allowed at the locations identified at EC 9.6675(1) except for (b), (e), (f), (j) and (k).
- (k) During the five year period following fenactment date], the City shall approve a permit for a digital billboard at the locations stated in this EC 9.6675(7)(k) notwithstanding any spacing standards which may otherwise prohibit the digital billboard, and the City shall not approve a permit for a digital billboard, other than those listed in this EC 9.6675(7)(k), that would violate any spacing standards with respect to the digital billboard locations identified and allowed herein. Except as specifically provided herein, this provision shall not act to prohibit or restrict digital billboards otherwise allowed by the code. This provision shall not apply to digital billboard permit applications submitted after the expiration of the five year period and will not act as a basis to approve or deny such applications.

E. Broadway North Line 200' W/O Hilyard. East Face

Franklin Blvd North Line 230' E/O Hilyard St. West Face

Coburg Rd West Line 190' N/O Frontier Drive. South Face

Coburg Rd East Line 270' N/O Oakmont. North Face

Coburg Rd East Line 350' S/O MLK. North Face

6th Ave North Line 150' E/O High St East Face

W. 7th South Line 100' E/O Jefferson. West Face

W 7th North Line 20' W/O Blair Blvd West Face

Chambers East Line 133' S/O 6th Ave. South Face

W 7th South Line 250' E/O W 5th West Face

9.6680 Employment and Industrial Sign Standards. The employment and industrial sign standards are hereby created and applied to all property zoned for employment and industrial use as set forth below. Signs are regulated to accommodate the minimal

street frontage of most parcels and the general proximity to highways and arterial streets.

* * *

- **(2) Permitted Sign Types.** Signs allowed under the industrial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Billboards;
 - (c) Digital Billboards;
 - (d) Digital signs;
 - (ee) Electronic message centers;
 - (df) Freestanding signs;
 - (eg) Marquee signs;
 - (fh) Projecting signs;
 - (gi) Readerboards;
 - (hj) Roof signs;
 - (ik) Under-marquee signs; and
 - (jl) Wall signs.

* * *

- (5) Maximum Height. All billboards, freestanding signs and roof signs shall be no more than 30 feet in height except freestanding signsup to 5 feet in height are allowed in the E-1 zone at a minimum of 5 feet from the front property line.
- **(6) Billboards.** Billboards regulated by the employment and industrial sign standards shall be subject to the following:
 - a) Billboards shall be permitted only along property which abuts the following named streets:
 - 1. Garfield Street north of 5th Avenue to the intersection of Roosevelt Boulevard.
 - Seneca Street north of 11th Avenue to the intersection of Roosevelt Boulevard.
 - 3. Bertelsen Road north of 11th Avenue to the intersection of Roosevelt Boulevard.
 - 4. Obie Street north of 11th Avenue to the end of the street, but no further north than the intersection of Stewart Road.
 - 5. West 11th Avenue from 200 feet east of the centerline of Chambers Street to Terry Street.
 - (b) No billboard shall exceed 250 square feet in area.
 - (c) Notwithstanding the required connection between perimeter wall size and billboard size established in (4)(b) of this section, a billboard not to exceed 200 square feet may be located on an otherwise vacant lot abutting any street designated in this section.
 - (d) The provisions of EC 9.6675(6)(d) to (i) shall apply to all billboards in areas regulated by the employment and industrial sign standards.
- (7) Digital Billboards. In addition to the standards in EC 9.6680(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:
 - (a) Minimum spacing between digital billboards facing the same

- <u>direction</u> shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards.
- (b) The change from one message to another message shall be no more frequent than once every 10-8 seconds.
- (c) The change from one message to another message shall be instantaneous.
- (d) Animation is not allowed.
- (e) The digital billboard shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 150 feet perpendicular to the sign face.
- (f) The digital billboard shall be equipped with a light sensor that automatically adjusts the intensity of the billboard according to the amount of ambient light.
- (g) The digital billboard shall be designed to either freeze the display in one static position, display a full black screen or turn off in the event of a malfunction.
- (h) Cutouts are not allowed.
- (i) Notwithstanding EC 9.1230, legal nonconforming billboards may be removed and replaced by digital billboards if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet and all other standards in this section must be met.
- (j) Digital billboards <u>must have a permit from the Oregon Department</u> of Transportation issued pursuant to ORS 377.725 are only allowed at the location described in EC 9.6680(6)(a)5.

Attachment D

From: MCKERROW Mike J

Sent: Thursday, July 16, 2020 10:37 AM

To: steven Rudnick < steven Rudnick < steven Rudnick < steven Rudnickelectricsigns.com>

Subject: RE: Eugene to Modify Sign Standards Related to Billboards and some Digital Signs

Steven,

Thanks for your timely response. We appreciate your input on trying to make sign codes less complicated. The bulk of this proposed code amendment allows traditional billboards to transition to digital billboards. While the draft includes some compatibility standards based on industry and ODOT parameters it allows more electronic signage than the current code. The proposed changes provide new allowances and do not further restrict signage compared to existing standards.

If you have time to look into it in more detail your electrical sign expertise would be helpful if you see any glitches or unintended consequences. Again, thanks for taking the time to comment.

Mike McKerrow Land Use Analyst

Building and Permit Services 99 West 10th Avenue Eugene OR 97401 Phone 541.682.5288

From: steven Rudnick <steve@rudnickelectricsigns.com>

Sent: Tuesday, July 14, 2020 5:35 PM

To: MCKERROW Mike J < MMcKerrow@eugene-or.gov>; dan@imagekingsigns.com; cgoodman@esasigns.com; 2133@fastsigns.com; dennis@fabcosigns.com; neal@neonsigns.com; info@salemsign.com; larry@nomadsign.com; info@oregonsignworks.com; pat.giani@gigr.com; dakstats@daktronics.com; curtis@rosecitysigns.com; Hoobler, Rob < rob.hoobler@outfrontmedia.com>; Valencia, Mary < mary.valencia@outfrontmedia.com>; Aaron Noteboom < aaron@noteboomlaw.com>; Chris Zukin < czukin@meadowoutdoor.com>; tjtorrey@comcast.net; John Fitzmaurice < rob. ifitzmaurice@lamar.com>; John Lehman < rob. ilehman@meadowoutdoor.com>; Mike Zukin < MZukin@meadowoutdoor.com>; Hill, Christie D < christie.hill@outfrontmedia.com>

Cc: DRAGOVICH Jenessa L < <u>JDragovich@eugene-or.gov</u>>

Subject: RE: Eugene to Modify Sign Standards Related to Billboards and some Digital Signs

[EXTERNAL ⚠]

I am sick and tired of restrictive sign codes that are constantly making it impossible for business to obtain signage they need, hurting out businesses and making it very expensive, to the point we can't charge enough, to make a good living.

We do NOT make money on farting around with the city constantly because it would take years to grow big enough to have dedicated staff for permitting. Further more signs that are too small are heard to read and if a customer is proud enough to have a large sign why can't they have it and buy who's initiative is it to restrict them?

I hope everyone at the cities will back off on restrictive sign codes and involve us before making more uninformed decisions.

I hope this helps allow signage over not allowing as is currently being seen. Steve Rudnick

P.S. I am a master sign electrician and licensed in both Oregon & Washington. I have been in business for over 11 years and it has never been harder to make a living until now.

Thanks for listening.



Steven Rudnick Rudnick Electric Signs LLC Owner/Master Sign Electrician O: (503) 263-3600 D: (503)263-... (503) 997-8882 Mobile steve@rudnickelectricsigns.c... 1400 S Township rd. Canby, OR. 97013-7758 www.rudnickelectricsigns.com

Rudnick Electric Signs LLC 1400 SE Township rd. Canby, OR. 97013 Steven Rudnick – CEO O: 503-263-4618

C: 503-997-8882

www.rudnickelectricsigns.com

From: MCKERROW Mike J < MMcKerrow@eugene-or.gov>

Sent: Tuesday, July 14, 2020 3:49 PM

To: dan@imagekingsigns.com; cgoodman@esasigns.com; 2133@fastsigns.com; dennis@fabcosigns.com; neal@neonsigns.com; info@salemsign.com; larry@nomadsign.com; info@oregonsignworks.com; pat.giani@gigr.com; dakstats@daktronics.com; curtis@rosecitysigns.com; steven Rudnick <steve@rudnickelectricsigns.com>; Hoobler, Rob <rob.hoobler@outfrontmedia.com>; Valencia, Mary <mary.valencia@outfrontmedia.com>; Aaron Noteboom <aaron@noteboomlaw.com>; Chris Zukin <czukin@meadowoutdoor.com>; tjtorrey@comcast.net; John Fitzmaurice <ifitzmaurice@lamar.com>; John Lehman <ifitehman@meadowoutdoor.com>; Mike Zukin <mz/><mzukin@meadowoutdoor.com>; Hill, Christie D <christie.hill@outfrontmedia.com>

Cc: DRAGOVICH Jenessa L < <u>JDragovich@eugene-or.gov</u>>; MCKERROW Mike J < <u>MMcKerrow@eugene-or.gov</u>>

Subject: Eugene to Modify Sign Standards Related to Billboards and some Digital Signs

Greetings from the City of Eugene,

You are receiving this email as a company who submits sign permits to the City of Eugene. The Eugene City Council has initiated a land use code amendment process to modify the existing sign code. The main goal of the proposed changes is to allow and regulate digital billboards and digital readerboards. The proposed amendments focus on how best to allow conversion of existing billboards to new digital technology with specific standards for maximum size, message change intervals, brightness, location and separation. The proposed amendments also include digital allowances for institutional uses and service stations and minor changes to the existing sign code suggested by staff to add clarity. The Council direction provided a limited scope for changes, so general changes to the existing sign code are not being considered through this process.

Staff will be holding a work session for the Planning Commission next Tuesday, July 21, 2020. The meeting agenda and materials, including the draft amendments, are available online here: https://www.eugene-or.gov/AgendaCenter/ViewFile/Agenda/ 07212020-1021. Then, on Tuesday, July 28, 2020, the Planning Commission will hold a virtual public hearing to receive feedback and testimony regarding the proposed amendments before they make a recommendation to City Council. The notice for the public hearing is attached with details on how to participate.

If you have any questions please feel free to contact me.

Mike McKerrow Land Use Analyst

Building and Permit Services 99 West 10th Avenue Eugene OR 97401 Phone 541.682.5288

DRAGOVICH Jenessa L

From: Brian Casady <BCasady@meadowoutdoor.com>

Sent: Monday, July 20, 2020 4:59 PM

To: DRAGOVICH Jenessa L

Cc: Aaron Noteboom; Mike Reeder; MCKERROW Mike J; Chris Zukin

Subject: A submission of a Powerpoint for Planning Commission Meeting on 7/28

Attachments: Eugene Digitil Powerpoint.PC.7.28.2020.pptx

[EXTERNAL ⚠]

Dear Jenessa,

Please find attached a brief power point that the billboard industry would like to present at the Planning Commission meeting on July 28th. Please let me know if you need any additional information from me on this.

Thanks,

Brian Casady

Real Estate Manager
Meadow Outdoor Advertising

Office: 541.296.9684 Cell: 541.993.4839 Fax: 541.296.1855

bcasady@meadowoutdoor.com www.meadowoutdoor.com



DIGITAL SIGNS FOR EUGENE

The Billboard Industry's input



Digital Billboards in Oregon:

A quick background

In 2011 the Oregon State Legislature approved digital billboards for Oregon.

SIZE: No larger than 672 sq ft

LOCATION: Commercial & Industrial land

BRIGHTNESS: Not more than 0.3 foot-candles over ambient light

DWELL TIME: No less than 8 seconds

SPACING: Same as conventional billboards (100' inside city)

PERMIT: On signs with state permit



Eugene Considers Digital Signs:

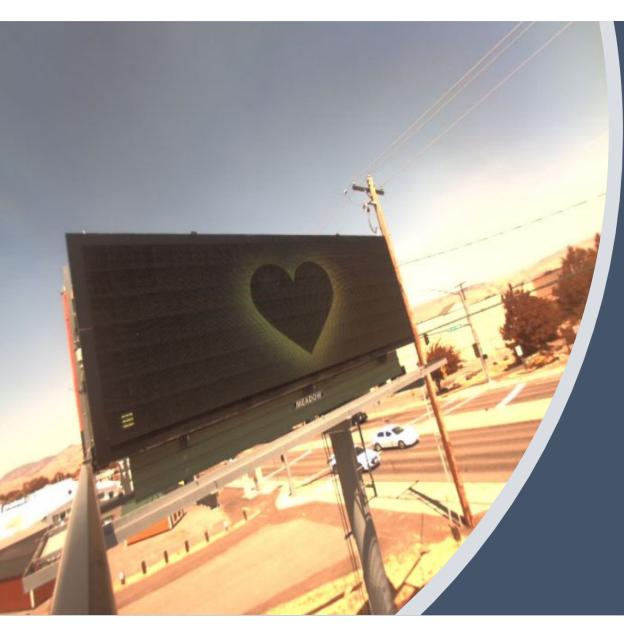
Billboard industry, city manager and city council began discussing digital signs for Eugene. Staff researched and drafted code amendments to allow and regulate digital signs in Eugene

2019 Present 2018 2020

> City Council directed staff to draft code amendments to allow digital signs in Eugene

Planning Commission to Consider Draft Digital code





Eugene's Draft Code:

SIZE: No larger than 300 sq ft

LOCATION: On some major arterials

BRIGHTNESS: Not more than 0.3 foot-

candles over ambient light

DWELL TIME: No less than 10 seconds

SPACING: 1200 ft

PERMIT: Only on legally placed signs

Billboard Industry Comments

We appreciate Staff's process and engagement with stakeholders

We are in agreement with Staff on *most* of the proposed code elements

A few changes the industry proposes and has discussed with Staff:

- LOCATION: On ALL major arterials
- DWELL TIME: No less than 8 seconds (national standard)
- **SPACING:** Clarify 1200 ft spacing is for signs *facing the same*
- PERMIT: City-managed permit process for even distribution of signs

Supplemental Information for the Record:

- FHWA Publication No. FHWA-HRT-09-18. "The Effects of Commercial Electronic Variable Signs (CEVMS) on Driver Attention and Distraction: An update."
- FHWA HEP. September 2012. "Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)"
- OAAA Summary of FHWA 2012 Study
- Albuquerque, NM & Richmond, VA. Safety Studies. Tantala Associates. March & November 2010.
- News Article. The Hill. "DOT Study finds digital billboards don't distract drivers." January 7, 2014.

https://thehill.com/policy/transportation/194654-dot-study-finds-digital-billboard-dont

 News Article. Recycling Today. "Lights Out." January 16, 2012 (on reduced waste and recycling of LEDs)

https://www.recyclingtoday.com/article/rt0112-recycling-led-billboards/

 Digital Billboard Lighting Explanation Video https://www.youtube.com/watch?v=SP4jEmA1ncY



DRAGOVICH Jenessa L

From: James Carpentier < James. Carpentier@signs.org >

Sent: Tuesday, July 21, 2020 9:23 AM

To: MCKERROW Mike J; DRAGOVICH Jenessa L; Eugene Planning Commission

Cc: pking@nwsigncouncil.org; David Hickey

Subject: Comments and Recommendations Eugene Draft Sign Code

Economic_Value_of_Signage_ES_SRF.pdf; Economic Value Of Signs - Univeristy of Cincinnati.pdf; **Attachments:**

NWSC ISA comments Draft Digital Sign Code 7.21.20.pdf; Texas A & M Traffic Safety & EMCs.pdf;

Agenda PC 07.21.20.pdf Final.pdf

[EXTERNAL ∧]

Honorable Eugene Planning Commission; Ms. Dragovich; Mr. McKerrow:

I am contacting you on behalf of the Northwest Sign Council and the International Sign Association. Both associations work with jurisdictions to assist in the creation of beneficial and enforceable sign regulations. Here are a number of resources at this link that includes informative resources including studies on regulating electronic message centers, content neutrality and wayfinding.

We have some attached comments and recommendations and reference documents cited, in regards to the draft sign code for your consideration.

Please include Patti King (Executive Director of the Northwest Sign Council and copied on this email) and I as stakeholders and let us know of any future meetings and or sign code drafts.

Do not hesitate to contact me with any questions.

Thanks

James B Carpentier AICP

Director State & Local Government Affairs

1001 N. Fairfax Street, Suite 301 Alexandria, VA 22314 (480) 773-3756 Cell www.signs.org | www.signexpo.org james.carpentier@signs.org

















July 21, 2020

Sent via email

To: Eugene Planning Commission; Jenessa Dragovich, Senior Planner; Mike McKerrow, Associate Planner

From: James Carpentier AICP, Director State & Local Government Affairs

Re: Digital Sign Code Amendments (City File #CA 20-2)

Honorable Eugene Planning Commission:

I am contacting you on behalf of the Northwest Sign Council and the International Sign Association. Both associations work with jurisdictions to assist in the creation of beneficial and enforceable sign regulations.

We appreciate the additional allowances that are being proposed for digital or electronic message centers (EMCs).

Policy/Community Considerations When Regulating EMCs

Community/Public Safety

We believe that EMCs will be beneficial for the community and end users that can avail themselves of this technology. EMCs can convey much more information than static signs so they are very effective. In addition, EMCs can be utilized to provide information for Public Service Announcements (PSAs), disasters, and Amber Alerts.

Economic Impacts

EMCs have been demonstrated to enhance and support local business as indicated in the attached University of Cincinnati's, *The Economic Value of Signs* case study, pages 37-39 and page 3 of the Executive Summary. This case study states the following on page 3 of the Executive Summary: "The car dealership case study found that the addition of a video sign board was associated with large increases in both service department revenue and customer count." The proposed code only allows for EMCs in the commercial and industrial up to 3 sq. ft. and 5 characters. This restrictive regulation is equivalent to a prohibition on EMCs in commercial and industrial districts. Therefore, we recommend that the City consider standards similar to those stated for Institutional uses be allowed for commercial and industrial zones. These standards can be tailored and balanced for each district so as to be compatible with the area aesthetics and also meet the needs of the business community. Also, to allow digital billboards up to 300 sq. ft. and limit EMCs to only 3 sq. ft. in commercial districts





and 20 sq. ft. for institutional uses is not equitable nor supportive of the local business community.

Traffic Safety

Texas A & M conducted a study, *Statistical Analysis of the Relationship between*On-Premise Digital Signage and Traffic Safety (attached). This study covered 4 states and 135 sign locations. This study states in the executive summary on pg. viii the following: "The results of this study provide scientifically based data that indicate that the installation of digital on-premise signs does not lead to a statistically significant increase in crashes on major roads."

We do have the following recommendations for your consideration. Our comments and recommendations are in **bold**, **italics and underlined**.

9.6620 Nonconforming Signs.

(3) Except as provided in EC 9.6675(7) or Except where only a change in display copy is made, any nonconforming sign which is structurally altered or has illumination installed shall be brought into compliance with all applicable provisions of the sign standards within 90 days and shall thereafter be kept in compliance with the sign standards.

We recommend that change in display copy be changed to face change. Face change is a term that is typically utilized in the industry.

<u>A sign that is retrofitted with LED illumination should be allowed since that does not constitute a</u> structural change and provides for enhanced energy efficiency.

- 9.6640 General Provisions.
- (4) Location Standards.
- (a) Setbacks. All signs shall comply with the setback requirements beginning at EC 9.2000 through EC 9.3980 and EC 9.6745 Setbacks Intrusions Permitted. Signs may be installed up to 5 feet into the required front yard setback except that freestanding signs up to 5 feet in height in the E-1 zone may be installed at least 5 feet from the front property line.

The setbacks vary from 0' in the C-2 and C-3 zones to 30' in the E-1-3 zones. The 5' setback in the E-1 zone and no setback in the C-2/C-3 zones is reasonable. Setbacks of 20' and 30' may require a sign to be located outside of the 20 degree "cone of vision," therefore making the sign less detectable and may not be safely seen be the intended viewer. See page 22 in the attached Evidence Based Model Code for more discussion on the cone of vision. As stated in the model code, "A driver's ability to observe and react to a sign outside the cone of vision drops rapidly outside this limit."





9.6640 General Provisions.

- **(9) Electronic Message Centers.** Except electronic message centers operated as public signs by governmental agencies, no electronic message centers are subject to the following limitations: or
- (a) Except as provided in subsection (b) of this section, that portion of any sign used as an electronic message center shall be larger than limited to 3 square feet in area, may display a message containing no more than 5 characters, or and must not change the displayed message at intervals of less than once every 3 seconds. No electronic message center, except for temporary construction use, shall exceed a maximum one-hour equivalent A-weighted sound pressure level of 50 dBa at the receiving property line when the receiving property is occupied by a dwelling, hospital, school, library or assisted care center.
- (b) Each service station may include up to 6 rectangular digital signs, constructed a minimum of 3 inches from each other, limited to 20 square feet in area cumulatively, and must not change the displayed message at intervals of less than once every 24 hours
- (10) Digital Signs. One digital sign up to 20 square feet in area is permitted per institutional use on a development site. Digital signs must be located a minimum of 50 feet from the property line of any residentially zoned property.
- All digital signs shall be subject to the following standards:
- (a) The change from one message to another message shall be no more frequent than once every 10 seconds.
- (b) The change from one message to another message shall be instantaneous.
- (c) Animation, scrolling or other perceived movement is not allowed.
- (d) The digital sign shall operate at an internal illumination intensity level of not more than 0.3 footcandles over ambient light levels as measured from a distance of 45 feet perpendicular to the sign face
- (e) The digital sign shall be equipped with a light sensor that automatically adjusts the intensity of the digital display according to the amount of ambient light.

An electronic message center and digital sign are the same technology. We suggest that one term be utilized, preferably electronic message centers.

Although it may be legal to allow an exception for electronic message centers that are operated by government agencies, this is not sound policy.

The 3 square foot allowance and 5 character limitation is not reasonable. This size will render EMCs not safely viewable and or legible. We suggest that standards be developed for each district with reasonable time place and manner restrictions.





We have not seen a regulation of this nature for EMCs that deals with sound pressure. What is the basis for this section and what issues is this regulation intended to address?

We are supportive to allow service stations to utilize EMCs. Limiting the hold time to 24 hours is not reasonable since pricing can change often. We suggest that allowances for EMCs not be stated by use such as service stations. EMCs should be regulated by district so as to avoid any content regulation.

We are supportive of the allowances for digital signs for institutional uses. We recommend that digital signs be allowed in other districts other than just institutional uses. Given these challenging economic times additional flexibility in messaging for customers has taken on a heightened importance. In these unprecedented times small businesses need options such as EMCs to enable effective and immediate communication to customers. In addition this technology can provide PSAs for disasters, emergencies and Amber Alerts, as previously noted. Therefore, we recommend that the City consider standards similar to those stated for Institutional uses be allowed for commercial and industrial zones. These standards can be tailored and balanced for each district so as to be compatible with the area aesthetics and also meet the needs of the business community. Also, to allow digital billboards up to 300 sq. ft. and limit EMCs to only 3 sq. ft. in commercial districts and 20 sq. ft. for institutional uses is not equitable nor supportive of the local business community.

General Comment applicable to several District Standards

<u>Digital signs are listed as only allowed for institutional uses. This comment applies to all the digital signs that are listed as allowed for the other uses/districts. It is not clear what is being proposed since "digital signs" is intended to only apply to institutional uses yet the draft lists digital signs allowed for Highway Commercial, Office, Central Commercial, General Commercial and Shopping Centers.</u>

We appreciate your consideration of our suggestions. Do not hesitate to contact me with any questions at james.carpentier@signs.org or 480-773-3756.

Sincerely,

James Carpentier, AICP

James Cayestan

SIGN RESEARCH FOUNDATION EXECUTIVE SUMMARY

THE ECONOMIC VALUE OF ON-PREMISE SIGNAGE



n 1997, the University of San Diego released a landmark study for the sign industry. It was the first time statistical analysis was used to determine the economic impact of on-premise signage to a business. The research used data from three case studies—a large fast food chain, a national home décor retailer and auto dealers in a metropolitan city—and the results are still widely quoted today.

In 2012, the University of Cincinnati's Economics
Center deepened the examination. Leaning heavily on
the original work, the University of Cincinnati's updates
included numerous additional case studies: a national
lodging chain, a national banking business, a specialty
store small business and a car dealership.
Both reports are called "The Economic Value of
On-Premise Signage." They show how signs act as
"silent salespersons"—branding businesses, providing
information about products and services, and pointing
customers to exact locations. In short, an on-premise
sign's economic impact on businesses—directly and
indirectly—is significant.

Researchers tackled the topic by exploring how changes in on-premise signage affect business performance.

Also part of the studies was the impact on consumers and the surrounding community.

Researchers

University of San Diego (1997):

Seth R. Ellis, Ph.D. Robert Johnson, Ph.D. Robin Murphy, M.B.A.

University of Cincinnati (2012):

Jeff Rexhausen, Principal Investigator Henry Hildebrandt, Co-Investigator Christopher Auffrey, Ph.D., Co-Investigator

KEY TAKEAWAYS

SIGNS POSITIVELY IMPACT CONSUMERS AND COMMUNITIES BY MAKING IT EASIER FOR SHOPPERS TO OBTAIN THE INFORMATION THEY NEED TO MAKE A PURCHASE.

- Sign visibility and conspicuity are especially important. In the case study of eight San Diego auto dealers, for example, 68 percent of people surveyed said that the sign had been an important factor in finding the dealer's location. In addition, 18 percent reported being aware of the service department because of the dealer's sign. And when one of the dealers was forced to move a sign to comply with a new code, 21 percent of that dealer's customer base reported that the business was hard to locate without the sign.
- Researchers determined that the addition of one sign at every fast-food outlet in Los Angeles would raise business revenues by \$132 million; those businesses would in turn pay an additional \$10 million in sales tax revenue to the local municipality.



American consumers who have driven by a desired business without finding it due to insufficient signage

CHANGES TO SIGNS DIRECTLY IMPACT BUSINESS PERFORMANCE.

- The studies proved that changes such as adding signs or replacing outdated or inoperable signs had positive effects on sales, number of transactions and profits. Roughly 60 percent of businesses studied reported average sales increases of 10 percent.
- Just one additional sign yielded sales increases of 4.75 percent, an impact greater than that brought on by a larger building, longer hours of operation or location longevity.
- Lower-performing stores benefitted the most from changes to signage, such as the addition of a sign to a building that previously didn't have one.
- Updates and improvements to existing signs led to a 5 percent weekly sales increase for many stores; underperforming stores saw weekly sales increase by 15 percent.

POSITIVE BUSINESS PERFORMANCE IS ASSOCIATED WITH EFFECTIVE SIGN DESIGN, PLACEMENT, AND DIVERSITY OF MEDIA.

- In the 2012 study, the car dealership found that adding a digital sign board increased not only service department revenue and customer traffic; it also created goodwill as a place for community-related public service messages.
- A key aspect of effective signage is proper regulation. Ideally, sign regulations balance community design objectives with full knowledge of how sign design and location impact business success. When sign codes are overly restrictive, businesses can be directly affected—as can consumers who have trouble finding those businesses due to inadequate/ineffective signage.

WHAT'S A SIGN WORTH?



Decrease in occupancy rates when one hotel chain moved its highly visible sign to a less conspicuous location



North American shoppers who associate sign quality with store and product quality



North American shoppers who make store choices based on the information communicated by store signs



Increase in weekly sales for one business that combined a major building sign modification with two additional minor changes

Read the Full Reports: The Economic Value of On-Premise Signage (University of Cincinnati, 2012), www.signresearch.org/EVOS2012,
The Economic Value of On-Premise Signage (University of San Diego, 1997), www.signresearch.org/EVOS1997

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The Economic Value of On-Premise Signage

Prepared for the Signage Foundation, Inc.

Prepared by the Economics Center, University of Cincinnati

August 2012

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August 2012









Executive Summary

Businesses of all sizes and types use on-premise signs to communicate with their customers. It has been suggested that on-premise signs and the regulations that limit them can significantly impact the performance of some types of businesses, yet there has been limited recent research to inform decisions about sign investment or regulation.

To provide more current insight, researchers at the University of Cincinnati conducted a national survey of businesses and a series of case studies. The purpose was to assess how changes in on-premise signage affect business performance. This report provides details about that research's approach and results. Business owners responding to the national survey reported that additional and improved signs are associated with increases in their revenues and profits. The case studies suggest that signage visibility and conspicuousness are especially important, and that signage plays an important role in a business' overall branding and marketing strategy. This research indicates that appropriately designed and located on-premise signage can be an important factor for retail business success. The implication of these results is that on-premise signage indirectly influences the vitality of a community and the quality of life of consumers by providing information about the availability of goods and services.

Examination of one field of economic theory – search theory – and application of this concept to the subject of signage presents a new explanation for why onpremise signs have positive economic impacts, not only for businesses, but also for consumers and communities: namely, signs make it easier for shoppers to obtain the information they need to make a purchase.

A national survey asked businesses about sign changes and the impact of those changes on business performance. In addition, detailed questions inquired about the nature of the business and the use of signs. The survey produced some significant findings regarding both economic impacts and sign preferences.

• Sign changes generally had significant, positive impacts on sales, number of transactions and profits. Roughly 60 percent of businesses reported increases averaging about 10 percent.

- Sign changes also led to small positive impacts on employment. Nearly a quarter of respondents reported hiring more people.
- While most single establishments and small firms have either wall signs or pole signs, most large companies have both. In general, larger companies tend to have more types of signs.
- Helping customers find their location was the most important purpose for respondents. Legibility is the most important characteristic of signs across all sizes of companies.
- Business logos and the size and location of the signs were more important for companies with more establishments, for whom branding is presumably more important, compared with single establishment companies.

Among the case studies, positive business performance was generally associated with greater use of on-premise signage and better quality signs, as the following results indicate.

- The national lodging chain case study found that the use of a digital electronic sign to display pricing was associated with increased average occupancy rates. The impact appeared to be especially strong for properties with lower occupancy rates.
- The national retail banking business case study found that pylon signs were strongly associated with high visibility, monument signs were moderately associated with high visibility, and wall signs contributed to identity but not visibility. In addition, pylon signs were associated with significantly more teller transactions.
- The specialty store small business case study demonstrated the need for signage to reaffirm the value offered by a niche retailer. Sign design must be sensitive to community and customer expectations, and able to reinforce the brand of a small business. The signage should communicate a "promise" of value for a product and/or service that is not commonly found elsewhere.
- The car dealership small business case study found that the addition of a video sign board was associated with increases in both service department revenue and customer traffic. An added benefit was the "goodwill" and reputational gain associated with using the video board for communityrelated public service messages.

Given the economic importance of signs, regulations should balance community design objectives with full knowledge of how sign design and location impact businesses success. Business success is important because of its impact on a community's tax base, and it ultimately leads to the availability of greater fiscal resources to provide needed community services.

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I. Introduction

Communication is perhaps the single most important activity for the success of human societies (Richmond & McCroskey, 2009). Signs are among the most important elements of visual communication. The visual communication provided by signs on our streets and highways is essential for an effective transportation system to aid in getting us where we want to go. Similarly, the visual communication provided by on-premise business signage is essential for the efficient function of our system of commerce and the success of many businesses. Effective signage can drive job creation, generate tax revenues, and provide quality access to goods and services.

Communities depend on clear, legible and conspicuous signs for direction, safety and information. Businesses have a long established history of using signs to announce their products and services. On-premise business signs are especially important within the context of our highly mobile society where we frequently venture to unfamiliar areas. On-premise signage allows a business to cost-effectively communicate with potential customers who are moving through its trade area. The wayfinding, identification and marketing information provided by on-premise signage is essential for assisting existing and potential customers in finding the goods and services they seek. This connection between customers and businesses is crucial for business success, and the local governments that depend on the employment and tax revenues which businesses generate.

On-premise signs are a potentially powerful medium for commercial communication. Frequently, on-premise signage is a key element, which is often used with other media, to develop and maintain a business brand. The more consistently that brand is communicated, the greater the likelihood that existing and potential customers will associate it with specific expectations for price, product brand, or service quality at specific locations.

On-premise signs that are designed well and properly located are especially important for generating impulse sales. While some goods and services are primarily purchased on the basis of careful consideration and forethought, many others are impulse purchases. Indeed, impulse sales generate an important part of revenue for a wide variety of retail businesses. One study (Conroy 2004) found 68 percent of purchases during major shopping trips were unplanned, and 54 percent on smaller shopping trips. In these cases, on-premise signage is critical.

This study provides current analysis of how on-premise signage is linked to business success. A California study from the 1990s indicated that changes to the number and location of on-premise signage can have a direct impact on business performance (Ellis, Johnson & Murphy, 1997). That study – which used statistical analysis of signage, business performance and location-specific data for two business chains – found that an increase in the number of on-premise signs at a particular site had a significant and positive impact on sales, number of customer transactions, and the amount of the average transaction. Case studies also have been used extensively in the small business and signage trade literature to document the impact of signage on the economic performance of businesses. For example, the New York State Small Business Development Center (Conroy 2004) details a number of case studies. One case, based on the experience of a car wash, documents the association of improved sign legibility and visibility with higher sales, as well as suggesting that the introduction of message boards can lead to increased sales. Another case, based on the experience of a small restaurant, documents the association of improved sign visibility and conspicuousness with increased sales. While these case studies do not provide conclusive evidence of the economic value of on-premise signage, they do provide insight to specific causal mechanisms that may be useful for interpreting the statistical analyses of the survey data.

For decades, alancing the signage needs of individual businesses with the broader concerns of communities has been a concern of local officials, the sign industry, and planning and design professionals. Funding for essential local government services such as police, fire, roads, and education often depend on the success of local businesses. This linkage between on-premise signage, business success, and local government revenues (and the public services they fund) highlights the need for sign regulation process to be informed by research such as is being conducted here. Signs regulations can and should promote designs that promote business success while meeting appropriate local standards.

The impact of on-premise signage is dependent on visual elements that may interact with and complement a business' marketing and branding strategies. Visual characteristics and perceptual concepts related to signs, symbols, semiotics, and the built environment have been addressed in Berger's Seeing is Believing (2007) and the two groundbreaking treatises by Tufte (Envisioning Information (1990) and Visual Explanations (1997)). An appreciation for the layering of economic and marketing roles together with a visual identity program becomes important for understanding the contribution of on-premise signage within a comprehensive marketing strategy.

The research presented in this report provides an analysis of the economic effects of signage within a context of varied scales and types of business. The objective of the study is to provide an updated assessment of the impact of signage on businesses and communities. Several earlier publications have identified key issues and economic factors associated with on-premise signage, with "The Economic Value of On-Premise Signage", "The Signage Sourcebook", and "What's Your Signage" providing reference and guidance for much of the past two decades. Except for the recent work of Taylor (2010; Taylor, Sarkees & Bang, 2012), the value of signage has lacked recent rigorous analysis.

This study uses survey data and case studies to bring the economic impact of on-premise signage into a clearer focus within prescribed theoretical frameworks and a diversity of sign applications. Venturi and Brown in "Learning from Las Vegas" (1971) analyzed the Las Vegas strip, its sign/buildings relationships, and their impact within our urban / suburban environment. Their study systematically assessed the visual impact of signs within a concentrated market area with ever-changing views from the automobile. Venturi was the first to connect on-premise signage to commercial symbols that contained economic value in their meanings beyond the direct communication objective and architectural product. Berger, Tufte, and others have provided additional understanding to advance the symbolic meanings contained in signage and signs. It is within such a broader framework that this research utilizes case studies in combination with economic data to bring the value of on-premise signage into a clear focus. Case studies are used for illustrating the diverse sign typologies and as an analytical interface with communities, brand identity, and the "marketing functions" of signs (Taylor, 2010).

II. Context

A. The Problem

The success of local retail businesses is important for creating jobs, generating tax revenues, and providing access to goods and services in communities both large and small (Blakely & Leigh, 2010). For most businesses, but especially those that sell retail goods and services, on-premise signs can be an important mechanism for attracting new customers and providing wayfinding for returning customers. This is especially true for businesses such as fast food restaurants, convenience stores, and gas stations for which impulse sales represent a substantial proportion of their total revenue (Conroy, 2004). Consequently, for a variety of economic and quality-of-life reasons, it is critical for the signage industry, businesses, and government agencies to maintain a current and nuanced understanding of how on-premise signs contribute to business performance.

B. Research Challenge

The primary research challenge has been to gather sufficient signage and business performance data to be able to reach conclusions about the effectiveness of onpremise signage. The need to collect both signage and performance data from a wide range of businesses, and draw from businesses' own experiences became clear from understanding the strengths and limitations of previous studies. A two-stage online survey model was designed and implemented with an initial survey, coupled with an opportunity for approaching self-identifying businesses to participate in follow-up, in-depth case studies.

Despite the relatively large number of survey respondents that we contacted, few businesses were willing to share detailed information about their signage and business performance. Assurances were given that proprietary information would be kept confidential and, where requested, names of businesses would not be used in any study disclosures. Ultimately, after persistent pursuit of leads from a variety of sources, three national/regional businesses agreed to share the necessary signage and performance data.

C. Previous Research

Research assessing the impact of signage on business performance must begin with an understanding of the fundamental purpose of on-premise signage: communicating with potential customers about where the business is located and the nature of its product or service. As such, signs may serve to establish or fortify a consistent business brand or image (Conroy, 2004). For some businesses, multi-media branding strategies may involve static on- and off-premise (billboard) signs, as well as television, radio, newspapers and flyers. Few small businesses can afford or justify such strategies, and rely on their on-premise signs for much of their marketing, particularly if communicating with potential customers is simply about identifying their product or service and location. New technology is expanding the sign choices available to businesses for communicating with potential customers. Electronic messaging and video displays on signs are becoming increasingly common, especially for businesses whose brand or image requires that they are perceived as cutting-edge in the quality of their products or services (Post & Pfaff, 2007).

On-premise signage is one of the most basic and yet complex forms of visual communication. Signage serves as a multi-purpose media that can identify an organization, business or place while at the same time marketing an idea, service, or product. There are a number of factors that should be considered in choosing a design and location for an on-premise sign because of the different communication purposes and audiences. For example, businesses seeking to capture impulse sales along a major highway will need different types of signage to be successful than those located in a pedestrian-oriented business district (Conroy, 2004).

Previous research has established the importance of well-designed and appropriately-placed signage for generating business revenue and associated tax dollars (Ellis et al., 1997). The exhaustive literature review and annotated bibliography by Christadoulou (2009) is the most comprehensive assessment of the recent signage research literature, containing 227 citations. Edelman (2009), in his presentation of Christadoulou's work, organized the literature into six areas: Business & Marketing, Graphic Design & Architecture, Engineering & Technology, Planning & Urban Design, Law and Psychology. Among these he found extensive overlap that made it difficult for researchers to organize the literature in a meaningful way.

Local governments recognize that sales, property, and income tax revenue are closely linked to the success of their businesses. In part to fortify arguments that signs are important for business success, seminal research was conducted to assess the impact of on-premise signage on the performance of a Southern California fast food restaurant chain and a national specialty import retailer (Ellis et al., 1997). The research used cross-sectional and time-series regression analyses to predict the impact of sign changes on site performance. For the fast food chain, a cross-sectional analysis estimated the effect of sign characteristics and control variables on sales revenue, number of transactions, and average amount per transaction. Among the variables included in the models, various signage improvements were the best predictors for all three outcome variables. For the specialty import retailer, multiple regression and time-series analysis estimated that sign specific changes or addition were associated with significant increases in sales revenues.

While the Southern California studies focused on fast food and specialty import chains, it has been argued that on-premise signage is likely to be even more important for small non-chain businesses (Conroy, 2004). Many small businesses do not have the relatively large marketing budgets and shared electronic media buys of national franchises. These small businesses are more likely to be dependent on their signage for most of their communication with potential customers.

Because the seminal investigation of the economic impact of signage used data from two chains, additional research is needed to determine if similar results extend to a broader range of retail businesses. Subsequent studies have contributed important and useful research in this area, yet none have estimated the economic value of on-premise signs across diverse business and local government contexts (Conroy, 2004). Consequently, important decisions about signage by businesses and local governments are frequently based on limited or no research because the results of existing studies are not adequately disseminated or are simply inapplicable. Indeed, local governments may impose stringent signage regulations based on vague aesthetic concerns, making it difficult for businesses to be creative and effective with their signage as a means of communicating with potential customers and without appreciating the potential economic and fiscal impacts of the restrictions. When a business depends on potential customers from outside of their community, effective signage becomes especially important. In such cases, signage location, visibility, and design are particularly critical. Equally critical is that local sign regulators recognize the need for creative approaches to signage for both business and community success (Blakely and Leigh, 2010).

The idea of communicating a coordinated visual message is important for business performance. A consistent approach to visual communication supports the branding of place by giving it a consistent identity. Businesses are working to sell their image, and local communities are doing the same but on a much larger scale. The ability of a business to successfully market itself is critical for the local economy. Branding serves to establish a base of customers, whether for a business or a community. When a sign is serving a community to its highest potential, such that it is visually appealing and noticed, it also seems to brand the business or organization that it represents. Eventually this image will be a familiar element for its viewers and they may want to know more about it (Heather, 2003). For both businesses and local governments, effectively designed and located signage is an essential part of a branding strategy (Heather, 2003).

D. Research Approach

Given the limitations of the earlier work, there is a clear need for an updated, rigorous study of the economic value of on-premise signage to guide both business and public policy decision-making. The purpose of this research is to address that need.

At the beginning of this project, the research team developed a conceptual framework for identifying possible relationships between on-premise signs and various economic impacts. The left side of this figure illustrates the complexity of on-premise signage. Research must consider more than just the size, number, and placement of signs; other signage and site characteristics can also play significant roles. On the right side, the listing of possible economic impacts suggests that signs may generate economic benefits not only for businesses but also for customers and communities.

Conceptual Framework for Economic Impacts of On-Premise Signs

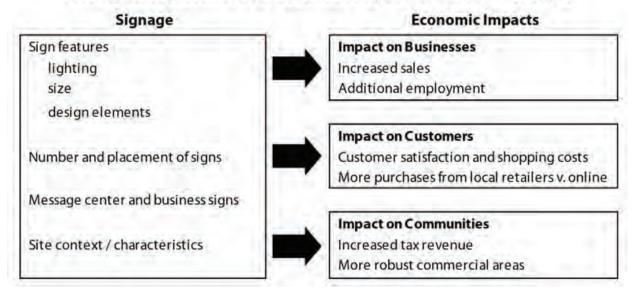


Figure 1: Conceptual Framework for Economic Impacts of On-Premise Signs

While no single research project can examine all of these elements and their interrelationships, this study attempts to move beyond the basic considerations that have characterized most previous research. Toward this end, a multi-faceted approach was selected, which includes applying elements of economic theory, developing and implementing a survey of sign users, and conducting case studies of a diverse set of businesses.

It is clear that on-premise signage is identified as a critical element for retail business and service industry providers for success, and it is also seen as indirectly influencing the vitality of the community. Therefore, this analysis takes a broad approach to considering the economic value of on-premise signage. This study is designed to appeal to a wide audience by attempting to use a common vocabulary to facilitate discussion of these findings among design professionals, regulatory professionals, and the sign industry.

III. Economic Theory and On-Premise Signs

Consideration of how signs benefit customers is an often overlooked, but a highly important dimension of the impact of on-premise signs. The recipients of the 2010 Nobel Prize in Economics were recognized for work in the area of search theory – a field that recognizes that information is not perfectly available, and obtaining it often requires time and other resources. Consequently, buyers often cannot purchase what or as much as they would like, nor can sellers meet these market demands efficiently. This research has implications for the sign industry because the principal purpose of on-premise signs – to provide information to potential buyers – is an area where this theory can be applied effectively.

The most fundamental sign message is typically about a) the existence of willing sellers and b) the types and prices of the items for sale, thus providing the most significant information that customers typically want. To the extent that signs effectively communicate the information sought by prospective customers, they reduce costs for consumers; conversely, when signs fail to communicate this information, they fail to reduce search costs of the consumers, businesses and communities. For businesses, a sign is often the primary way for the consumer to learn that the business even exists (Taylor, 2010). Significant economic research in this field continues today.

Customers' search costs include the value of the additional time spent searching for goods and services that match their wants. The consumer must make a decision—informed by any available signage—about the shopping potential of the store versus the option of continuing to search for other potential opportunities. For this section, we use this well-developed search theory to explain the process of a consumer evaluating prospective stores. This theory can help researchers better understand the effect of information on consumer behavior, such as the impact of a more visible sign on "downstream" businesses. The theory can also help researchers better understand how quality signage can lead to less total driving, increasing safety and reducing travel costs.

This figure provides an overview of the implications of applying search theory to the field of business signage. Just as good signage has a series of three consequences that produce positive economic impacts, impaired signage has a comparable series of three adverse consequences that produce negative economic impacts.

Impacts and Economic Theory: What Search Theory Tells Us					
Good Signage Impaired Signage					
1. Proper signage yields information to potential buyers, reduces transaction costs, improves well-being.	1. Inadequate information has costs for both sellers and buyers.				
2. Better information allows buyers and sellers to find each other for a transaction.	2. Consumers are less well-off because of higher search costs.				
3. Sign information moves markets toward an efficient outcome.	3. Internet sellers gain at the expense of other sellers and the communities where those sellers are located.				

Figure 2: Impacts and Economic Theory: What Search Theory Tells Us

A. Origins of Search Theory

Most students of economics are taught the basic model in which consumers enter a market, a price is determined, and then a subset of these consumers will complete transactions with producers if that price jointly suits them. This outcome depends on a set of assumptions that lead us to a familiar conclusion: that a single price will be established, allowing potential buyers and sellers to choose whether they will take part in a transaction, and leading to determination of how much of the product will be sold. One of these simplifying assumptions – that information is freely available to everyone –does not reflect the realities of imperfect and costly information that business owners and consumers face on a daily basis. In reality, perfect information rarely exists, which often leads to many different prices for the same product.

Economists in the middle of the 20th Century sought to reconcile the theoretical prediction of the basic model with the variation in prices observed all around us. It became clear that adjustments to the basic model would be necessary to gain understanding of a world in which transactions for the same good were being completed at quite different prices, or in which inferior goods were bought and sold for the same price as superior ones.

B. Relevance of Search Theory to On-Premise Signage

Toward this goal, search theory, which examines how people make choices with limited information was pursued most famously by economists George Stigler and John McCall. In order to properly study information, its costly¹ nature had to be recognized. Search theory was originally applied to labor markets in the 1970s by Dale Mortenson and Christopher Pissarides. In 2010 the Royal Bank of Sweden chose to honor Professors Mortenson and Pissarides with a Nobel Memorial Prize in Economic Sciences². In recent years, mainstream circles are recognizing the work that had already been scrutinized and affirmed by numerous scholars and graduate students for a generation.

In the work of Mortenson and Pissarides, search theory considers the employment decision of a job-seeker comparing an offer in hand against the "shadow of the future." The certainty of the offer on the table must be balanced against the prospect of continuing his job search into the future to seek potentially an even greater wage. Continuing the search is risky, and takes time. Because any other offer would begin at a later time, it would have to be at a more lucrative wage to match the value of the offer in hand; and there is always the possibility that future job offers might be at lower wages, not higher.

A well-known finding from search theory is that more uncertainty about the future causes a delay in the searcher's commitment. In other words, an offer in the present may be less attractive compared to a better offer that might occur if the search should continue. The job-seeker balances that potential upside gain by preparing to decline offers that are seen as unfavorable in comparison to anticipated future options.

Thus, in search theory, the searcher – whether a job seeker or a shopper – compares the value of the known alternative against the potential costs and benefits of continuing to search. It is clear that better information about these options makes it easier for searchers to form expectations about the unknown alternatives and whether or not to continue searching, assisting in producing a better match. In order to connect search theory with signage, suppose that the person is a prospective buyer driving down the street in search of a gift for a friend. She encounters a series of stores that may or may not sell an acceptable item. If business signage is inadequate, learning about a price and other qualities of a potential purchase may involve a costly decision to enter a store, requiring expenditures of both time and travel. It is in this situation that information — not just about pricing but also about the quality and nature of the goods on sale — will be useful in sharpening the perception of the future that enables a purchase to take place. In such a situation, higher quality signage reduces these information costs, making buyers and sellers better off.

¹ Economists use the term "scarce" to recognize something that is inherently limited in quantity, and therefore deserving of a price; information represents different tiers of cost, with some of it being readily available and easily processed, and some being only one of those or neither.

² Peter Diamond also shared in the Nobel Memorial Prize in Economics in 2010.

Signs provide signals to consumers. A store's sign may signal price, quality, convenience, and/or reliability. This signaling is illustrated by competing gas stations that post their prices immediately next to each other. Other information on their signs may help them to compete on other factors, all of which assist the purchaser by providing information that reduces consumer uncertainty. This sign information not only helps stores compete with each other but also with internet retailers, who generally have a large advantage over store retailers in providing information to consumers.

Search theory also provides insights about businesses that are trying to complete a transaction with a searcher. In the labor market application of search theory, making a job offer is costly to the employer because he must invest time, first in finding and screening job candidates and then in training a new employee. Because of these costs (and the risk of entrusting key business elements to a new employee whose competence is uncertain), the employer is highly motivated to find effective means in searching for prospective employees. This is comparable to the circumstances in which business owners compete for customers. Although stores and other businesses are searching for customers and clients rather than employees, many forms of advertising — television, radio, celebrity endorsements — represent costly signals because advertising space is scarce. Among these, outdoor signage ranks favorably in terms of effectiveness according to surveys of consumers (Kellaris, 2011).

James Kellaris, who holds the Gemini Chair of Signage and Visual Communications in the University of Cincinnati's Carl H. Lindner College of Business has illustrated how good signs reduce search costs by making information more available to consumers. Utilizing data collected in a 2011 survey of over 100,000 North American shoppers, Kellaris found that:

- Shoppers associate sign quality with store and product quality (34%); and
- Shoppers make store choices based on the information communicated by store signs (29%).

Potential customers often lack significant pieces of information. Even when businesses attempt to convey this information through their on-premise signage, characteristics of those signs and the surrounding environment, as well as other impediments, often inhibit the communication of this information. Kellaris also found that nearly half (49.7%) of American consumers have driven by a desired business without finding it because of insufficient signage.

There are significant anecdotal examples where the loss of good signage caused measurable decreases in the value of businesses. When one motel that had a highly visible sign moved to a less conspicuous location, it found that occupancy rates decreased 36 percent, which reduced its \$960,000 value by 42 percent (Bass, 2010). Furthermore, the loss of a sign can have consequences that extend to surrounding businesses and the larger community. Real estate appraiser Richard Bass documented the case of a business on the back side of a Florida mall that lost the pylon sign that gave it visibility. The loss of customers eventually led to closing the store. Because surrounding mall businesses relied on the traffic generated by that store, they also closed.

Search theory has explained the role of information and how higher costs of obtaining information reduces the welfare of both the consumer and the producer. For job seekers, lower search costs allow them to be more selective, implying greater productivity shared between worker, firm, and (ultimately) the consumer. For consumers, improving information through better signage will decrease the time and resources needed to investigate another vendor. Reducing information costs effectively makes everyone better off.

By facilitating less costly sales, better information through signage can positively affect the broader community through economic growth (especially through increased employment and wages) and a stronger base for sales, income and property taxes. While others may focus on the intangible impacts on communities of quality signage, such as their contributions to a sense of place and identity, as well as building social capital and community pride, we emphasize that search theory explains the economic benefit of signage.

IV. National Survey

A. Survey Approach

To gain a broad perspective about a variety of on-premise signage considerations, a survey was prepared and distributed to all types of businesses in the US that use signs. The survey provided businesses the option of responding either online or by a mailed response. Questions were asked about sign changes and the impact of those changes on business performance. In addition, detailed questions inquired about the nature of the business and the use of signs (number, size, location, type).

Respondents were initially solicited by email, post cards and personal contacts. Also, newspaper and newsletter articles about the survey included information about the survey's Internet address and asked businesses to complete the survey online. An effort was made to gain responses from a geographically diverse cross section of the different types of large and small businesses that use signs to attract and retain customers. This approach was used in order to collect responses from a wide range of such businesses rather than to produce a random national sample. While the objective of employing this method was to collect data from respondents who have greater awareness of on-premise signage issues, responses did not indicate a response bias toward heavy signage users; in fact, one third of respondents reported no sign changes in recent years.

B. Survey Results

A total of 225 businesses responded to the nationwide survey of business sign users. Of these, 213 were usable responses. Of these respondents, 70 percent had a single establishment, while the remaining 30 percent were classified as either small (2-10 establishments) or large companies (more than 10 establishments). Single establishment businesses are more common among retail trade respondents (84%), and comprise about half of respondents in the accommodation and food service industry (52%).

The following table shows that, as large as these proportions are among survey respondents, single establishment businesses are even more common nationally, based on a census of U.S. businesses. However, these proportions are sufficiently comparable to be able to draw conclusions from the survey about general use of business signage.

Table 1: Single-Establishment Businesses as a Proportion of All					
Survey Respondents 2008 National Date					
All businesses	70%	90%			
Retail trade	84%	90%			
Accommodation and food services	52%	70%			

In order to understand whether having multiple signs was important for their perceived impact on business performance, respondents were asked about the number of signs at a typical establishment. As shown in Table 2, over two-thirds of respondents had only one or two signs, a little more than a quarter had three to five signs, and only 4 percent reported 6 or more signs. Larger companies (10+ establishments) were far more likely to have more than 2 signs, with over half reporting 3 or more signs at a typical establishment.

Table 2	Table 2: Number of Signs at a Typical Establishment by Size of Company					
	All	Single	Small	Large		
	(n=213)	(n=150)	(n=35)	(n=28)		
1-2 signs	69%	72%	71%	46%		
3-5 signs	26%	23%	26%	43%		
6+ signs	5%	5%	3%	11%		

(Small companies have <10 establishments, Large companies have 10 or more establishments)





Left: Oakley Pub & Grill; Right: Buca di Beppo

³ These national figures come from the 2008 Statistics of U.S. Businesses (SUSB). The SUSB is an annual series of national economic data by enterprise size and industry. SUSB covers most of the country's economic activity. The series excludes data on non-employer businesses, private households, railroads, agricultural production, and most government entities.

Questions about the types of signs were also included in the survey because this is frequently an issue addressed as part of sign regulations. As shown in Table 3, among the types of signs at a typical location, wall and pole signs were most common. While most single establishments and small firms have either wall signs or pole signs, most large companies have both. In general, larger companies tend to have more types of signs.

Table 3: Types	Table 3: Types of Signs at a Typical Establishment by Size of Company					
	All	Single	Small	Large		
	(n=213)	(n=150)	(n=28)	(n=28)		
Wall sign/s	60%	53%	54%	89%		
Pole sign/s	53%	46%	49%	86%		
Wall & pole signs	27%	19%	23%	75%		
Monument sign/s	25%	15%	29%	71%		
Other sign/s	30%	28%	31%	39%		

(Small companies have <10 establishments, Large companies have 10 or more establishments)

Some of this variation in the amount of signage may be due to the different industry mix among large companies, but even when restaurants are the only category considered, large companies use more signs. This may be the result of a number of factors, such as differences in types of location and different customer markets.

As part of the survey, respondents were asked to rate on a 0 (zero) to 3 scale -- with 0 being not at all important and 3 being extremely important -- the relative importance of their signage for several common purposes of signs. Overall, the two sign purposes with the highest scores are: 1) making their business stand out; 2) helping potential customers find their location. These two purposes received generally high scores across all business size categories.

As shown in Table 4, the size of the company (and presumably access to multiple marketing modes to facilitate "branding") did make a difference. Companies with more establishments perceived 'brand reinforcement' as relatively more important compared to companies with a single establishment ($\gamma=0.73$)⁴. This was reinforced when businesses were asked which purpose is the most important: 38 percent of large companies identified branding/image, compared to 14 percent of small firms and just 3 percent of single establishments. Other sign purposes showed measurable but weaker association with company size: compared to large companies, single establishments tended to give slightly more weight to using signs to inform about goods/services, and small companies generally use signs a bit more to inform about promotions ($\gamma=0.16,0.25$).

 $^{^4}$ A commonly-used statistical test for measuring the strength of association between two variables such as those used in this survey is Goodman and Kruskal's gamma (γ). Gamma measures the proportional reduction in error; it identifies how much the error in predicting variable "y" is reduced by taking variable "x" into account. In general, if $\gamma = 0.60$ or greater, the association is very strong, while a figure of 0.30 reflects a moderate association; if $\gamma = 0.20$, the association is weak.

Table 4: Mean Scores for Perceived Importance of Signs for Common Purposes, by Company Size
(n = Number of Respondents)

	(II – Nullibel Ol	nespondents)		
	All	Single	Small	Large
	(n=213)	(n=150)	(n=35)	(n=28)
Help customers find location	2.73	2.75	2.63	2.79
Make business stand out	2.68	2.67	2.68	2.75
Reinforce branding/image	2.42	2.30	2.57	2.86
Inform about goods/services	2.23	2.28	2.17	2.04
Inform about promotions	1.76	1.71	2.03	1.64

(0=Not at all important, 1=Slightly important, 2=Moderately important, 3=Extremely important)

When data on sign types and purposes are compared, those reporting that the sign purposes of "making their business stand out" and "reinforcing their branding/image" are extremely important were slightly more likely to have pole signs $\gamma = 0.20$, 0.31). Some of the survey's findings about sign quality, number, and readability have been replicated in a more recent survey (FedEx Office, 2012), which found that:

- About three fourths of consumers have entered a store or referred a friend because of a sign that made the business stand out, and two thirds have made a purchase as a result.
- Conversely, most consumers indicate that bad or no signage deters them from entering a store.
- Sign readability is the most important sign factor in causing consumers to try a store's product or service.

Respondents also were asked to rate various signage characteristics in order to determine which specific characteristics were perceived to be most important. As shown in Table 5, among all companies, "being clearly readable" was the most important characteristic. This was true across all sizes of companies. However, again, the size of the companies did make a difference. Among companies with more



establishments, and for whom branding is presumably more important, including their business logo was reported as more important compared with single establishment companies ($\gamma = 0.72$). Compared to other businesses, large companies also gave somewhat greater weight to "size / location" ($\gamma = 0.51$). Among small businesses, including single establishments, "conspicuousness" was the second most important characteristic, rated considerably higher than 'size and location' and "logo or branding" ($\gamma = 0.49, 0.31$).

Table 5: Mean Scores for Perceived Importance of Sign Characteristics, by Company Size

	All (n=213)	Single (n=150)	Small (n=35)	Large (n=28)
Clearly readable	2.90	2.91	2.79	2.96
Conspicuousness	2.75	2.78	2.62	2.75
Size and location	2.64	2.65	2.43	2.86
Illumination	2.56	2.57	2.46	2.61
Logo or branding	2.43	2.30	2.60	2.86

(0=Not at all important, 1=Slightly important, 2=Moderately important, 3=Extremely important

Two of these sign elements were associated with signage types. Those businesses reporting that the sign elements of being 'clearly readable' and 'size/location' are "extremely important" were somewhat more likely to have pole signs ($\gamma = 0.48, 0.44$).

In order to assess how actual changes in signage might be related to the perception of the importance of signs, businesses were asked if they had made improvements in their signage over the past five years and their perceptions of the impact the sign changes had on four measures of business performance: (1) sales, (2) number of transactions, (3) profits and (4) staffing. About two thirds (66%) of all respondents reported one or more types of changes. Among the changes, as shown in Table 6, seven in ten of these companies reported making changes in their sign design. More than half (52%) improved sign visibility, while nearly half (47%) increased the number of signs, and three in ten made the signs larger. Because almost all changes consisted of more than one of these types of change, it was not possible to determine whether one change produces greater impacts than another.

Table 6: Types of Changes Made to Signs Over the Past 5 Years				
Changed the design of signs	70%			
Enhanced the visibility of signs	52%			
Increased the number of signs	47%			
Increased the size of signs	30%			

Most of the companies reporting sign changes indicated that these sign changes had large, positive impacts across three of the four measures of business performance, with smaller but still positive impacts on the fourth measure. As shown in Table 7, between 59 percent and 65 percent of the companies making sign changes reported increases in profts, transactions and sales, with average increases of 9, 11, and 12 percent, respectively. These findings about the impact of enhancing on-premise signage are consistent with findings recently reported by Dr. Charles R. Taylor, John A. Murphy Professor of Marketing, and his colleagues at Villanova University (Taylor, Sarkees & Bang, 2012).

Increases in staffing were reported by a smaller proportion of the companies (23%), with an average increase of 6 percent. Employment growth may have been tempered by the national economic downturn rather than representing a different type of relationship with signage changes compared to sales, transactions and profits.

Table 7: Perceived Impact of Sign Changes on Business Performance						
Performance Measure	% Reporting Increase	Average Increase				
Sales	65%	12%				
Transactions	62%	11%				
Profits	59%	9%				
Staffing	23%	6%				

Additional analysis of the relationship between business performance and various signage factors revealed a number of sign characteristics that correlated with positive economic impacts.

- Businesses emphasizing 'conspicuousness' as a sign element were somewhat more likely to report larger increases in store sales ($\gamma = 0.45$), and those giving a high priority to size/location were slightly more likely to report larger increases in store sales ($\gamma = 0.28$).
- Businesses with pole signs were somewhat more likely to report larger sales gains ($\gamma = 0.42$).
- Those that experienced gains in sales, customers, and profits were much more likely to attribute those gains at least partially to their sign changes ($\gamma = 0.80, 0.74, 0.75$).

Some survey respondents included contact information with their surveys for additional follow-up. Researchers were able to reach roughly one third of those who provided this information (13 of 38), and they provided additional responses to questions during a brief interview. Most of these businesses surveyed were single establishments in free-standing structures or storefronts in a main business district . They were located on a site either having 45-50 mph speed limits and far from curb, or 25-30 mph and within 20ft of curb. Most interviewees indicated that 60 percent or more of their revenues were obtained from regular/repeat customers.

Most of these interviewed businesses added electronic message signs, and they indicated that their new signs had positive business impacts, but the results are skewed by what they characterized as poor general economic conditions. All affirmed that they had experienced an increase in business since they added new signs, but most were not very significant. Three or four contacts reported vast improvements (increases of over 40%) compared to business revenue prior to new signs. When questioned about use of their new signs, these businesses generally indicated that they had become more involved with sign "activities." They referenced very active updating information (a couple times a week), constant design change, and posting community "reputation boosting" information. Illumination at night was mentioned by customers as a great attention-getting advertisement while closed. When asked what they would do differently or what they would do for their next sign update, many said they wanted more electronic messaging capabilities, having already witnessed the impact on business performance. Some wished for a video board, feeling this would dramatically boost business, but couldn't be justified with current revenues and budget. These types of dialogues can serve as yet another foundation for future research.

This survey has generated numerous insights into how on-premise signage affects the business performance of retailers, hotels and eating places in order to inform important decisions about private signage investments as well as public discussions about signage restrictions. This research would have been much easier, and perhaps already completed, if the required data was available as part of public secondary datasets. Unfortunately, this is not the case, and this research has been required to rely on the cooperation of businesses to share proprietary data. Businesses agree to share data, usually on the condition that the results are shared with them, because they appreciate the need for this research for their own benefit as well as that of the communities where they operate.

Given that this survey captured self-reported information about individual businesses, questions may arise about its objectivity and validity. Fortunately, a body of marketing research has established that the self-reports of business owners about the factors that influence the performance of their business are highly correlated with those factors that could be identified using independent, objective data (see Robinson & Pearce, 1988; Venkatraman & Ramanuiam, 1986). Consequently, the results here can be reasonably considered to reflect the role of on-premise signage for a broad range of retail businesses.

V. Case Studies

Four case studies, drawn from a wide range of business sizes and types, offer detailed insights about the economic impacts that on-premise signage can have. Among the case studies, positive business performance was generally associated with greater use of on-premise signage and better quality signs.

A. National Lodging Chain – Value Place

Value Place is the largest economy extended-stay franchise in the country. Founded in 2002, it opened its 100th location in 2008, and its 175th in 2010. All properties have about 120 suites and are newly constructed.

According to the company's website, its properties combine hotel convenience

and apartment essentials. Its business model is designed to appeal particularly to small and mid-sized business owners and families who are relocating to a new community.

The company has specific signage standards. The primary sign requirements consist of a wall sign with the company's logo on at least one side of the building, and a pole sign that displays its logo and pricing information.

The company also has several location criteria for its properties. The primary criteria are: interstate visibility, or at least a location along a primary arterial; a middle- to moderate-income area; and strong population density within a five-mile radius. These characteristics made it a useful case study.



Value Place has developed a number of pole sign configurations to help it communicate its message to potential customers. Its preferred arrangement utilizes an LED-lit changeable electronic sign. Changeable electronic signs are preferred because they can more effectively communicate multiple messages and because they are considered to be better at attracting attention. In those locations where sign regulations prevent the use of such signs, Value Place uses signs with large plastic numerals, similar to those that gasoline stations post to advertise their prices. Approximately 73 percent of all properties have changeable electronic signs, while 26 percent use signs with plastic numerals, and the remaining one percent lack any pricing signage.

How does the type of signage affect the performance of various properties? For those with changeable electronic signs, 2010 occupancy averaged 11.2 percentage points above breakeven, while those with plastic signs averaged 9.5

Impact of Sign Type

Electronic Plastic

Q1 Q2 Q3 Q4

Figure 3: Impact of Sign Type

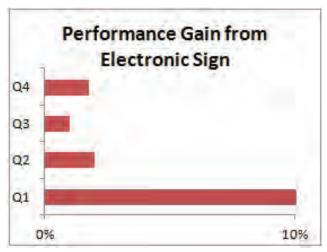


Figure 4: Performance Gain from Electronic Sign

points above this threshold. However, further analysis of this data shows that the advantage attributable to changeable electronic signs is predominately realized by properties in the bottom performance quartile.

To perform this analysis, properties were first divided according to the type of sign they use to advertise their pricing. Next, each of these two groups was divided into four quartiles, based on their occupancy rates, and each group was compared with the other on a quartile-by-quartile basis.

As shown in the figure 3, in each quartile, electronic sign properties had a higher average occupancy rate than properties with plastic signs, but the difference was small, except in the lowest-performing quartile (Q4). This graph omits the scale for occupancy rate figure to protect the confidentiality of performance data provided by the company.

Specifically, the performance gain from the use of electronic signs was in the range of one to two percent in the top three quartiles, but it jumps up to a ten percent advantage in the lowest quartile, as shown in figure 4. This suggests that those locations that are already performing well and have plastic signs are likely to experience limited benefit from the installation of an electronic sign. On the

other hand, such a sign change is likely to produce a substantial boost to the occupancy rates of properties that are currently struggling. This finding about economic benefits is consistent with other research on changeable electronic signs (van Bulck, 2011).

Signage with Price Information: Story of One Property

A second component of this case study involved a signage change at one property. At one Value Place location where local officials prohibited any pricing data on the property's sign, occupancy rates were so low that it was, at best, breaking even. After an extended period of discussions and negotiation, the company reached a compromise with local officials that provided for a multi-tenant sign that included space for Value Place, as the lead tenant in the development, to post its pricing. The new sign was erected in late October of 2010, nearly three years after the property opened.

For this analysis, information provided by the company consisted primarily of three years of monthly data on occupancy rates. Monthly data on posted and actual charged weekly rates were also provided in order to demonstrate that only negligible changes had occurred in prices.

The impact of the new sign has been significant. In the first nine months after its installation, the property has experienced an average occupancy rate that is 19 percentage points higher than the same nine-month period for the two preceding years. As a result, the property has now become consistently profitable, even in traditionally slower months. In addition, the property is now projected to generate an additional \$30,000 a year in hotel tax revenues.

B. National Retail Banking Business

A bank with more than 500 branches nationally, which we will call Secure Savings, agreed to provide data about the use of signage as it pertains to Secure Savings' branch characteristics and performance. Secure Savings requested that its identity not be disclosed in the presentation of this case study.

The banking industry uses on-premise signage extensively and spends a great deal of money on branding, design, placement, purchase, and maintenance of its signs. Retail banking is a highly competitive industry, and branch visibility receives much attention and investment.

Some of the operating characteristics in retail banking are similar to those in the retail trade and accommodation/ food service industries. For example, in resource materials prepared for its members, the Bank Marketing Association advises: "Banks need to think more like retailers. Convenience retailers such as restaurants or gas stations know the value of good visibility. If your customers can't see your sign or find your building, they won't visit your branch" (Beery, 2002).

Signage concerns begin at the site selection stage. Selection criteria for Secure National Bank include visibility and convenience of access, along with population density and size. "We need to be visible so that, when people need us, in their minds, they know where we are," stated one of the bank's real estate executives.

Case Study Approach and Data

Secure Savings has extensive data on its branches, which permit a more extensive analysis that explores issues beyond the basic signage considerations that have dominated previous research. As with the previous case study, this analysis focused on 47 locations within a single metropolitan area, which serves to eliminate many non-signage factors that would otherwise be difficult or impossible to control for.

The dataset for this analysis includes details about:

- Standard sign factors: number, type, size, height, design;
- Unique data on visibility and placement;
- Assessments of market factors for each branch location; and
- Business performance metrics.

Two types of analysis are described here. The first examines the relationship between the sign packages for individual branches and an independently-conducted evaluation of branch visibility. The second analysis examines the impact of both of these dimensions on branch performance.

Comparing Signage to Banking Center Visibility

Using the data on these individual banking locations, it is possible to examine the relationship between the visibility score assigned to the banks and their on-premise signage characteristics. These scores were part of a broader six-factor assessment of banking center conditions that was performed by an outside consultant. To illustrate how scores were assigned to banking centers on these characteristics, the description of the visibility categories is presented. For more detail on the remaining categories please see the technical appendix.

The other five characteristics on which bank branches received a score from one to five (with 5 being the best score) were: location, accessibility, and parking for the banking center; and land use pattern (land use mix and density, traffic flow) and life cycle (age and economic vitality) of the surrounding area.

Table 8. Banking Center Visibility Score Categories						
5 4 3 2						
Location is immediately visible from a great deal of distance and is easily found.	Location is immediately visible and can be seen in the traffic patterns with little difficulty.	Is visible but no more or less than surrounding competitors or retailers.	Is partially visible from the surrounding roadway although obscured by impediment like landscaping or other building.	Building is easily missed when driving by and is likely wholly or partially obscured		

Table 12 contains information on the proportion of banking centers in each score category for the factors mentioned above. The great majority of banking centers (nearly 80%) received a visibility score of 4 or better. On the other three banking center characteristics – their location, accessibility and parking – the banking centers showed greater variation. The surrounding areas tended to receive average to strong scores for land use patterns, indicating they generally would be expected to give reasonable support to the bank branches, while life cycle showed greater variation.

Score	Ba	nking Cente	er Characterist	Surrounding Area Ch	aracteristics	
Visibili		Visibility Location		Parking	Land Use Pattern	Life Cycle
5	36.2%	23.4%	17.0%	4.3%	40.4%	14.9%
4	48.9%	46.8%	38.3%	34.0%	25.5%	14.9%
3	12.8%	25.5%	40.4%	46.8%	27.7%	44.7%
2	2.1%	4.3%	4.3%	10.6%	6.4%	25.5%
1	0.0%	0.0%	0.0%	4.3%	0.0%	0.0%

The primary question is the extent to which sign characteristics of the banking centers are related to the independently assigned visibility score. The table below contains summary statistics on the sign characteristics of the banking centers, grouped according to the visibility score. Generally speaking, banking centers with higher visibility scores also tend to have more signage. In particular, pylon (or pole) and wall letter signs are more prevalent among locations with the highest visibility score. Across the 17 locations with a visibility rating of 5, there are 0.94 pylon signs, on average. These locations also have substantially more square footage of signage, 226 square feet on average, than lower scoring locations.

Table 10. Banking Center Sign Characteristics by Visibility Score							
Visibility	Number of	lumber of Average Number of Signs					
Score	Banking Centers	Pylon	Monument	Wall Letters (Vertical)	Wall Letters (Other)	Square Feet	
5	17	0.94	0.29	0.71	1.29	226	
4	23	0.30	0.52	0.61	1,17	165	
3	6	0.17	0.50	0.67	1.17	108	
2	1	0.00	1.00	1.00	1.00	105	

The amount and type of signage are not the only factors that contribute to a banking center's visibility score; the characteristics of the physical location and surrounding area also play a role. To examine this relationship, the Economics Center analyzed a statistical model predicting the probability that a banking center would have the highest visibility rating. The model calculated the probability that a banking center location received a visibility level of 5 as a result of the following:

the number of signs by type (pylon, monument, wall letters);

- the total square footage of signage;
- other banking center characteristic scores (location, accessibility, parking);
- surrounding area characteristic scores (land use pattern, life cycle).

The modeling technique allows for estimating the impact that each included variable contributes to the outcome of interest. Thus, by taking into account what is known about the banking centers and the surrounding areas (condition scores), the model permits an assessment of the added value of the included sign characteristics on the visibility score. The table below contains the results.⁵

Table 11. Probability of Hav		
Explanatory Variable	Impact on	Statistically
	Probability	Different From
		Zero
Number of Signs, by Type		
Pylon	0.91	Yes
Monument	0.38	Yes
Wall Letters Vertical	0.08	No
Wall Letters Other	0.12	No
Total Square Footage of Signage	-0.003	Yes
Banking Center Characteristics		
Location	0.43	Yes
Accessibility	0.08	No
Parking	-0.08	No
Surrounding Area Characteristics		
Land Use Pattern	-0.06	No
Life Cycle	0.12	No

⁵ See the technical appendix for a table containing the full regression results.

Factors That Affect Bank Visibility

The statistical analysis indicates that three factors have effects of much greater magnitude than the others. These three –location, pylon signs, and monument signs – are illustrated in the figures 5 and 6.

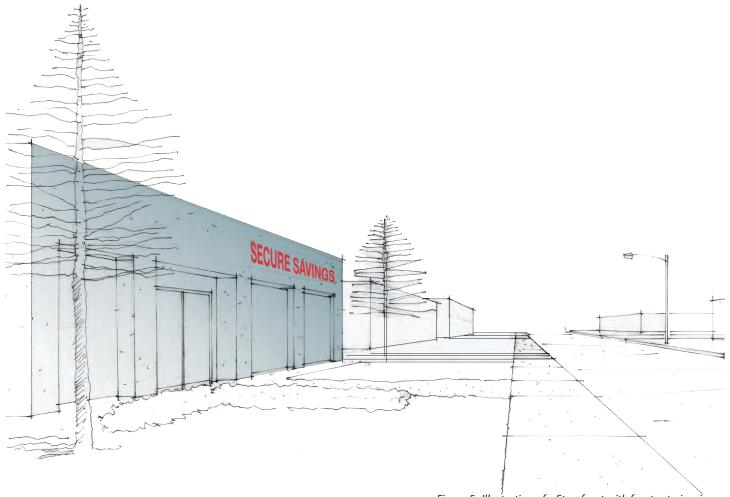


Figure 5: Illustration of a Storefront with front exterior sign

Having the prime location in the market results in a 43% greater likelihood of receiving the highest visibility score, compared to just a good and visible location.

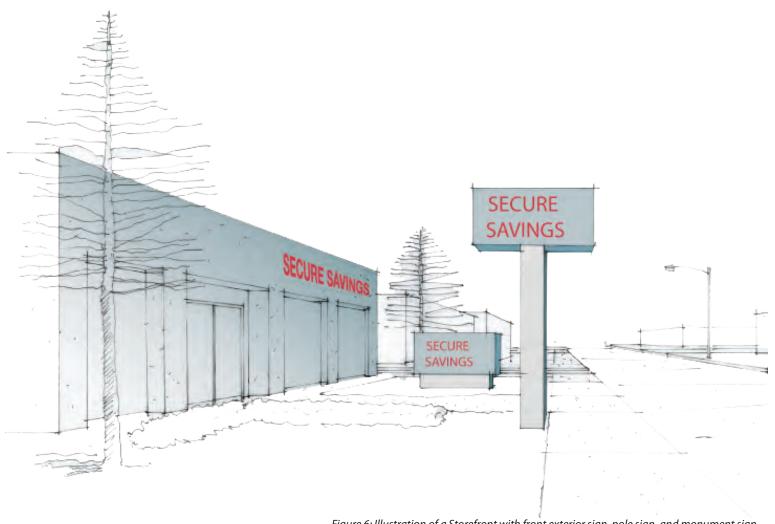


Figure 6: Illustration of a Storefront with front exterior sign, pole sign, and monument sign

The monument sign increases the probability of a maximum visibility score by 38%; the pylon sign increases the probability by 91%.

As shown above, certain on-premise signage has the greatest impact on bank visibility. The presence of pylon and monument signs increases the probability that a banking center has the highest visibility rating, even after taking into account other characteristics of the banking center and surrounding area. Specifically, each pylon sign is estimated to nearly double the probability (91% increase) of a visibility rating of 5, while a monument sign increases the probability by a little more than one-third (38%). According to one bank executive, "Pylon is the first choice because it can be seen from farther away." Acknowledging that mature trees occasionally block views of the signs, he observed that a pylon sign stands out more, which helps customers locate and drive to the bank more easily and safely.

Among the factors included in the model, the only other one that appears to have a significantly positive impact on visibility is one of the banking center characteristics – location – which produces a 43 percent increase in the probability of a top visibility score. The total square footage of signage is estimated to have a weak, negative

relationship to the probability of having the highest visibility rating. Each additional square foot of signage on premise is associated with a decrease of 0.3 percent in the likelihood of the location having the highest visibility rating. This result may occur because banking centers in poorer quality locations are compensating with more signage.

Comparing Signage to Banking Center Performance

The second part of the analysis examines the impact of signage and other condition characteristics on branch performance. The sample consisted of the same 47 banking locations previously analyzed. The outcome of interest was average monthly teller transactions in 2011. This component of the analysis modeled the incremental impacts of on-premise signage and condition characteristics on the number of average monthly teller transactions. The model analyzed teller transactions as a function of:

- the number of signs by type (pylon, monument, wall letters);
- other banking center condition scores (location, accessibility, parking); and
- surrounding area condition scores (land use characteristics, life cycle).

Table 16 contains the results of the model.⁶ The results indicate that, when taking into account the other variables, a pylon sign is associated with 1.15 times the average monthly number of teller transactions. The statistical significance of this result is relatively weak, but the magnitude is roughly the difference between a bank having 375 daily teller transactions and 325 transactions. This difference is a considerable impact on monthly transactions, and no other signage characteristics exert a statistically significant impact on the outcome of interest.

Not surprisingly, the rating given to banking center parking is the only other variable that has an impact on teller transactions. As these transactions occur on-site, it is reasonable that banking centers with more available and more easily accessed parking would also tend to have more transactions.

⁶ See the technical appendix for a table containing the full regression results.

Explanatory Variable	Impact on Monthly Transactions	Statistically Different From Zero
Pylon	1.15	Yes
Monument	1.03	No
Wall Letters Vertical	1.09	No
Wall Letters Other	1.00	No
Banking Center Conditions		
Location	0.93	No
Access	1.09	No
Parking	1,15	Yes
Surrounding Area Conditions		
Land Use Characteristics	1.08	No
Life Cycle	1.03	No

C. Specialty Retail Small Business – Bob Roncker's Running Spot

This case study addresses a small business retail establishment in its expansion from one store to four stores in a major Midwestern city. The study examines a local specialty store chain of four small stores specializing in running and walking shoes, accessories, and apparel. These niche specialty retail stores provide an ideal case study for the effectiveness of signage and branding. The four retail outlets have a single owner. The original store has been in business for 30 years, adding three stores over the past several years. A program to refresh store signage in the context of an expanded branding strategy has paralleled the company's bricks-and- mortar growth.

The first Bob Roncker's was established in 1981, offering industry-specific advice and high quality running/walking products. This first store was located in an older street-car suburb business strip on a busy commuter artery that leads to both the downtown and a major university within the region. The regional trade area has about 1.2 million residents. Early in 2008, a second store was added in a similar, well-established commuter suburb near the outer interstate beltway, a substantial distance from the city core..Later in that year, a third store was opened in an historic suburb located alongside a popular bike / running path. A fourth store opened in 2009 near

a successful riverfront commercial development. All four stores are devoted to retail sales of quality specialty running / walking lifestyle products.

This small specialty retail store case study offers insight into the role of on-premise signs at several levels: as an element of communication within the context of a specific streetscape; as an element of a comprehensive branding strategy within a niche market; and as reaffirming the stores' commitment to quality goods and services. This study also demonstrates how a small retailer can use signage to target a specific, narrow market within an upscale residential community with strict sign regulations. The small retailer has fewer options for communicating with its existing and potential customers. This requires that signage and branding strategies be an integrated package that is consistently applied.

Each of the four stores' building configurations, architectural styles and signage regulations present unique challenges for on-premise signage. Each requires site-specific signage design while maintaining consistency in graphic communication. Graphic composition and sign 'appropriateness' need to be balanced while maintaining conspicuity and legibility.

Store One: The original store location

This two-story brick structure sits close to a major busy street in a small suburban commercial district outside the urban core of a major river city. The modest face-mounted sign has a distinctive logo and san serif calligraphic style typeface. The clarity of the sign itself is due to the careful composition of elements – logo and graphically-stylized business name. The clean design and signature-styled font letters reflect the owner's desire for straightforward business dealings, personal service, and quality products. The well-designed painted sign is constructed and composed to reflect the commitment to customer satisfaction and product quality rather than conspicuity and over -powering visibility. Modesty and visual restraint set the theme for all of the four store signs, allowing consumers to focus on quality and service of their brand over expediency and budget.



Store One has four on-premise signs: a face-mounted building sign on the second floor façade, a small facemounted door sign providing store hour information, a very small bayonet mounted sign, and a sandwich curb sign for special events and sale announcements. Because of the 10-foot sidewalk set back distance of the building and the parallel curb parking, the two small face-mounted signs are only readable from directly across the street. It is a direct

view perpendicular to the building's brick façade. This doesn't allow visual access to the sign from moving traffic in either direction. A moveable sidewalk sandwich sign provides an opportunity to announce specials, but the curb parking and small sidewalk trees obscure any chance for good readability to the fast moving traffic. The bayonet sign is so small (approximately 9" x 20") and placed under the awning as to obscure the communication value to all but pedestrians within 10 to 20 feet of the store entry.

The store has updated its awning and added a distinctive brand graphic logo and descriptive stylized text that is located on the front of the awning's sloped surface and fascia. The new awning design strategically plays off the color palette of the city's dominant university to reinforce the store's local commitment to its customer base. The awning is the best choice for added signage because regulatory codes allow only limited signage development and is restrictive to face-mount signs. The new awing signage has added a distinctive branding presence to the façade and a new communication identity that the building's other signs are unable to provide. This signage addition also adds a 'freshness' to the façade and provides a point of location for the fast moving traffic. Personal interviews with customers noted that the new signage graphics have helped identify the store from the street and have contributed to their interest in visiting.

Store Two: Expansion store 1999

The first addition to the store chain occurred in 1999. Following the precedent of the original store, modest signs are placed more for communication with pedestrian and slow moving traffic. This attitude and restraint is a response to the context of the small historic commercial district located within a quaint suburban neighborhood. A tenuous free-standing sign and a small, stylized, bayonet sign identify the store entry. Because of the building's setbacks, curb parking, and adjacent buildings, the store window displays and entry are hidden from street traffic. A sandwich sign is also used to announce sales and events. The low-key signage attitude fits with the community's desire for residential scale and historic references to maintain the up-

scale historic suburban lifestyle. Signage here is only a reminder for the entry and is not intended to take on much of a leadership role in expanding the consumer base. Other branding means are utilized. Signage is down-played with the bayonet-style sign, adding to the traditional small town atmosphere.





Store Three: Expansion store 2009

The established logo and stylized type of the original store helps the on-premise signs take a more prominent role at the third location. Located in a refurbished suburban train station, the signage must reach out to the community to pinpoint the store's location and attract new customers. The abandoned railroad tracks are now a popular biking and running / walking route that generates many retail opportunities. This location allows and requires the signs to pull away from the building and be

located for vehicular traffic, bicyclists, runners and walkers. A prominent sign gives motorists good viewing from adequate distances, and a temporary sandwich sign adds to the attractiveness of a quaint business. The ambiance of the park-like setting with generous entry distances allows the building's face sign to be larger and out of balance to the station's low roof profile and large overhangs. This location tolerates stronger on-premise signage with an increased scale. Conspicuity and readability are balanced within the established sign composition that contains the store brand. Impulse purchases happen often as the bike / running path attracts many consumers that require replacement of their specialized running / walking appeal, or are attracted to the new product availability.

Store Four: Expansion store 2009

The last expansion store is located within a revitalized urban setting near the downtown area. A renovated building awning and logo bayonet sign announce the store to pedestrians and vehicular traffic. Located in a popular evening entertainment district, this running store attracts persons that would not be visiting the suburban locations. A large wall sign that faces the active evening retail and entertainment



area also helps attract customers to the store for impulse and special sales buying.

The building integration is successful in attracting retail sales in its entertainment district location, with the store offering expanded evening shopping hours. The signs are well-organized and the design quality supports the clean, well-manicured building. At this location the signage supports an image and message of quality retail products, and presents a comfortable 'fit' with the adjacent

businesses. As such, it demonstrates an inviting quality that supports its brand identity. Signage in this location has an opportunity to impact sales. Sales are reported to be increasing, and this store and the original store generate the highest sales per month of the four store chain. It is also important to note that other branding activities are utilized less in this location than in the other stores. It can be inferred that the on-premise signage is a major contributing factor to the store's solid sale performance. On–premise signage is the most developed in this location, with the most signs in number and size as compared to the other three locations.

Overall Assessment

At first glance, small specialty businesses such as Bob Roncker's may not seem to offer much in on-premise signage impact. Closer examination provides a greater understanding of the complex variables in on-premise signage and provides a view of a strategic approach to expansion and signage updating, which could be applied to future research involving the analysis of chain retailers. This case study provides a good illustration of how implementation of a branding plan and retail expansion plan that includes on-premise signage can positively impact business performance. According to the Bob Roncker's business manager, Verne Johnson: "One of our primary goals, since converting our Glendale shop from a New Balance Concept store in 2008, has been on branding the Bob Roncker's Running Spot name. It continued to be a key element in our marketing and advertising programs as we added stores in Loveland, later on in 2008, and Newport in 2009.

"Store signage has no doubt helped us in achieving that goal; improving the image of the Running Spot brand / identity in the greater Cincinnati marketplace. That, along with our continued focus on customer service and quality solution in footwear, apparel, fitness training programs, and other associated running / walking gear has helped us improve our sales performance at all store locations. This target branding strategy has helped make the Running Spot a successful and profitable business for over 30 years and has allowed the brand to expand into four complete stores."

These comments are consistent with the results of a recent national consumer survey that indicates that potential buyers take note of business signage, and make decisions based on it. Nearly three-quarters of respondents reported that they entered a business because signage caught their attention. Similarly almost 80 percent said that they remembered a business later because of the signs. Seventy-five percent of respondents also referred someone else to a business because of notable signage. (FedEx Office, 2012).

Small businesses like the Running Spot depend upon on-premise signage because of the communication value with potential customers. Better economic performance was reported in stores having the most complete and prominent signage. All stores are on healthy economic footing, with the original store and the store in the urban entertainment district showing the best performance. These two stores have the most complete signage package with fresh, legible signs placed in visible locations. While location and signage differences among the four stores preclude a rigorous statistical analysis of the role of on-premise signage in business performance, there

does appear to be a general correlation between superior signage and superior performance. This is also consistent with the business managers' assessment that their signage has resulted in positive performance because it is able to effectively communicate with large numbers of potential customers.

D. Small Business - Chuck Anderson Ford

Chuck Anderson Ford is located in Excelsior Springs MO, which is part of the Kansas City metro area. The business is located within a typical commercial strip on an arterial highway.

In March of 2011, owner Mike Anderson added a new pylon video board to the existing dealership signage, which includes a traditional Ford-logo pylon sign and other business signage. This sign was added primarily as part of an effort to increase the dealership's service business. The new 30-foot pylon sign has a 96-square-foot full-animation, electronic message center. Previously, that portion of the dealership was identified by a 22-square-foot sign that read "Body Shop."

The new sign was not only larger, but it offered better illumination and design, in addition to its messaging capabilities. The electronic sign draws much more attention to Anderson's business.

For example, in 2011, Anderson used the new sign to advertise a corporate tire sale, and even though a Goodyear Tire Center is located directly across the street, Anderson Ford had the fourth-highest tire sales figure among US Ford dealers.



Case Study Approach

To assess the economic impact of the new sign, Anderson Ford provided monthly data on service department customers and sales for 2010 and 2011. To smooth out monthly fluctuations, the chart below presents the data as two-month averages. Using a base of 100 for the average monthly customer count during 2010, customer figures during 2011 increased from an index of 90 in January and February (the two months prior to adding the new sign) to 108 in the first two months after the new sign and 119 at the end of 2011, showing an average gain of 4.5 percent every two months.

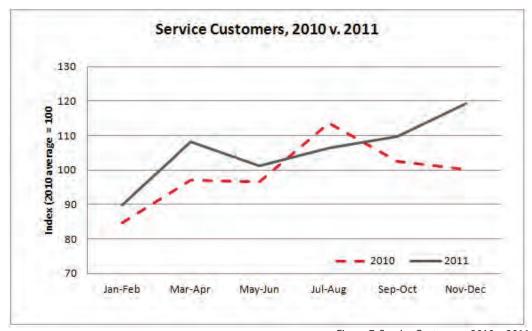


Figure 7: Service Customers, 2010 v. 2011

In figure 7, note that 2011 showed an average year-over-year increase in the number of service customers of 6.5 percent during the ten months after the installation of the new sign.

Mike Anderson indicates that his current service clientele can be identified as 34 percent first-time/new customers and 66 percent regular/repeat customers. This suggests that more customers are learning about his business, and it is reasonable to assume that at least a portion of this new business is coming as a result of the new sign.

A similar analysis was performed on the sales figures, but these numbers were tracked against national auto parts store sales to account for the generally improving national economy. This analysis avoided figures for the winter months (December, January, February) because of the potential for weather-related distortions. Year-over-year figures were compared for the March-to-November periods of 2010 and 2011. This also corresponded well to the introduction of the new sign at Anderson Ford. While US auto parts sales for March-November 2011 were up 5.5 percent over the previous year, Anderson Ford service revenue increased by 10.8 percent in this nine-month period of 2011, compared to 2010. Overall, given the increase in busi-

ness since the sign was installed, Mike has hired three new salespeople, two service technicians and one body-shop person, increasing his employees from 28 to 34, and his business is still growing.

As important as these sales figures are for the dealership, revenue doesn't tell the whole story. The new sign has directly contributed to other positive impacts – on the reputation/brand and visibility of the business. An estimated 30 percent of the new sign's message time is focused on community announcements and public service messages. Examples include:

- Tornado-watch notices,
- The community's annual Oktoberfest,
- A cancer walk-a-thon, and
- Local student recognitions.

These messages generate attention and positive feedback for the business. According to Anderson, "It's about goodwill and being a member of the community. The sign has had a big impact on how we're perceived." When the company first decided to add the new sign, it was seen as an innovative idea that would help to set it apart for its competitors. Now, Anderson says, "The attention I've received has endorsed my decision. The sign has helped us to communicate with the customer on a continual basis. We would for sure do it again!"

VI. Summary of Research Findings

The research shown in this report indicates that appropriately designed and located on-premise signage can be an important factor for retail business success. The implication of these results is that on-premise signage indirectly influences the vitality of a community though the availability of goods and services, jobs and public services. Sign regulations should balance community design objectives with full knowledge of how sign design and location impact businesses success. Business success is important because of its impact on a community's tax base and ultimately leads to the availability of fiscal resources to provide needed services.

We began by providing an intellectual underpinning that uses economic theory to present a new explanation for why on-premise signs have positive economic impacts, not only for businesses, but also for consumers and communities. This explanation can foster more well-informed discussions between sign vendors and users and between sign users and regulators.

The following summarizes this study's findings, based on a national business survey and business cases studies assessing the impact of on-premise signage on business performance.

The national business survey found:

- Legibility is the most important characteristic of signs across all sizes of companies;
- Use of business logos, and the size and location of the signs were more important for companies with more establishments, compared with single establishment companies;
- Sign changes generally had significant, positive impacts on sales, number of transactions, and profits;
- Sign changes had smaller positive impacts on employment.

Among the case studies, positive business performance was generally associated

with on-premise signage changes as the following indicates:

- The national lodging chain case found that the use of a digital electronic sign to display pricing was associated with higher average occupancy rates.
 The impact appeared to be especially strong for properties with lower occupancy rates;
- The national banking case study found that pylon signs were strongly
 associated with high visibility; monument signs were moderately associated
 with high visibility; wall signs contributed to identity but not visibility.
 In addition, pylon signs were associated with significantly more teller
 transactions;
- The small specialty store case study demonstrated the need for signage to reaffirm the value offered by a niche retailer. Sign design must be sensitive to community and customer expectations, and able to reinforce the limited brand of a small business. The signage should communicate a "promise" of value for a product and/or service that is not commonly found elsewhere;
- The car dealership case study found that the addition of a video sign board was associated with large increases in both service department revenue and customer count. An added benefit was the "goodwill" and reputational gains associated with using the video board for community-related public service messages.

While many of these findings are statistically significant, larger sample sizes in surveys and case studies should be sought in future research. It is always appropriate to exercise caution when interpreting case study findings because results do not necessarily transfer from one industry or geographic setting to another. While these case study findings about particular individual businesses are not necessarily generalizable, they are important, particularly because the subject is so complex that a comprehensive analysis covering all business types and signage considerations is unlikely to be undertaken. Furthermore, the similarity of some case study findings with survey results suggests that this study deserves careful consideration by researchers, practitioners, and local officials.

VII. Conclusion

The research presented in this report provides current information for better understanding the economic impact of on-premise signage. The national business survey results provide insight to how different types and sizes of businesses use and value their signage. The survey results also provide details about the specific aspects of signs that different types of businesses consider most important. The case study results have reinforced the survey results and provide detailed examples of improved business performance resulting from specific changes in signage. The ultimate goal of this research has been to provide the signage stakeholders with timely, relevant information to inform their decisions about using on-premise signs to jointly serve the needs of both individual businesses and communities where they are located. As we have attempted to convey, the impact of signage on an individual business location is complicated by a number of factors related to the specific physical, social, and regulatory context of that location, as well as the specific customer base and product offered by the business. Our results suggest that careful identification and consideration of those factors is likely to result in more effective signage. The implication is that with respect to on-premise signage, one size does not fit all, and that to maximize their effectiveness, different types and sizes of business need tailor their signs to their specific needs. Most reputable sign companies already know and appreciate this, though this may be new insight for some businesses. Perhaps the stakeholders that can most benefit from our analyses are some of the sign regulators.

Our work should not be interpreted to suggest that all sign regulations hinder business performance. While this research has emphasized the important role of successful businesses in a community's overall quality of life, we recognize that thoughtful signage design standards can accommodate both the needs of businesses and communities. Indeed, it is clear from our work that sign regulation incentivizing legible, visible, and conspicuous signs can boost business performance, especially for the small businesses that can catalyze growth.

A. Implications for Businesses

Businesses make decisions about their signage within the context of their available financial resources, target customer base, and location characteristics. The results

presented in this report emphasize the importance of carefully assessing the role signage plays in a business' overall marketing and branding strategy given the specific characteristics of a particular location. The specific sign designs and types used to achieve these objectives will depend on multiple factors related to the business location, including view distance, street/road curvature, number of traffic lanes, speed limits, landscaping, building setback, and sightline obstructions from other signs, buildings, poles and berms, and potentially many other factors. The case studies reinforce the idea that particular signs may be effective for one type of business but not be well-suited for another. Clearly the digital electronic signs that work so well for the hotel chain would be ineffective for the specialty shoe store. Likewise, the video sign that works well to enhance sales and community relations for a single-establishment car dealer may be difficult for a banking chain to use at neighborhood branches and integrate into their national branding strategy.

B. Implications for Communities

Both private and public decisions about signs can have important implications for communities. As previously indicated, the results of this study show that signs that are legible, visible, and conspicuous are important for retail businesses. The implication is that sign regulations should balance community design standards with site-specific technical requirements for promoting business success. The alternative is that businesses are less successful and governments have less revenue to support their services. Second, it is important for planners and local officials to understand how the purposes and uses of signs differ for single establishments, small companies, and larger companies. Sign regulations that constrain one purpose may disadvantage the businesses that depend on it. This may be the case especially for smaller, single establishments, which are frequently more dependent on signs as a primary means of communicating their location and products or services to potential customers. On the other hand, regulations that encourage quality signage that communicates effectively at low cost may help small businesses. Given that such small businesses frequently serve as engines of job growth, such policies can be especially appropriate as part of neighborhood economic growth strategies.

C. Implications for Future Research

Taken together, the results of this research have significant implications for businesses and communities, and they suggest important considerations to guide future research in this area. Much of the work reported here is based on data collected directly from businesses, which are an irreplaceable source of information for signage research. Those who attempt to replicate this research will find that most businesses, regardless of size, are hesitant to share such detailed data about individual locations despite extensive assurances of confidentiality. Because research in this field is important for informing business investments as well as public policy, future research will benefit from efforts that would enable business signage and performance data to be made more accessible to researchers. Associations within the signage industry might be able to establish mechanisms or protocols to facilitate data availability while ensuring confidentiality.

This study can serve as a foundation and guide for practitioners and researchers who want to contribute to the development of more effective signs and improved signage practices. For those who are committed to this collaborative venture, new questions will arise from their application of these research findings, and future research will play a key role in the success of their efforts.

Appendicies

1. Survey Instruments

UC Sig	n Survey
 Introduction The University of Cincinnati is examining how differences or changes in on- premise signs affect businesses. 	3. How important are each of these elements in your sign? Importance (Check one box in each row)
We are using this brief survey, which you can complete in about 5 minutes, to obtain information about the views and experiences of sign users.	Conspicuous ("stands out")
If you have any questions or want to contact us regarding this research, please call or email me.	Clearly readable Logo or branding
Jeff Rexhausen, Associate Director of Research Economics Center, University of Cincinnati jeff rexhausen@uc.edu	Illumination (lighting/brightness) Size and location
Purposes of Signs Signs play an important role in contributing to business success. Their economic value comes from the impacts they have on business activity. To produce these effects, signs serve a variety of functions. A. How important is each of these purposes for your on-premise signs?	3. Your Business If you have more than one type of business, please limit your responses to the one type for which signs are most important. You may also complete an additional survey for a separate type of business. To make it easier for you to respond, we encourage you to base answers on estimates or your best recollections, if you don't have specific data at hand.
Importance (Check one box in each row)	A. Which of these best describes your business? (Check one) Small business - independent Small business - franchise of a chain
Make your business stand out from others	Large retailer (incl. food service and retail banking) Other type of business (describe below)
Reinforce branding/image	Oties type of business (describe below)
Help potential customers find your location	
Inform about available goods/services Inform about promotions (sales, etc.)	8. How many establishments (business locations) do you have?
Other (describe below)	C. At a typical business location, which of these types of exterior signs do you use? (check all that apply)
	Wall sign
B. What do you consider the most important purpose of your on-premise	Pole sign
signs? (Check one)	Monument sign
Provide visual identity and uniqueness	Other signs (describe below)
Reinforce brand familiarity	
Show location to potential customers	
Provide information about available goods and services	D. At a typical business location, how many exterior signs do you have? (Check one) 1-2 3-5 6 or more

	Temporary loss of a sign
	Permanent loss of a sign
4. Sign Changes and Impacts	Reduction in sign size
	Loss of sign visibility (obstructed, lowered, farther from street)
A. Do you have any business locations at which there have been any of these types of changes to one or more signs in the past 5 years? (check all that apply)	E. In connection with these sign changes, what business impacts did vexperience?
Increase in number of signs	(Check direction and \$\\ 2\\ 2\\ 2\ \ \ \ \ \ \ \ \ \ \ \ \ \
Increase in sign size	14/8/3/3/3/3/3/3/3/5/8/
Enhancement of sign visibility (higher, closer to street,	amount of change) / 2/3/3/3/3/3/3/3/3/3/3/
placement on building, etc.)	Total sales volume
Change in sign design (refresh look, new type, illumination)	Number of transactions
	Other (describe below)
experience, and how large were they? (Check direction and amount of change)	Other Information and Interest in Research Findings A. Please indicate what types of information you might be willing to a should now rise about your rise charges of the continue of
(Check direction and amount of change) Total sales volume Number of transactions Staffing (employment)	
(Check direction and amount of change) Total sales volume Number of transactions Staffing (employment) Profits L. If sales, staffing, and/or profits increased, what were the top 2 reasons	A. Please indicate what types of information you might be willing to sabout your sign changes. (check all that as Details/stories about types of sign changes Data on business impacts (data to be kept confidential;
(Check direction and arnount of change) Total sales volume Number of transactions Staffing (employment) Profits Liff sales, staffing, and/or profits increased, what were the top 2 reasons	A. Please indicate what types of information you might be willing to sabout your sign changes. (check all that as Details/stories about types of sign changes. Data on business impacts (data to be kept confidential; no reference to your business in the study) Ditta on business impacts (data to be kept confidential, but naming your business in the study)
(Check direction and amount of change) Total sales volume Number of transactions Staffing (employment) Profits Lif sales, staffing, and/or profits increased, what were the top 2 reasons for growth? (check two)	A. Please indicate what types of information you might be willing to about your sign changes. (check all that as Details/stories about types of sign changes Data on business impacts (data to be kept confidential; no reference to your business in the study) Ditta on business impacts (data to be kept confidential,
(Check direction and arnount of change) Total sales volume Number of transactions Staffing (employment) Profits C. If sales, staffing, and/or profits increased, what were the top 2 reasons or growth? New or refreshed signs	A. Please indicate what types of information you might be willing to sabout your sign changes. (check all that as Details/stories about types of sign changes. Data on business impacts (data to be kept confidential; no reference to your business in the study) Ditta on business impacts (data to be kept confidential, but naming your business in the study)
(Check direction and amount of change) Total sales volume Number of transactions Staffing (employment) Profits C. If sales, staffing, and/or profits increased, what were the top 2 reasons for growth? New or refreshed signs Increased number of signs	A. Please indicate what types of information you might be willing to sabout your sign changes. (check all that as Details/stories about types of sign changes. Data on business impacts (data to be kept confidential; no reference to your business in the study) Dipta on business impacts (data to be kept confidential, but naming your business in the study) If so, please provide your phone number and/or email for us to contact
(Check direction and amount of change) Total sales volume Number of transactions Staffing (employment) Profits C. If sales, staffing, and/or profits increased, what were the top 2 reasons for growth? New or refreshed signs Increased number of signs Increased other advertising/marketing	A. Please indicate what types of information you might be willing to about your sign changes. (check all that as Details/stories about types of sign changes. Data on business impacts (data to be kept confidential; no reference to your business in the study) Ditta on business impacts (data to be kept confidential, but naming your business in the study) If so, please provide your phone number and/or email for us to contact. B. Would you like to receive a brief summary of the findings of this
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Impact of On-Premise Signs	
2. What do you consider the most important purpose of your on-premise signs?	
Provide visual identity and uniqueness	
Reinforce brand familiarity	
Show location to potential customers	
Provide information about available goods and services	

Impact of On-Premise Signs

1. Introduction

The University of Cincinnati is examining how differences or changes in on-premise signs affect businesses.

We are using this brief survey, which you can complete in about 5 minutes, to obtain information about the views and experiences of sign users.

If you have any questions or want to contact us regarding this research, please email me at jeff.rexhausen@uc.edu.

Jeff Rexhausen, Associate Director of Research Economics Center, University of Cincinnati

2. Purposes of Signs

Signs play an important role in contributing to business success. Their economic value comes from the impacts they have on business activity. To produce these effects, signs serve a variety of functions.

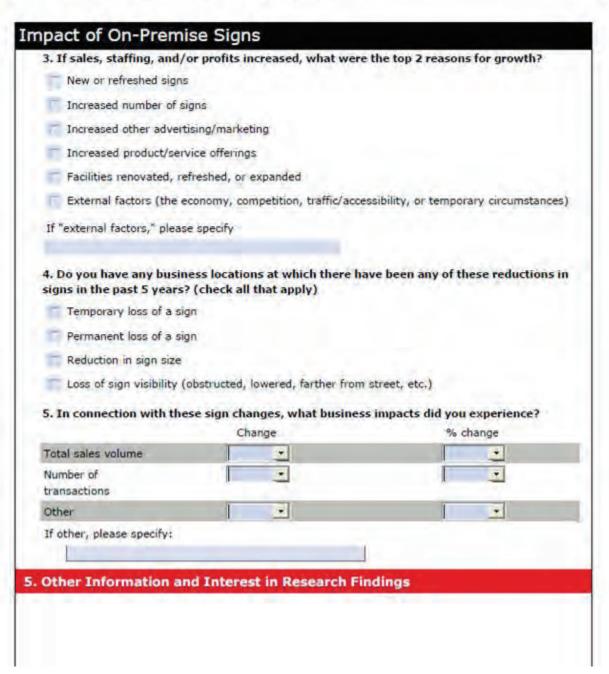
1. How important is each of these purposes for your on-premise signs?

11	Extremely important	Moderately important	Slightly important	Not at all important
Make your business stand out from others				
Reinforce branding/image	2	70	90	20
Help potential customers find your location	-			
Inform about available goods/services	20	6	n n	2
Inform about promotions (sales, etc.)		-	77	
Other (describe) Other:	8	-	0	(2)

2. What do you consid	and the same of the same	ALL LESS CARLES	, yam an premise	
Provide visual iden	tity and uniqueness			
Reinforce brand far	niliarity			
Show location to p	otential customers			
Provide information	about available go	oods and services		
3. How important are	each of these ele	ments in your s	ion?	
A Marie Anna State	cremely important	Moderately important	The same of the same	Not at all importan
Conspicuous ("stands out")	9	0	3	2
Clearly readable	100	- 6	0	- II
Logo or branding	- 1		- 4	
		-	-	
Illumination				900
Illumination (lighting/brightness) Size and location	R	- 8	3	78
(lighting/brightness) Size and location Your Business you have more that pe for which signs a lirvey for a separate	re most import type of busines	ant. You may	also complete ar	additional
(lighting/brightness) Size and location Your Business you have more that pe for which signs a privey for a separate of make it easier for stimates or your best and business - in Small business - for Large retailer (incl.)	type of busines you to respond, t recollections, t describes your be dependent anchise of a chain food service and in	ant. You may ss. , we encourag if you do not ousiness?	also complete an	additional
(lighting/brightness) Size and location Your Business you have more that pe for which signs a price for a separate of make it easier for stimates or your best small business - in Small business - fire	type of busines you to respond, it recollections, t describes your bedependent anchise of a chain food service and re-	ant. You may ss. , we encourag if you do not ousiness?	also complete an	additional
(lighting/brightness) Size and location Your Business you have more that pe for which signs a privey for a separate of make it easier for stimates or your best timates or your best Small business - in Small business - from Large retailer (incl.)	type of busines you to respond, it recollections, t describes your bedependent anchise of a chain food service and re-	ant. You may ss. , we encourag if you do not ousiness?	also complete an	additional
(lighting/brightness) Size and location Your Business you have more that pe for which signs a survey for a separate of make it easier for stimates or your best stimates or your best Small business - in Large retailer (incl.) Other type of business if other, please specifications	type of busines you to respond, it recollections, t describes your be dependent anchise of a chain food service and re	ant. You may ss. we encourag if you do not ousiness? etail banking)	also complete an ne you to base an have specific dat	additional
(lighting/brightness) Size and location Your Business you have more that pe for which signs a privey for a separate of make it easier for stimates or your best timates or your best Small business - in Small business - from Large retailer (incl.)	type of busines you to respond, it recollections, t describes your be dependent anchise of a chain food service and re	ant. You may ss. we encourag if you do not ousiness? etail banking)	also complete an ne you to base an have specific dat	additional

Page 2

Impact of On-Premise Signs 2. What do you consider the most important purpose of your on-premise signs? Provide visual identity and uniqueness Reinforce brand familiarity Show location to potential customers Provide information about available goods and services



Impact of On-Premise Signs 2. What do you consider the most important purpose of your on-premise signs? Provide visual identity and uniqueness Reinforce brand familiarity Show location to potential customers Provide information about available goods and services

Impact of On-Premise Signs 1. Please indicate what types of information you might be willing to share about your sign changes. (check all that apply) Details/stories about types of sign changes Data on business impacts (data to be kept confidential; no reference to your business in the study) Data on business impacts (data to be kept confidential, but naming your business in the If you have information, please provide your phone number and/or email so that we may contact 2. Would you like to receive a brief summary of the findings of this research project? No If "yes," please provide email address. 3. Thank you for contributing to this research. Please invite your business colleagues to also participate. The more information we receive, the better the insights we will be able to provide in our report. Please go to "http://business.uc.edu/uc-sign-survey-extra" to answer a few more questions about sign impacts. We also welcome your comments and suggestions.

2. Retail Banking Technical Appendix

To examine the impact of signage and location characteristics on the visibility score, a binary variable taking on a value of 1 if the location received the highest score, and 0 otherwise, was constructed. Assuming that the probability of the outcome of interest is normally distributed gives rise to a standard probit model. As the coefficients from a probit model are not directly interpretable they have been transformed into marginal effects. The marginal effects displayed in the table below give the change in the predicted probability of having the highest visibility rating for a given one-unit change in the explanatory variable.

Dependent Variable: Visibility Score of 5				
Explanatory Variable	Marginal Effect	Coefficient Estimate	z-value of Coefficient Estimate	
Number of Signs, by Type				
Pylon	0.91	14.411**	1.99	
Monument	0.38	6.010**	1.96	
Wall Letters Vertical	0.08	1.314	1.01	
Wall Letters Other	0.12	1.959	1.42	
Total Square Footage of Signage	-0.003	-0.053*	-1.79	
Banking Center Characteristics				
Location	0.43	6.777**	2.09	
Accessibility	0.08	1.318	1.15	
Parking	-0.08	-1.236	-1.09	
Surrounding Area Characteristics				
Land Use Pattern	-0.06	-0.929	-0.95	
Life Cycle	0.12	1.822	1.43	
Intercept		-35.011**	-1.97	
Pseudo R ²		0.7952		

^{***} significant at the 1% level

^{**} significant at the 5% level

^{*} significant at the 10% level

The measure of banking center performance selected for analysis was the number of average monthly teller transactions in 2011. Because the outcome of interest is a quantity that takes on discrete, nonnegative values, a count regression assuming a negative binomial distribution was used. The functional form assumed that the variance of the outcome was a linear function of the mean. The coefficient estimates are not easily, directly interpretable. The transformed impacts are the estimated change in the number of teller transactions for a one unit change in the corresponding explanatory variable. The estimate for "alpha" appearing in the table below is statistically significant, indicating that the conditional variance of the dependent variable is over-dispersed relative to the conditional mean, confirming the use of a negative binomial distribution as opposed to a Poisson distribution.

Dependent Variable: Number of Average Monthly Teller Transactions			
Explanatory Variable	Impact on Monthly Transactions	Coefficient	t-value
Number of Signs, by Type			
Pylon	1.15	0.144*	1.73
Monument	1.03	0.027	0.27
Wall Letters Vertical	1.09	0.084	1.08
Wall Letters Other	1.00	-0.004	-0.09
Banking Center Characteristics			
Location	0.93	-0.071	-1.03
Access	1.09	0.086	1.54
Parking	1.15	0.138**	2.1
Surrounding Area Characteristics			
Land Use Pattern	1.08	0.081	1.25
Life Cycle	1.03	0.03	0.6
Alpha		0.101***	4.91
Intercept		7.981***	21.02
Log-Likelihood		-429.52	

^{***} significant at the 1% level

^{**} significant at the 5% level

^{*} significant at the 10% level

There are several important potential sources of biases that impact the reliability of the results. As mentioned previously, the datasets analyzed were small and also focused on a single type of business in one industry. The small number of observations may render the point estimates themselves inaccurate. Additionally, there may be important variables that have been omitted from the analyses due to lack of data. These omitted variables may be another source of inaccuracy. It is possible that, where data available, inclusion of these variables would change the sign, magnitude or significance of the remaining variables. Finally, as the data were not a random sample of businesses the results are not necessarily applicable to other industries or indicative of the impacts of business signage generally.

	Score Descriptions				
	5	4	3	2	1
Visibility	Location is imme- diately visible from a great deal of distance and is easily found.	Location is immediately visible and can be seen in the traffic patterns with little difficulty.	Is visible but no more or less than surrounding competitors or retailers.	Is partially visible from the surrounding roadway although obscured by impediment like landscaping or other building.	Building is easily missed when driving by and is likely wholly or partially obscured
Location	Banking Center is in the prime location within the immediate submarket or trade area. Easily accessible.	Banking Center is in good and visible location within the trade area, although it is not on the prime corner.	Banking Center is serviceable. Its location is generally acceptable and would be easily found by those looking for it.	Banking Center location is flawed in some way (i.e. poor traffic patterns, development moving traffic away from site).	Immediate trade area has moved away from this location or deteriorated in that it is not servicing the customer base.
Access	BC is immediately accessible from either direction from the roadway for both entry and exit. Traffic signal at access. Easy left, in & out.	BC is accessible from either direction although may have shared easement with contiguous retailer. Easy to modestly easy left, in or out.	Is generally acces- sible, however is susceptible to traffic issues at peak times. Tough to moderately tough left, in or out.	Has some. consistent access issues attributable to traffic or easement points. Tough left, in or out.	Access is poor du- to constant traffic issues or shared egress points that are far away from BC location. No left, in or out.
Parking	Immediate parking around the banking center is abundant. Plenty of parking even at peak times.	Parking is plentiful. As long asemployees park in designated spaces, there is typically enough spaces.	Parking is gener- ally good, how- ever at peak times customers pay have to use sur- rounding retail for overflow parking.	Parking is tight and at peak times it is likely customers have to wait on spaces.	Inadequate or no designated parking.
Land Use Pattern	Trade area is strong mix of residential, retail and business. Marked by density and high traffic. Compact.	High density and good traffic flows, however, is either retail heavy or residential heavy.	Trade area has strong commuter traffic but is not buoyed by a strong retail cluster. Sprawling.	Trade area is retail destination location. Sometimes termed "On an Island".	Trade area is spread out and not buoyed by a dominant strong traffic path or retail destination
LifeCycle	Trade area is growing quickly. Expectations for considerable amount of popu- lation and retail growth in the immediate area.	Strong trade area. Expectation for modest growth and improving surrounding development.	Mature trade area. Growth has plateaued due to lack of space that constrain further development.	Declining trade area. Demographics are declining and surrounding retail vacancy is increasing.	Trade area is marked with high vacancy of both retail and residential.

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Statistical Analysis of the Relationship between On-Premise Digital Signage and Traffic Safety

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December 17, 2012

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ABBREVIATIONS

The abbreviations shown below are used in this report.

AADT Annual Average Daily Traffic

ADT Average Daily Traffic

AASHTO American Association of State Highway and Transportation Officials

AIC Akaike Information Criterion

ANOVA Analysis of Variance

BIC Bayesian Information Criterion

CEVMS Commercial Electronic Variable Message Signs

CG Control Group

DF Degrees of Freedom
EB Empirical Bayes
EBB Electronic Billboard

FHWA Federal Highway Administration HSIS Highway Safety Information System

HSM Highway Safety Manual
LCD Liquid Crystal Display
LED Light-Emitting Diode
MS Mean of Sum of Squares

MSE Error Mean Square

MST Treatment Mean Square RTM Regression to the Mean

SAR Spatial Autoregressive Model

SEM Spatial Error Model

SFI Signage Foundation, Inc.

SPF Safety Performance Function

SS Sum of Squares

SSE Sum of Squares for Error SST Total Sum of Squares

TTI Texas A&M Transportation Institute

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EXECUTIVE SUMMARY

The use of digital on-premise signs, which are typically business-related signs that have the ability to change the displayed message, has increased significantly in recent years. On-premise digital signs are located on the same property as the businesses they promote, and some part — or a significant part in some cases — of the sign contains a digital display that can be programmed to change the message at pre-set intervals. Because the use of these signs has increased, jurisdictions have used local sign codes or ordinances to regulate the manner in which digital messages are displayed. Jurisdictions typically justify these regulations by citing traffic safety impacts. However, no comprehensive and scientifically based research efforts have evaluated the relationship between on-premise digital signs and traffic safety.

In this study, researchers collected large amounts of sign and crash data in order to conduct a robust statistical analysis of the safety impacts of on-premise digital signs. The statistical tools used the latest safety analysis theory developed for analyzing the impacts of highway safety improvements. The research team acquired the crash data from the Highway Safety Information System, which is a comprehensive database of crash records from several states. One of the advantages of these data is that they also include information about roadway characteristics, such as the number of lanes, speed limit, and other factors. The research team then acquired information about the location of on-premise digital signs from two sign manufacturing companies. Through significant effort by the researchers, these two datasets were merged into a single dataset that represented potential study locations in California, North Carolina, Ohio, and Washington. Of the initial set of over 3,000 possible sites, the research team was able to identify 135 sign locations that could be used for the safety analysis. Potential sites were eliminated from consideration due to any of the following factors:

- The sign location was not on a roadway that was included in the crash dataset; only major roads were represented in the crash data.
- The sign location provided by a sign manufacturing company could not be verified through online digital images of the location.
- Only signs installed in calendar years 2006 or 2007 could be included in order to have adequate amounts of crash data before and after the sign was installed.

The research team then used the empirical Bayes method to perform a before-after statistical analysis of the safety impacts of the on-premise digital signs. In a before-after study, the safety impact of a treatment (in this case, the installation of an on-premise digital sign) is defined by the change in crashes between the periods before and after the treatment was installed. However, simply comparing the crash frequencies (known as a naïve before-after analysis) is not adequate to account for factors such as regression to the mean (a statistical concept that explains why after data can be closer to the mean value than the before data) and to provide a means of controlling for external factors that can also cause a difference in crash frequencies. The empirical Bayes method represents the recommended procedure for evaluating the impacts of safety treatments because it overcomes the deficiencies of the naïve method. The safety impacts are represented by the safety index, which is indicated by the symbol θ . In simple terms, the safety index represents a ratio of safety in the after period compared to safety in the before period, although it is not as

simple as dividing the crashes in the after period by the crashes in the before period. A safety index greater than 1.0 indicates an increase in crashes in the after period, and a value less than 1.0 indicates a reduction in crashes in the after period. However, because of the variability in the crash data, the analysis must have statistical validity. Statistical variability is established by defining the 95 percent confidence interval for the safety index, which is based on factors such as sample size and the variability of the data. If the 95 percent confidence interval includes the value of 1.0, then there is a 95 percent chance that there is no statistically significant change in crashes between the before and after periods.

The results of the statistical analysis are presented in Figure 1. This figure shows that the safety index for all of the states was 1.0 with a 95 percent confidence interval that ranged from 0.93 to 1.07. This indicates that, for the 135 sites included in the analysis, there was no statistically significant change in crashes due to the installation of on-premise digital signs. The same can also be said about the results for each of the four states on an individual basis because the confidence interval for safety index for each state includes 1.0. The larger confidence intervals for some of the states are due to greater variability in the data and/or smaller sample sizes. The researchers also analyzed single-vehicle and multi-vehicle crashes and found the same result of no statistically significant change in crashes. Finally, the researchers performed an analysis of variance for the sign factors of color, size, and type of business and found no statistically significant differences in the mean safety index values for individual factors.

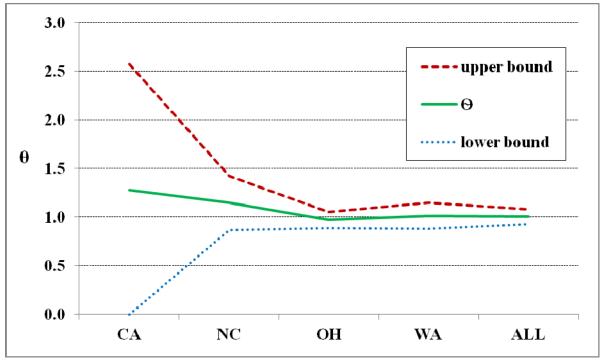


Figure 1. Summary of study results

The results of this study provide scientifically based data that indicate that the installation of digital on-premise signs does not lead to a statistically significant increase in crashes on major roads.

CHAPTER 1: INTRODUCTION

For many generations, most signs — including both traffic and business signs — were static. They displayed only one message that did not change with time. Advances in information display technologies in recent years have led to an increase in the use of many types of digital signs, particularly in the area of on-premise and off-premise business signs. On-premise digital signs provide the ability to communicate a wide variety of messages and to change the manner in which the message is presented over time. As such, these digital signs represent a significant advancement in communication technologies and the ability to deliver valuable marketing information to potential customers. However, some groups have raised questions related to the traffic safety aspects of business signs that change messages on a frequent basis. The traffic safety concerns are often related to issues of potential driver distraction from the roadway due to the dynamic nature of these signs. These safety concerns are sometimes addressed through local regulation of these types of signs, which may prohibit or limit the use of on-premise digital signs. These regulations tend to be developed at the local level and do not have a significant level of scientific, nationally based research supporting the regulations.

The traffic safety concerns associated with on-premise digital signs have existed for some time, but there has been little research, particularly on a national level, that directly addresses the safety impacts of on-premise digital signs. In part, this is due to the fact that the use of such signs has grown only in the last 5–10 years. The research described in this report was conducted to provide a scientifically based, national analysis of on-premise digital signs so that the traffic safety impacts of such signs can be better understood.

RESEARCH APPROACH

The basic research method used in this study is a before-after statistical analysis of the change in traffic crashes at locations where digital signs were installed. The research team used digital sign installation information provided by sign manufacturers to identify locations in selected states where digital signs had been installed in the 2006–2007 time frame (this time frame was selected to provide adequate numbers of crashes in both the before and after periods). The analysis locations were limited to California, North Carolina, Ohio, and Washington because these states are part of the Federal Highway Administration (FHWA) Highway Safety Information System (HSIS). The HSIS is a database of crash records that includes detailed information about the roadway and crashes, including such factors as the number of lanes, the speed limit, crash severity, and other factors. The researchers then mapped the sign sites to the crash datasets to identify locations with crashes. These locations were then analyzed to compare the crashes before installation of the digital sign to the crashes after installation of the sign using statistical analysis procedures.

DESCRIPTION OF A DIGITAL SIGN

For the purposes of this study, a digital sign is defined as a sign that uses an electrical display, such as a liquid crystal display (LCD) or light-emitting diode (LED), to provide changeable

messages or graphics. There are several types of digital signs, including digital billboards, indoor video advertisements, and street-level advertisements (such as LED signs on bus shelters). For this study, the researchers focused only on on-premise digital signs, which are signs located on the same property as the business with which they are associated. The research effort did not include or address off-premise signs or billboards.

RESEARCH ACTIVITIES AND REPORT ORGANIZATION

There were five major activities associated with this research effort. The study began by reviewing and evaluating previous research on the safety aspects of digital signs and the statistical methods that other researchers have used to evaluate the safety aspects of signs. Chapter 2 describes the results of the review of background information. The researchers then began to collect information related to digital signs and crash data in the selected states. The sign information included the location and date of installation, and the crash data included the location and date. The researchers then devoted extensive effort to matching the locations and dates of the signs and crash datasets. Chapter 3 describes the sign and crash data and how the two datasets were merged together. Once this was accomplished, the next step was to develop a valid and scientifically based statistical analysis procedure to determine if there were any statistically significant changes in crashes after installation of digital signs. Chapter 4 describes the development of a statistical methodology, including a comparison of the advantages of the different options for conducting the statistical analysis. Finally, the research team used the results of the statistical analysis to define the key study findings, which are described in Chapter 5. Chapter 6 presents the conclusions and recommendations for the research study.

CHAPTER 2: BACKGROUND INFORMATION

This chapter provides a review of the literature related to on-premise digital signs and their impacts on traffic safety. The review also includes a summary of statistical methods that can be used for evaluating the safety effects for these types of signs. Although the majority of the work has been related to off-premise digital signs, key studies associated with off-premise signs are nonetheless briefly discussed here. It should be pointed out that compared to other types of roadway-related operational and design features, such as access point density on urban arterials or on-street parking designs, the number of documents that are related to either on- or off-premise signs is relatively small.

On-premise signs are signs that are located on the same property as the activity described in the sign, while off-premise signs are located away from the activity identified in the sign. Off-premise signs are also known as third-party signs or outdoor advertising, and the most common example is a billboard. In general, off-premise signs have a larger visible area, which is attributed to the fact that these signs usually have greater surface areas and have higher mounting heights than on-premise signs. Furthermore, off-premise signs have a larger viewership because they are usually located adjacent to freeways and major highways with higher traffic volume. On the other hand, on-premise signs are installed on private property where a company conducts its business, and most are located along urban streets or local roadways. According to *The Signage Sourcebook* (U.S. Small Business Administration, 2003), the viewing opportunities for outdoor advertising (typically 333,350 cars per day) are much greater than those for an on-premise sign (30,000 cars per day).

The literature review is divided into two sections. The first section summarizes studies related to on-premise digital signs. The second section presents the summary of two key studies associated with off-premise digital signs.

ON-PREMISE DIGITAL SIGNS

This section describes the characteristics of the studies that have examined the relationship between safety and on-premise digital signs. To the knowledge of the authors, only two studies have investigated this relationship. It should be pointed out that the safety relationships identified in these research documents were not based on crash data but more on opinions and hypotheses, which limits their value as a direct measure of on-premise sign safety. The first study was conducted by Mace (2001). This author performed a literature review and listed two hypotheses about how on-premise signs can influence crash risk. The first hypothesis states that on-premise business signs distract drivers' attention from their primary driving tasks, resulting in higher crash risks. The second hypothesis asserts that on-premise business signs may mask the visibility of regulatory and warning road signs, which also can negatively influence crash risk.

On the other hand, Mace (2001) noted positive effects associated with commercial signs. He reported that commercial signs could reduce unnecessary traffic exposure by providing adequate navigation information for drivers, such as providing restaurant information for hungry drivers.

However, only measuring the frequency and duration of drivers' distraction may not represent the safety impacts of on-premise signs because a study published earlier showed that half of the objects that drivers see are not related to driving tasks (Hughes and Cole, 1986). In other words, besides on-premise signs, other roadside features may also distract drivers. The possible solution to minimize the negative effects of an on-premise sign, but still keep its positive effects, is to separate the sign's content to primary (navigation) and secondary (commercial) information.

Although, in the past, on-premise signs and off-premise signs were treated as distinct signage, they are becoming more homogeneous in terms of characteristics. In the second study, Wachtel (2009) mentioned that more roadside businesses, especially those with multiple users (e.g., shopping centers, auto malls, sports complexes, and entertainment places), now install larger-sized on-premise digital signs because of the lower cost and better performance of the LED display. Wachtel indicated that the largest digital advertising sign in the world is an on-premise sign in New York City. This sign is 90 ft tall and 65 ft wide, and is mounted on a 165-ft-tall steel post on the roof of the warehouse. The visible distance is over 2 miles. Wachtel also suggested that some on-premise signs affect traffic safety more than some off-premise digital signs because the locations and elevations of on-premise signs might be closer to the road users. In addition, the angles of on-premise signs may be out of the cone of vision and require extreme head movements to read.

In summary, these two studies showed more research is needed for understanding the relationship between on-premise digital signs and crash risk.

OFF-PREMISE DIGITAL SIGNS

This section is divided into two parts. The first part describes two key studies that have examined the safety effects of off-premise digital signs. The second part covers methodologies that have been used for estimating these effects.

Safety Effects

There are two reports that provide reviews of the findings, methods, and key factors related to the safety effects of off-premise digital signs. The first systematic study related to the impacts of off-premise signs was conducted 11 years ago by Farbry et al. (2001). Their study reviewed earlier reports and analyses (including those about electronic billboards and tri-vision signs) and provided the foundation for the second study written by Molino et al. (2009). In the second report, Molino et al. (2009) reviewed 32 related studies, which included those initially reviewed by Farbry et al. (2001), and noted that the majority of studies reported a negative effect between digital billboards and traffic safety. Although the number of studies that showed harmful impacts is five times more than the number of studies that showed no harmful impacts, the authors suggested that this ratio may not be strong evidence to prove the negative effects linked to electronic billboards (EBBs). The individual studies considered by these researchers had very different study methods and statistical powers, which can have a significant effect on the quality and results of the research.

Another important finding in the Molino et al. (2009) report is that drivers usually have spare attention capacities, and they can be distracted from their driving tasks by roadside objects (such as EBBs). However, these distractions may be riskier when the driving demands increase, such as in fixed hazard areas (e.g., intersections, interchanges, and sharp curves), in transient risky conditions (e.g., adverse weather, vehicle path intrusions, and slow traffic), or when other important information is processed at the same time (e.g., an official traffic sign). In other words, not only will the sign's internal characteristics (overall size, legend size, color, contrast, luminance level, etc.) affect crash risk, but so will external environmental factors (type of road, speed, weather conditions, time of day, etc.). Hence, Molino et al. list all possible key factors and suggest further studies to examine how they could influence safety. These factors are categorized into two groups: independent and dependent variables. The independent variables are separated by subject into five subgroups: billboard, roadway, vehicle, driver, and environment. It should be noted that the relationship between EBBs and on-premise signs is discussed in the environment subgroup, and dynamic factors of on-premise signs, such as change rate, motion, video, and sound, are listed as extremely important. The dependent variables are separated into vehicle behavior, driver/vehicle interaction, driver attention/distraction, and crash categories. Since there are hundreds of related key factors, the authors claimed that "No single experiment can provide the solution" and suggested future research programs to address the following topics: (1) determining when distraction caused by commercial electronic variable message signs (CEVMSs) affects safe driving, (2) investigating the relationship between distraction and various CVEMS parameters, and (3) examining the relationship between distraction and safety surrogate measures, such as eye glance and traffic conflicts.

Table 1 summarizes the literature review results from these two reports. This table shows that the results of crash studies are not consistent, and most studies have some important weaknesses, such as neglecting biases related to the regression to the mean (RTM) (discussed below) and site-selection effects (using the naïve method), low statistical power, and analysis results based on erroneous assumptions. It should be noted that only post-hoc crash studies are listed here because this study focuses on the change of crash rate caused by on-premise digital signs.

As mentioned, Table 1 shows that the results related to the safety effects of off-premise signs are inconsistent. The inconsistencies can be fully or partly attributed to various study limitations. For instance, the studies in the Wachtel and Netherton report (1980) and Wisconsin Department of Transportation report (1994) both used a naïve before-after study methodology (methodology approaches are described in Chapter 4), and they did not account for the RTM bias, which may change their estimates of crash rate and safety effects of signs. The general idea of RTM is that when observations are characterized by very high (or low) values in a given time period and for a specific site (or several sites), it is anticipated that observations occurring in a subsequent time period are more likely to regress toward the long-term mean of a site (Hauer and Persaud, 1983). Also, these studies should provide the variance of estimators (that is the uncertainty associated with the estimator) for judging the statistical significance of their results. Moreover, grouping studies where the objectives or types of signs are different is not appropriate. For example, the goal of the report prepared by Tantala and Tantala (2007) was to study the safety impacts caused by converting traditional billboards to digital billboards, while other studies focused on the safety impacts after installation of new digital billboards. Those are two distinct effects that are examined and should not be grouped together to evaluate the safety effects of on-premise digital

signs. Wachtel (2009) also noted other limitations in Tantala and Tantala's study, such as a lack of adequate before-after and comparison group data; no clear definition and reasonable calculation of the visual range and legibility range of EBBs; and no crash data related to adverse weather, impaired drivers, and interchanges.

Table 1. Safety effects of off-premise digital signs

Study	Methods	Data Type	Results	Location	Sample Size
Wachtel and Netherton (1980)	Naïve before- after study	Crash frequency	The crash reduction of target area was 10% less than the overall reduction (after the installation of the signs)	Tele-Spot sign, Boston	Not provided
Wisconsin Department of Transportation (1994)	Naïve before-	Crash frequency,	Crash rate (eastbound): all crashes increased 36%, sideswipe crashes increased 8%, and rear-end crashes increased 21%	Milwaukee,	2
	after study	Average daily traffic (ADT)	Crash rate (westbound): all crashes increased 21%, sideswipe crashes increased 35%, and rear-end crashes increased 35%	Wisconsin	2
Smiley et al.	Before-after study (empirical Bayes)	Crash frequency, ADT, safety performance function	Downtown intersection sites: no significant change in crash rate (all crashes increased 0.6%, injury crashes increased 43%, and rear-end crashes increased 13%)	Toronto, Canada	3
(2005)	Before-after study (control group)	Crash frequency, ADT, control group	Rural sites: no significant change in crash rate based on most compared sites	Toronto, Canada	1
Tantala and Tantala (2007)	Naïve before- after study	Crash frequency,	No significant change in crash rate	Cuyahoga, Ohio	7
Tantala and Tantala (2009)	No description of the method	control group, ADT	No significant change in crash rate	Cuyahoga, Ohio	7

The second shortcoming in Tantala and Tantala (2007) is that they used a simple correlation analysis between sign density and crash rate to examine safety effects of billboards. Using this approach, they found that the correlation coefficients among the scenarios analyzed were very low (around 0.20), indicating that the installation of billboards did not increase the number of crashes. This may well be true, but they did not use the right analysis tool. For investigating the relationship between sign density and the number of crashes, it is more appropriate to develop one or several regression models since the safety analyst can have a better control over other factors that can influence the number and severity of crashes (Lord and Mannering, 2010). In a regression model, several independent variables can be included, which is better to estimate the variable of interest (such as the installation of digital signs). However, it should be pointed out that the before-after study, as performed in this study, still remains the best methodological approach for estimating the safety effects of an intervention.

Among all studies in Table 1, Smiley et al. (2005) provides the more reliable results since they used a before-after method using a control group (CG) and empirical Bayes (EB) approach. The

only limitation is related to the small sample size. The authors of the study only evaluated three sites. Even with a small sample size, the EB method can still be successfully used to evaluate the safety effects of an intervention, as was done by Ye et al. (2011). Ye et al. (2011) used the EB method to estimate the safety impacts of gateway monument signs, which can be categorized as one type of off-premise sign. Gateway monuments are roadside structures used to introduce a city or town. These monuments usually have the name of the city or town and are located at the city limits.

According to Wachtel et al. (2009) and Farbry, (2001), using crash data might not be a precise method because crashes usually have multiple causal events, which are difficult to extract from crash datasets. For example, they noted that sign internal variables (such as size, brightness, viewing angle, etc.) might play main roles in drivers' distraction or ignoring of official traffic signs, while other external factors affect conflicts and crash risk. Although those reasons may be legitimate, utilizing crash data is still the best approach for evaluating the safety effects of interventions as well as those associated with operational and design features (Hauer 1997). As stated by Hauer, "It follows that, in the final account, to preserve the ordinary meaning of words, the concept of safety must be linked to accidents." Furthermore, using crash data have other advantages: lower cost and fewer artificial errors. Firstly, the cost of conducting a before-after crash study is much lower than human-centered methods because the researchers do not need to purchase equipment and hire participants for conducting driving tests. Secondly, crash data are based on crash reports, which can provide a more accurate measure of safety than surrogate measures such as speed, driver behavior, or other measures. Only by conducting a before-after crash study can one provide results that combine multiple casual variables in the real world. Other methods cannot displace the above advantages, which explain why the research team selected the before-after methodology for estimating the safety effects of digital signs.

Characteristics of the Evaluation Methods Used in Previous Studies

This section describes the characteristics of other methods used in previous studies for examining the safety effects of off-premise digital signs. In addition to a crash before-after study approach, the most common study methods that have been used for examining the safety impacts of off-premise signs include eye fixations, traffic conflicts, headways and speeds, and public surveys. Most studies used one or more of the above methods to examine the impacts of off-premise signs (Molino et al., 2009). For instance, Smiley et al. (2005) used four different methods (eye fixation, conflict study, before-after crash study, and public survey) for examining a video sign located in Toronto. On the other hand, Lee et al. (2007) used eye fixations and a questionnaire for their study. It should be noted that the results from multiple measurements are usually inconsistent.

Briefly, the eye fixation study method uses an eye-tracking system to record drivers' eye movements. The results (e.g., eye glances and durations) can provide direct evidence of where drivers are looking while driving, leading to assumptions as to whether drivers are distracted when they are driving near or toward a sign (or at other roadside features). Traffic conflicts, often referred to as surrogate measures of safety, can be used for identifying risky driving behaviors, such as braking without good reason, inappropriate lateral lane displacement, and delays at the start of the green traffic signal phase. Headways and vehicle speed can be used to

assess distracted drivers since those drivers tend to have shorter headways and higher speed variances.

Most details about experiment design, such as the participant number, study site size, driving route length, and experiment duration can be found in Appendix B of the report prepared by Molino et al. (2009). In the current study, the researchers focus the discussion on the before-after crash data study method for two reasons. First, Molino et al. (2009) did not provide a detailed experimental design for using crash data, and some studies were criticized for inappropriate methodology (Tantala and Tantala, 2007; 2009). Second, the costs associated with other experimental methods are significant and are greater than the resources that were allocated for the current research study. According to Molino et al. (2009), the budgetary costs to conduct research using other experimental methods vary between \$0.4 million and \$0.8 million for using on-road instrumented vehicles, \$2 million and \$4 million for conducting a naturalistic driving study, and \$1 million and \$3 million for using an unobtrusive observation approach.

CHAPTER 3: STUDY DATA

To conduct the safety analysis, the research team had to develop plans for collecting the necessary data, manipulating the data into a format that could be used for the safety analyses, and then conducting the statistical analysis to identify the safety impacts of on-premise digital signs. The success of this project relied upon the ability to acquire two distinct sets of data and the robustness of the individual datasets. The two datasets needed for the analysis included (1) information regarding the location and installation dates for on-premise digital signs, and (2) data regarding crash histories on the roadways in the vicinity of the on-premise digital signs. The latter also included information about operational (e.g., traffic flow and speed limit) and geometric (e.g., functional class and lane width) design features located at and adjacent to the onpremise digital signs. From the beginning of the project, the research team expected to use the HSIS crash data for the crash history dataset. The real challenge of this project was identifying specific information about on-premise digital signs for the states represented in the HSIS, and the researchers encountered numerous challenges in acquiring this information. Once the data for both groups were acquired, the researchers had to overcome differences in the datasets so that the data could be merged into a single dataset for analysis. The activities associated with the acquisition of the crash data, acquisition of the sign data, and the merging of the two datasets are described in this chapter.

CRASH DATA

The HSIS is operated and maintained by the FHWA, and is widely used for safety research programs that provide input for public policy decisions. The HSIS is a multistate relational database that contains crash, roadway, and vehicle information. Crash information/files contain basic crash information, such as location (based on reference location or mile-point), time of day, lighting condition (e.g., daylight, dark and no lighting, dark and roadway lighting, etc.), weather conditions, crash severity, the number of related vehicles, and the type of crash (e.g., head-on, right angle, sideswipe, etc.). Each row in the spreadsheet file contains crash information for individual crashes and a unique ID number, and each column represents a variable. The roadway information/files provide traffic and geographic information for each roadway segment, such as annual average daily traffic (AADT), speed limit, beginning mile-point, end mile-point, number of lanes, lane and median width, shoulder width and type, rural or urban designation, and functional classification. The vehicle information/files contain driver and vehicle information, such as a crash identification number, driver gender, driver age, contributing factor (possible casual factor), vehicle type, and others. These individual file types can be linked together as a whole dataset. For example, crash files and road files can be linked by their location information (route number and mileage), or crash files and vehicle files can be linked together by their crash identification number.

Currently, there are seven states that actively participate in the HSIS: California, Illinois, Maine, Minnesota, North Carolina, Ohio, and Washington. However, the HSIS has an upper limit on the amount of data that can be requested by researchers (including the number of states, the request area, and total variables). To maximize the value of the crash data that they could request, the

research team held discussions with the research advisory panel to identify the states (from the list of seven HSIS participating states) where there would be higher concentrations of on-premise digital signs. Based on this input, the research team requested HSIS data for California, North Carolina, Ohio, and Washington in order to get a maximum number of study sites. All crash datasets were downloaded from the HSIS website and stored in a spreadsheet format. The definitions for the variables in a state's crash data were found in the HSIS guidebooks. It should be noted that each state has its own guidebook and data record format. In other words, one specific variable might be available for some states, but this variable may have different meanings or category types, or even be unavailable for other states. The inconsistent definitions among different states' crash datasets can affect the quality of analysis and results when selecting specific variables for identifying target crashes (such as rear-end crash) needed for more advanced analysis. The differences between states also create challenges when trying to merge data into a single dataset for analysis.

Although the HSIS dataset provides the most comprehensive crash data from different states, the HSIS has some limitations. First, the HSIS only includes crashes that occur on major roads, such as interstate highways, U.S. highways, and state highways. The HSIS dataset may not include crash-related data for secondary roads in rural areas or city streets in urban areas, including arterial streets that are major roads in a city but are not on the state highway system. Table 2 identifies the level of crash coverage and roadway length for each state selected for the analysis.

Table 2. HSIS crash coverage and roadway length by state

	Tuble 24 11515 crush coverage una roua way tength by state
California	 More than 500,000 crashes occur each year; HSIS includes about 38% of those crashes. HSIS includes 15,500 miles of mainline (non-ramp) roadways.
North Carolina	 About 230,000 crashes occur each year; HSIS includes 70% of those crashes. Of the 77,000 miles of roadway on the North Carolina state system, approximately 62,000 miles are included in the database.
Ohio	 About 380,000 crashes occur each year; HSIS includes 40% of those crashes. In Ohio, about 116,000 miles of highway in total; HSIS includes approximately 19,500 miles of roadway.
Washington	 1. 130,000 crashes occur each year; HSIS includes 37% of those crashes. 2. HSIS contains 7,000 miles of mainline (non-ramp) roadway.

Another limitation of the HSIS data is that the dataset is not continuously updated. The HSIS data represent the final crash datasets from each state after the state has processed the crash data. As a result, the HSIS dataset may not include the last several months or more of crash data from a state. Currently, the most updated HSIS crash data are through 2009 (California is updated to 2008), so the most recent one or two years of crashes are not included in the HSIS data. Also, the oldest HSIS crash data extend back only through 2004. Limiting crash data to the period from 2004 to 2009 was a significant consideration in this research project because the large growth of on-premise digital signs is relatively recent, having mostly grown since the mid- to late 2000s. The lack of data for the last two to three years created challenges with respect to developing a robust statistical analysis procedure. For a comparison of safety impacts of a treatment (such as installation of a digital sign) to be meaningful, both the before and after analysis periods need to be about equal and as long as possible. This meant that, to have two-year analysis periods (two years before and two years after) in the safety analysis, on-premise digital signs needed to be

installed in either 2006 or 2007. In order to focus the safety analysis on the long-term impacts of on-premise digital signs, the researchers did not include the calendar year of installation of a sign in the analysis. For example, if a sign was installed in 2006, the before period was calendar years 2004 and 2005, and the after period was calendar years 2007 and 2008.

An additional limitation of the HSIS crash data is that the crash location within the HSIS is identified to the nearest 0.1 mile (528 ft) on the roadway. This required the safety analysis to be conducted for the tenth of a mile length of roadway that a sign was located within. The level of accuracy is the primary reason that 0.1 miles was chosen as the effective area of the sign.

The researchers viewed the limitations mentioned above as minor and ones that had minimal impact on the study results. There are no comparable crash datasets available to researchers that could be used for a similar type of analysis of crashes. The only alternative available to the researchers would have been to try and obtain crash data from individual agencies where onpremise digital signs have been installed. Such an approach may have provided more specific data about individual signs and site characteristics, but would have resulted in an extremely small dataset. The researchers felt that such small sample sizes would not provide sufficient robustness for statistical analysis and that the approach using the HSIS data provided greater scientific validity and robustness, as discussed in the previous chapter.

SIGN DATA

With the acquisition of the HSIS data, the research team had information to analyze crashes but had no idea about where to conduct the analysis. Determining the location for the crash analysis required information regarding the location of on-premise digital signs. Furthermore, due to the date limitations of the HSIS data, only sign sites where the sign was installed in 2006 or 2007 could be used for the crash analysis. So the research team began the process of identifying locations in California, North Carolina, Ohio, and Washington where on-premise digital signs had been installed on major roads in 2006 or 2007.

Initial attempts to identify sign locations focused upon getting information from the Signage Foundation, Inc., (SFI) research advisory panel. However, the results did not provide a large enough sample size for a robust statistical analysis. The research team began to contact sign installation companies but encountered challenges in acquiring the large amount of data needed to conduct the research. The primary challenge associated with contacting sign installation companies (which are the same companies that market the signs to individual businesses) was the proprietary nature of the business information the research team was requesting. Another challenge was the large number of individual companies that needed to be contacted to develop a robust sample size.

Because of the challenges of working with sign installation companies, the research team shifted the focus to sign-manufacturing companies. Eventually, the research team was able to work with two electronic sign-manufacturing companies to get a list of on-premise digital signs installed in any of the four study states during 2006 or 2007. Each of the two lists was converted into datasets for use in the research effort. The first dataset (dataset #1) contained 2,953 sign sites and 27 variables, which included the characteristics of signs and roads, such as sign order date, sign

address (road, county, and state), the nearest cross street and its distance from the sign, the nearby cross street with the highest volume and its distance from the subject intersection, and traffic volume on the subject road. The research team did not use the road information from dataset #1, relying instead upon the road data in the HSIS crash dataset. This ensured consistency in the approach with the different sign datasets. Also, the sign installation date was considered to be the sign order date plus two weeks. This assumption was based on input from the signmanufacturing company. Since the entire year that the sign was installed was excluded from the analysis, this was considered not to be a critical issue.

The second dataset (dataset #2) had 63 site addresses and 10 variables. Unlike the first dataset, most variables in dataset #2 were related to product information, such as installation data, sales representative, product name, matrix, color, customer ID (address), and status of signs.

For the analysis, these two datasets were combined as one for use in analyzing the crashes by individual state. The combined dataset was further refined by removing all sign locations that were not installed in either 2006 or 2007. The calendar year that a sign was installed was treated as the construction year, and the crashes that occurred in that year were removed from the analysis. The entire calendar year was removed from the analysis due to uncertainty over the actual installation date of the sign since the data provided only the order date for the sign. Removing the entire calendar year associated with installation also eliminated the novelty effect associated with implementing a new feature. The second variable, the sign installation address, was used to select related crashes by the sign's location and default sign-effective areas. For example, the researchers defined the crashes located within 0.1 miles from the target signs as related crashes. In reality, the effective area could be larger or smaller depending upon the sign size. The procedure used for this analysis did not adjust the effective area based on sign size or other factors. Overall, significant effort was put into ensuring the accuracy of the sign datasets because the quality of the data had a huge impact on the precision and accuracy of the analysis.

DATA-MERGING PROCEDURE

The previous sections explain how the researchers obtained their study data (the sign dataset and the crash dataset) and the characteristics of each dataset. This section gives more details about the dataset-merging procedure. Several steps were involved in merging the crash and sign location datasets into a single dataset that could be used for statistical analysis. The early steps focused on confirming that the digital sign was still in place and near the road that it is related to. This was needed because a site could have an address on one road but have the sign facing traffic on another road bordering the site property. The later steps focused upon converting the street address of the sign location to a route and milepost value that could be used with the crash dataset. This complex effort was necessary due to the fact that the sign and crash datasets used different location methods. The sign dataset was based on the site address, while the crash database was based on route number and milepost. For example, a location in the sign dataset would record a location with "1234 North Highway 101, Anytown, WA 98584," but the HSIS would show the same location as "route number = 23101" and "mile post = 335.72." In order to define the related crashes that were adjusted to the target signs, the researchers needed to transfer sign locations into the HSIS location system. The basic steps are described below and illustrated in Figure 2.

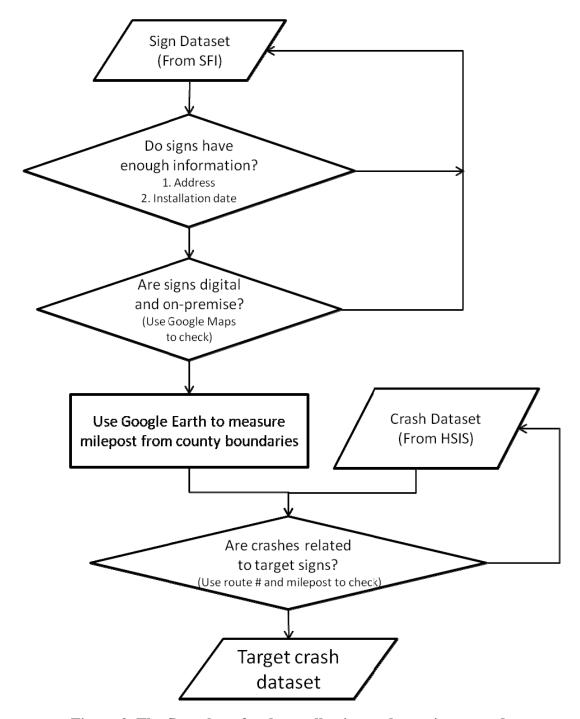


Figure 2. The flow chart for data collection and merging procedure

1. For each record of the combined sign dataset (3,016 total records), the research team evaluated the location information (typically a street address) and the sign order date. Records with missing or incomplete location information or with assumed sign installation dates that were not in 2006 or 2007 were deleted from the dataset.

- 2. Research team members then verified the location of the sign using the site address in the sign dataset and taking the steps listed below. Figure 3 shows an example table that the researchers used for the above data collection, including screenshots of Google Maps and Google Earth (Google Earth, 2008). Columns 1–3 are the address information given by the sign companies. Columns 4–7 are determined through Google Maps, and Columns 8–11 are determined through Google Earth.
 - a. The sign was located in Google Maps using the site address.
 - b. Using the Street View feature of Google Maps, a member of the research team identified the sign on the site or deleted the record with a note that the on-premise digital sign could not be identified. There were some challenges associated with finding digital signs using the Street View pictures from Google Maps, including fuzzy pictures with low resolution, which made it difficult to evaluate some signs, and digital signs that were not obvious during the daytime (Street View provides only daytime pictures).
 - c. The screen image of the subject sign was saved, and basic sign characteristics were identified and/or estimated. Examples include sign color, size, and business type.
 - d. An initial determination was made as to whether the sign was located on a major road that would be part of the HSIS crash dataset. If the road was not expected to be a major road, the record was deleted from the dataset.
- 3. The sign location was entered into Google Earth to determine the county in which the sign was located and the mileage from the county border. This included identifying the county identification code in the appropriate HSIS manual for a given state. This provided the milepost location information needed to relate the sign location to the location information in the crash dataset. Defining the milepost information required doing the following:
 - a. Identifying the neighboring county, which was used to determine in which direction the mileposts were increasing.
 - b. If the county had mileposts restarting at zero at the county borders, determining in which direction they were increasing, based on the number of lanes at the borders. If the direction could not be determined, a general rule of increasing from west to east or south to north was used.
 - c. Using the path tool in Google Earth to measure the distance from the county border to the sign. This distance and the beginning milepost at the county border established the milepost of the sign.

An example (using the above procedure) can be founded in Appendix A. After target sign locations were transferred into the HSIS locating system, a statistics software package, "R," was used to select the related crashes among the whole HSIS dataset.

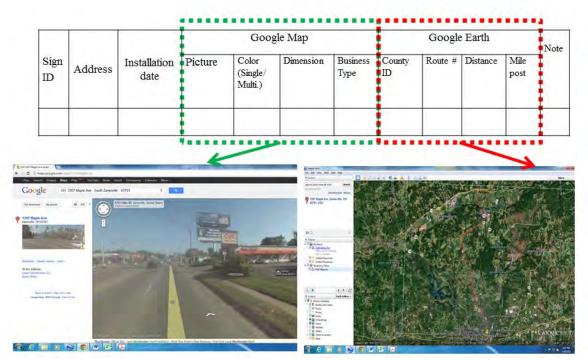


Figure 3. Example work table of site data collection

CHAPTER 4: STUDY METHODOLOGY

Evaluating the effects of treatment on the number and severity of crashes is a very important topic in highway safety. For the last 30 years, various methods have been proposed for evaluating safety treatments (Abbess et al., 1981; Danielsson, 1986; Davis, 2000; Hauer, 1980a; Hauer, 1980b; Hauer et al., 1983; Maher and Mountain, 2009; Miranda-Moreno, 2006; Wright et al., 1988). The methods are classified under two categories: the before-after study and the cross-sectional study. In a before-after study, the safety impacts of an improvement or treatment at a given location are determined by comparing the change in crashes before and after the improvement/treatment was installed. In a cross-sectional study, crashes or crash rates on two different facilities with similar characteristics except for the improvement of interest are compared. The before-after study is typically more desirable because it provides a more direct evaluation of the safety impacts. Although they have been used by some researchers (Noland, 2003; Tarko et al., 1998), cross-sectional studies are more difficult to conduct because different facilities are rarely identical in all features except the one of interest. Hence, the cross-sectional approach was not used in this research. The before-after type of study can be further divided into several types:

- naïve before-after study,
- before-after study with control group,
- before-after study using the EB method, and
- before-after study using the full Bayes approach.

The before-after study using the full Bayes approach is a more recent development in statistical safety analysis, developed and used by several noted safety researchers (Hauer and Persaud, 1983; Hauer et al., 1983; Hauer, 1997; Li et al., 2008; Persaud and Lyon, 2007). The advantages and disadvantages for each of the above before-after methods are described in more detail in this chapter.

A BEFORE-AFTER STUDY AND A CROSS-SECTIONAL STUDY

As mentioned previously, observational crash studies can be grouped into two types: the beforeafter study and the cross-sectional study. The selection of the study type is based on the availability of historical crash data, traffic volume, or the comparison group. The following sections provide details about the before-after methodology.

The Before-After Study

The before-after study is a commonly used method for measuring the safety effects of a single treatment or a combination of treatments in highway safety (Hauer, 1997). Short of a controlled and full randomized study design, this type of study is deemed superior to cross-sectional studies since many attributes linked to the converted sites where the treatment (or change) was implemented remain unchanged. Although not perfect, the before-after study approach offers a

better control for estimating the effects of a treatment. In fact, as the name suggests, it implies that a change actually occurred between the "before" and "after" conditions (Hauer, 2005).

As described by Hauer (1997), the traditional before-after study can be accomplished using two tasks. The first task consists of predicting the expected number of target crashes for a specific entity (i.e., intersection, segment where an on-premise sign was installed, etc.) or series of entities in the after period, had the safety treatment not been implemented. In other words, the before-after approach described by Hauer compares the expected number of crashes in the after period with the treatment installed to the expected number of crashes in the after period had the treatment not been installed. The calculation for each expected number of crashes is based on numerous factors, including the actual number of crashes in the before condition, the actual number of crashes in the after period, and incorporation of site-specific and statistical considerations. The symbol π is used to represent the expected number of crashes in the after period (a summary of all statistical symbols used in this report are presented in Appendix B). The second task consists of estimating the number of target crashes (represented by the symbol λ) for the specific entity in the after period. The estimates of π and λ are $\hat{\pi}$ and $\hat{\lambda}$ (the caret or hat represents the estimate of an unknown value). Here, the term "after" means the time period after the implementation of a treatment; correspondingly, the term "before" refers to the time before the implementation of this treatment (an on-premise digital sign in this study). In most practical cases, either $\hat{\pi}$ or $\hat{\lambda}$ can be applied to a composite series of locations (the sum of i's below) where a similar treatment was implemented at each location.

Hauer (1997) proposed a four-step process for estimating the safety effects of a treatment. The process is described as follows (see also Ye and Lord, 2009):

- Step 1: For i = 1, 2, ..., n, estimate $\lambda(i)$ and $\pi(i)$. Then, compute the summation of the estimated and predicted values for each site i, such that $\hat{\lambda} = \sum \hat{\lambda}(i)$ and $\hat{\pi} = \sum \hat{\pi}(i)$.
- Step 2: For i=1, 2, ..., n, estimate the variance for each, $Var\{\hat{\lambda}(i)\}$ and $Var\{\hat{\pi}(i)\}$. For each single location, it is assumed that observed data (e.g., annual crash counts over a long time frame) are Poisson distributed and $\hat{\lambda}(i)$ can be approximated by the observed value in the before period. On the other hand, the calculation of $Var\{\hat{\pi}(i)\}$ will depend on the statistical methods adopted for the study (e.g., observed data in naïve studies, method of moments, regression models, or EB technique). Assuming that crash data in the before and after periods are mutually independent, then $Var\{\hat{\lambda}\} = \sum Var\{\hat{\lambda}(i)\}$ and $Var\{\hat{\pi}\} = \sum Var\{\hat{\pi}(i)\}$.
- Step 3: Estimate the parameters δ and θ , where $\hat{\delta} = \hat{\pi} \hat{\lambda}$ (again, referring to estimated values) is defined as the reduction (or increase) in the number of target crashes between the predicted and estimated values, and $\hat{\theta} = \hat{\lambda}/\hat{\pi}$ is the ratio between these two values. When θ is less than one, the treatment results in an improvement in traffic safety, and when it is larger than one, the treatment has a negative effect on traffic safety. The term θ has also been referred to in the literature as the index of effectiveness (Persaud et al., 2001). Hauer (1997) suggests that when less than 500 crashes are used in the before-after study, θ should be corrected to remove the bias caused by the small sample size using

the following adjustment factor: $1/[1+Var\{\hat{\pi}\}/\hat{\pi}^2]$. The total number of crashes was over 500, but the adjustment factor had to be applied when subsets of the data, such as single- or multi-vehicle crashes, were analyzed.

• Step 4: Estimate the variances $Var\{\hat{\delta}\}$ and $Var\{\hat{\theta}\}$. These two variances are calculated using the following equations (note: $Var\{\hat{\theta}\}$ is also adjusted for the small sample size):

•
$$Var\{\hat{\delta}\} = Var\{\hat{\lambda}\} + Var\{\hat{\pi}\}$$
 (Eq. 1)

•
$$Var\{\hat{\theta}\} = \frac{\hat{\theta}^2 [(Var\{\hat{\lambda}\}/\hat{\lambda}^2) + (Var\{\hat{\pi}\}/\hat{\pi}^2)]}{[1 + (Var\{\hat{\pi}\}/\hat{\pi}^2)]^2}$$
 (Eq. 2)

The four-step process provides a simple way for conducting before-after studies. Three common before-after methods will be introduced in the following sections. All three methods use the same four-step process.

COMMON METHODS FOR CONDUCTING A BEFORE-AFTER STUDY

Having selected the before-after study approach, the research team then needed to decide which specific before-after method would be the most appropriate for analyzing the safety impacts of on-premise digital signs. This section of the report describes the methodologies and data needs associated with three before-after study types: naïve before-after studies, before-after studies with a CG, and the EB method.

Naïve Method

Among all the before-after methods, the naïve method is the simplest. The estimation of θ is simply equal to the ratio between the number of crashes in the after period and the number of crashes in the before period (which is used to predict the number of crashes in the after period if the treatment was not implemented). Equation 3 illustrates how the index of safety effectiveness is calculated. This method is very straightforward, but it is seldom used in the current safety study because it does not account for the RTM bias. Not including the RTM bias could overestimate the effects of the treatment or underestimate the safety impacts. The naïve method does not account for external factors that occur at the local or regional level, such as changes in weather patterns or economic conditions.

$$\hat{\theta}_{naive} = \frac{\hat{\lambda}}{\hat{\pi}} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij2}^{T}}{\sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij1}^{T}}$$
(Eq. 3)

Where

 $\hat{\theta}_{naive}$ = the estimate of safety effectiveness by using the naïve method,

 $\hat{\pi}$ = the predicted number of crashes for the treatment group in the after period,

 $\hat{\lambda}$ = the estimated number of crashes for the treatment group in the after period,

n =the sample size,

t =the time period,

 N_{ij1}^{T} = the observed response for site i (T = treatment group) and year j (in the before period), and

 N_{ij2}^{T} = the observed response for site i (T = treatment group) and year j (in the after period).

The result can be adjusted when the traffic flow and time interval are different between the before and after periods. It is adjusted by modifying the predicted number of crashes as shown in Equation 4:

$$\pi = r_d r_f \sum_{i=1}^n \sum_{j=1}^t N_{ij1}^T$$
 (Eq. 4)

Where

 r_d = the ratio of the duration between the after and before periods, and

 r_f = the ratio of the traffic flow between the after and before periods.

Control Group Method

The CG method can be used to help control for external factors. The number of crashes collected at the control sites is defined as μ (before) and ν (after). The adjusting factor, the ratio of ν to μ , is used to remove the effects caused by other external factors from π in the theorem. Equation 5 illustrates how to adjust the naïve estimate. It should be pointed out that the RTM could technically be removed if the characteristics of the control group are exactly the same as those of the treatment group. However, getting control group data with the exact same characteristics may not be possible in practice, as discussed in Kuo and Lord (2012). Collecting control group data usually adds extra cost and time compared to the naïve method since more data needs to be collected.

$$\hat{\theta}_{CG} = \frac{\hat{\lambda}}{\hat{\pi} \times \frac{\hat{V}}{\hat{\mu}}} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij2}^{T}}{\sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij1}^{T} \times \sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij1}^{C}}$$
(Eq. 5)

Where

 $\hat{\theta}_{CG}$ = the estimate of safety effectiveness by using the control group method,

 $\hat{\lambda}$ = the estimated number of crashes for the treatment group in the after period,

 $\hat{\pi}$ = the predicted number of crashes for the treatment group in the after period,

 \hat{v} = the estimated number of crashes for the control group in the after period,

 $\hat{\mu}$ = the estimated number of crashes for the control group in the before period,

 N_{ij1}^T , N_{ij1}^C = the observed responses for site i (T = treatment group and C = control group) and year j (in the before period), and

 N_{ij2}^T , N_{ij2}^C = the observed responses for site i (T = treatment group and C = control group) and year j (in the after period).

Empirical Bayes Method

The EB method is recommended in the *Highway Safety Manual* (HSM), published by the American Association of State Highway and Transportation Officials (AASHTO) and approved for use by the FHWA (AASHTO, 2010). The HSM is a recent document that defines standardized procedures for conducting safety analyses of highway safety improvements. The EB method combines short-term observed crash numbers with crash prediction model data in order to get a more accurate estimation of long-term crash mean. The EB method is used to refine the predicted value by combining information from the site under investigation and the information from sites that have the same characteristics, such as range of traffic flow, number of lanes, lane width, etc.

As an illustration, Hauer et al. (2002) use a fictional "Mr. Smith" to illustrate use of the EB method: Mr. Smith is a new driver in a city. He has no crash records during his first year of driving. Based on past crash histories for the city, a new driver in that city has 0.08 accidents per year. Based only on Mr. Smith's record, it is not reasonable to say that he will have zero accidents or have 0.08 accidents for the next year (based on the average of all new drivers but disregarding Smith's accident record). A reasonable estimate should be a mixture of these two values. Therefore, when estimating the safety of a specific road segment, the accident counts for this segment and the typical accident frequency of such roads are used together.

The index of safety effectiveness is illustrated in Equation 6. With the EB method, the analyst first estimates a regression model or safety performance function (SPF) using the data collected with the control group. Then, the model is applied to the sites where the treatment was implemented to get a preliminary predicted value for the after period. The EB method is then used to refine the estimate to account for the RTM bias and the external factors. It is possible for the EB method to be biased if the characteristics of the treatment and control groups are not the same (Lord and Kuo, 2012).

$$\hat{\theta}_{EB} = \frac{\hat{\lambda}}{\hat{\pi}} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij2}^{T}}{\sum_{i=1}^{n} \sum_{j=1}^{t} M_{ij1}^{T}}$$
(Eq. 6)

Where

 $\hat{\theta}_{EB}$ = the estimate of safety effectiveness based on the EB method;

 $\hat{\pi}$ = the predicted number of crashes for the treatment group in the after period;

 $\hat{\lambda}$ = the estimated number of crashes for the treatment group in the after period;

 M_{ij1} = the expected responses for site i for the EB method,

$$\boldsymbol{M}_{ijl} = \boldsymbol{W} \times (\hat{\boldsymbol{\Lambda}}_l) + (1 - \boldsymbol{W}) \times (\sum_{j=1}^t N_{ijl});$$

W =the weight for sites for the EB method, $W = \frac{1}{1 + \hat{\Lambda} \cdot \times \hat{\alpha}}$;

 $\hat{\Lambda}_1$ = the estimate for the average number of crashes of all sites in the before period; and $\hat{\alpha}$ = the estimate of the dispersion parameter.

 $\hat{\Lambda}_1$ and $\hat{\alpha}$ can be estimated using two different approaches (Hauer, 1997). They can be estimated based on a regression model or the method of moment. Both are calculated using data collected as part of the control group. For this research, the average number of crashes and dispersion parameter were estimated using a regression model.

CALCULATION PROCEDURES AND EXAMPLES

The EB before-after method was applied to this study with the regression models or SPFs selected from the HSM (AASHTO, 2010), which includes road types from two to five lanes. As for sites located on wider roads (six lanes and eight lanes, which are not covered in the HSM), the researchers used the SPFs from a Texas A&M Transportation Institute (TTI) study (Bonneson and Pratt, 2009). The number of crashes in each year during the before period (Λ_i) was estimated using the regression model shown in Equation 7:

$$\Lambda_i = \exp(a + bLn(AADT_i) + Ln(L_i))$$
 (Eq. 7)

Where

 Λ_i = the estimator for the average number of crashes per year for site i,

a,b = the coefficients in the regression model,

 $AADT_i$ = the average daily traffic volume for site i,

 L_i = the road length for site i, and

Ln =natural logarithm.

Table 3 shows the regression coefficients (a, b) used in Equation 7 for multi- and single-vehicle crashes.

One of the sign sites in Ohio provides an example of the detailed calculation of $M_{i,EB}$. This site is on an urban 4-lane divided highway segment in Allen County. As shown in Table 3, its intercept is -12.34 for multi-vehicle crashes and -5.05 for single-vehicle crashes, while the coefficients for the AADT are 1.36 and 0.47, respectively. For the analysis used in this report, a multi-vehicle crash is one involving two or more vehicles in the same collision.

Using the EB method, the analysis procedure to get the expected number of crashes in the before period has the following steps:

1. Identify the route number and milepost by the site's address. More specifically, the address of the example site is "1234 ABC St, Name of City, Allen County, OH." Follow the data analysis procedures discussed in Chapter 3 to identify that the route number is 657676309 and the milepost is 7.58.

Table 3. Coefficients for multi and single-vehicle crash regression model

Cua sh Trun s	Dood Too *	Regression C	Coefficients	Diamondian Donomaton (a)
Crash Type	Road Type*	Intercept (a)	AADT (b)	Dispersion Parameter (α)
	2U	-15.22	1.68	0.84
	3T	-12.4	1.41	0.66
Multi- vehicle	4U	-11.63	1.33	1.01
	4D	-12.34	1.36	1.32
	5T	-9.7	1.17	0.81
	2U	-5.47	0.56	0.81
	3T	-5.74	0.54	1.37
Single- vehicle	4U	-7.99	0.81	0.91
vemere	4D	-5.05	0.47	0.86
	5T	-4.82	0.54	0.52

Note: *U = undivided road, T = road with two-way left turn lane, D = divided road.

- 2. Based on the route number and milepost obtained above, use R statistical software to select the related crashes and road files from the HSIS dataset, which includes (1) the observed crashes near the target sign site, (2) the observed crashes in the control group sites (10 sites, which are adjusted to the target sign site on the same road), and (3) the target road file, such as traffic volume, the number of lanes, and median type. For example, the number of observed crashes at the example site is 1 in 2004, and the crash counts of the related 10 control group sites are 0, 0, 1, 1, 0, 0, 0, 0, 1, and 1. The AADT of the site is 19,753 (vehicles/day), and it has four lanes.
- 3. Use Equation 9 to predict the crash number of the example site:

$$\begin{split} \hat{\Lambda}_{2004} &= \exp(a + b(Ln(AADT)) + Ln(L) \\ \hat{\Lambda}_{2004,\text{multi}} &= \exp(-12.34 + 1.36 \times Ln(19753) + Ln(0.2)) = 0.61 \\ \hat{\Lambda}_{2004,\text{single}} &= \exp(-5.05 + 0.47 \times Ln(19753) + Ln(0.2)) = 0.13 \\ \hat{\Lambda}_{2004} &= \hat{\Lambda}_{2004,\text{multi}} + \hat{\Lambda}_{2004,\text{single}} = 0.74 \text{ (crashes/year)} \end{split}$$

The estimated crash counts of the site and its control group sites are 0.74 and 6.64, respectively (the estimated multi-and single crash counts of its control group are 5.36 and 1.28).

4. Due to using the SPFs from the HSM instead of the local SPFs from any existing studies conducted in the same study area, it is necessary to multiply the results by a calibration factor to adjust the prediction value (refer to Appendix A in the HSM for more details). The calibration factor of single-vehicle crashes at the example site in 2004 is 3.13, which is equal to the ratio of observed crashes in the control group divided by the predicted crash number in the control group $(3.13 = (1 \times 4 + 0 \times 6)/1.28)$. By multiplying the above calibration factor, the final crash number estimation for the example site in 2004 should be 0.42 (=0.13×3.13). A calibration factor was calculated for each site and each year included in the study.

5. Repeat steps 3 and 4 to get the final prediction crash number for the example site for each year in the before period. By doing so, the estimated multi- and single-vehicle crash counts of the site in 2005 are 4.65 and 0.21, respectively. Using the summary of this prediction crash number and dispersion parameter (obtained from Table 3) results in the weights (*W*) for this site for the multi- and single-vehicle crashes, which are 0.07 and 0.65, respectively:

$$W = \frac{1}{1 + \hat{\Lambda}_{1} \times \hat{\alpha}}$$

$$W_{multi} = \frac{1}{1 + (5.43 + 4.65) \times 1.32} = \frac{1}{1 + 10.08 \times 1.32} = 0.07,$$

$$W_{\text{single}} = \frac{1}{1 + (0.42 + 0.21) \times 0.86} = \frac{1}{1 + 0.63 \times 0.86} = 0.65$$

6. Because traffic volume and other explanatory variables may change between the before and after periods, the researchers used one factor to account for this difference. The crash counts of the example site in 2007 and 2008 can be estimated by repeating steps 3 and 4. The estimated multi- and single-vehicle crash counts of the site in the after period are 0.84 and 0.67, respectively. Factors are estimated by:

$$r = \hat{\Lambda}_{after} / \hat{\Lambda}_{before}$$

$$r_{i,multi} = (12.76/3) / (10.08/2) = 0.84$$

$$r_{i,single} = (0.63/3) / (0.63/2) = 0.67$$

Also, if the time periods (Y) of the before and after periods are different, one factor is needed to adjusted it. Here, the before and after period are both two years:

$$t_i = Y_{i,after} / Y_{i,before} = 3 / 2 = 1.5$$

7. Using the EB method, the expected total number of crashes that would occur during the after period had the on-premise digital sign not been installed was 2.63:

$$\begin{split} \mathbf{M}_{i,\text{EB}} = & \left[\mathbf{W} \times (\hat{\Lambda}_1) + (1 - \mathbf{W}) \times (\sum_{j=1}^{t} N_{ij1}) \right] \times r_i \times t_i \\ \mathbf{M}_{i,\text{multi,EB}} = & \left[0.07 \times 10.08 + (1 - 0.07) \times 0 \right] \times 0.84 \times 1.5 = 1.14 \\ \mathbf{M}_{i,\text{single,EB}} = & \left[0.65 \times 0.63 + (1 - 0.65) \times 3 \right] \times 0.67 \times 1.5 = 1.49 \\ \mathbf{M}_{i,\text{all FB}} = & 1.14 + 1.49 = 2.63 \end{split}$$

8. The variance of the EB estimate at the example site is calculated by:

$$Var(M_{1,EB}) = (1 - W) \times M_{1,EB} \times r_i \times t_i$$

$$Var(M_{1,multi,EB}) = (1 - 0.07) \times 1.14 \times 0.84 \times 1.5 = 1.31$$

$$Var(M_{1,single,EB}) = (1 - 0.65) \times 1.49 \times 0.67 \times 1.5 = 0.54$$

$$Var(M_{1,all,EB}) = 1.31 + 0.54 = 1.85$$

9. The safety index of the example site is:

$$\hat{\theta}_{EB} = \frac{\hat{\lambda}}{\hat{\pi}} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{t} N_{ij2}^{T}}{\sum_{i=1}^{n} \sum_{j=1}^{t} M_{ij1}^{T}} = \frac{9}{2.63} = 3.43$$

10. The 95 percent confidence interval of the example site is given as.

$$\hat{\theta} \pm Z_{0.25} \sqrt{Var(M_{1,EB})} = \left[3.43 \pm 1.96 \times \sqrt{1.85}\right] = \left[0.76, 6.10\right]$$

The same method was applied to other locations using the appropriate SPFs. The next chapter provides the final results of the completed safety analysis.

CHAPTER 5: RESULTS

The previous chapter explained why the research team chose to use the EB analysis procedure and provided an example of how the EB analysis was conducted. The first section of this chapter provides the results of the before-after study for each state and all the states combined. The second section provides more details about how digital on-premise signs impact traffic safety for multi-vehicle and single-vehicle crashes. The third section provides a description of an analysis of variance of the means of the safety index (θ) among the different sign characteristics such as sign color, sign size, and type of business.

INDIVIDUAL AND COMBINED RESULTS

As described in Chapter 3, the research team acquired the sign dataset from sign manufacturers. However, many signs were excluded from the analysis because of missing information in the dataset provided by the sign manufacturers or limitations in the HSIS crash dataset. The researchers retained only sign sites satisfying the following conditions:

- 1. the sign was located in Washington, North Carolina, Ohio, or California;
- 2. the sign was installed in 2006 or 2007 in order to have adequate time in both the before and after analysis periods to compare crash histories; and
- 3. the sign was located on a major road because the HSIS crash dataset usually does not include crashes that are located on minor roads or private driveways.

Table 4 shows the progression in sample sizes based on sites meeting the conditions identified above. For example, the original dataset for Washington included 413 site addresses that might have an on-premise digital sign. In order to make sure there was an adequate before-after crash data period for further analysis, the researchers had to filter these site addresses. The first filter excluded sites where the sign was not installed in 2006 or 2007, which was needed so that there was adequate time before and after the sign was installed to perform the safety analysis. About 40 percent of the Washington sites (159 sites) met this criterion. Then, the research team used the Street View function in Google Maps to double-check whether a digital sign was present at the given addresses and whether the sign was on a major road since the HSIS crash dataset only included crashes on major roads. Only 33 sites fit this criterion. The result was that in Washington, the research team was able to use about 33 of the 400 original sites, giving an 8.0 percent yield on the raw data.

Chapter 3 mentions that the main advantage of this study is the large sample size of data and advanced statistical methods that provide more accurate results than in similar studies. Figure 4 shows the sample size of this study in relation to other published papers and reports. This study has 135 sites from four states, a number much higher than the sample size of other similar studies. Hence, the results of this study are more robust and accurate.

Table 4. Sign site sample size yield

Number of Sites	California	North Carolina	Ohio	Washington	All States
Included in original list from sign manufacturers	86	249	372	413	1,120
Sign installation time between 2006–2007	27	94	178	159	458
Digital signs & located on major roads	6	40	73	34	153
With HSIS crash data (all crashes)	6	33	63	33	135
Data yield rate	7.0%	13.3%	16.9%	8.0%	12.1%
With HSIS crash data (multiple-vehicle crashes)	6	31	61	33	131
With HSIS crash data (single-vehicle crashes)	6	32	63	33	134

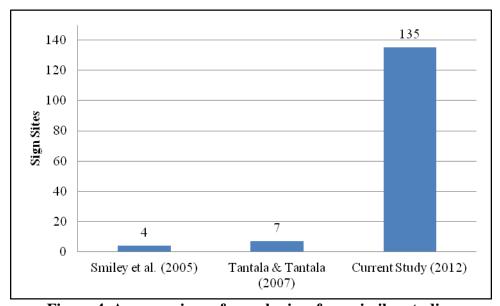


Figure 4. A comparison of sample sizes from similar studies

Table 5 presents the before-after results from the EB and the naïve statistical analysis methods. The naïve method results are provided only for comparison purposes as the naïve analysis method does not provide as meaningful results as the EB method. The results are also presented graphically in Figure 5. A safety effectiveness index (θ) of 1.0 indicates that there was no change in crashes between the before and after conditions. An index greater than 1.00 indicates that there was an increase in crash frequency in the after condition, while a value less than 1.00 indicates a decrease in crash frequency. The upper and lower bounds indicate the limits of statistical significance. If the value for θ is between the upper and lower bounds, then the change in crashes is not statistically significant at a 95 percent confidence level. A larger sample size usually leads to a smaller difference between the upper and lower bounds, but this may not always be the case since it is also governed by the variability observed in the data.

Table 5. Results of statistical analysis of before-after crash condition

C4a4a	EI	od	Naïve Method			
State	Lower Bound	θ	Upper Bound	Lower Bound	θ	Upper Bound
California	0.00	1.25	2.53	0.28	0.85	1.41
North Carolina	0.87	1.14	1.41	0.88	1.13	1.39
Ohio	0.89	0.97	1.05	0.95	1.05	1.15
Washington	0.88	1.01	1.15	0.79	0.90	1.01
All states*	0.93	1.00	1.07	0.93	1.00	1.07

Notes: *"All states" represents the combined data of the four states.

Naïve method values provided for comparison purposes only.

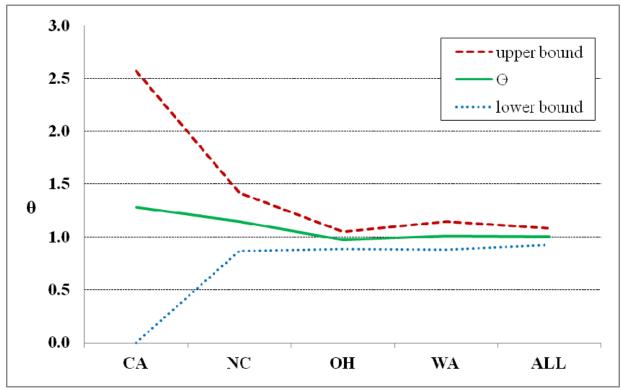


Figure 5. The safety effectiveness index and the 95 percent confidence interval for each state (all crash types)

The overall results show that there is no statistically significant increase in crash frequency after installing the on-premise digital sign because the safety effectiveness index (θ) for the entire dataset (all states) is 1.00, and the 95 percent confidence interval is 0.93–1.07 (which includes the index value of 1.00). The results for individual states are similar: no statistically significant safety impacts were observed after the installation of digital signs. In addition, one can see the width of the 95 percent confidence interval is largest for the California data. This is due to the variability of the California data and the small size of the sample set (only 6 sites). Comparing the width of the confidence intervals, from the widest to narrowest, the order is California > North Carolina > Washington > Ohio > All States.

RESULTS FOR CRASHES RELATED TO MULTIPLE AND SINGLE VEHICLES

The next analysis effort evaluated the possible safety impacts of on-premise digital signs on different types of crashes. There are several common methods to group crashes into different categories, such as the number of related vehicles, the injury levels, the collision types, and so on. Such groupings may provide some insight into the safety impacts of specific crash types, but the estimated impacts might not be precise because of a smaller sample size.

The additional analysis separated crashes into two subgroups: single- and multi-vehicle crashes. All calculations and notations were the same as used previously. By using the EB method to analyze crash data related to multiple vehicles, the researchers determined that the safety effectiveness index is equal to 1.00 for all states, and the 95 percent confidence interval varies between 0.96 and 1.21. Because the confidence interval of the safety effectiveness includes 1.00, there is no statistically significant change in crash frequency after installing the on-premise digital sign. Figure 6 graphically illustrates the results for multi-vehicle crashes. The 95 percent confidence intervals are slightly larger in this figure than in Figure 5.

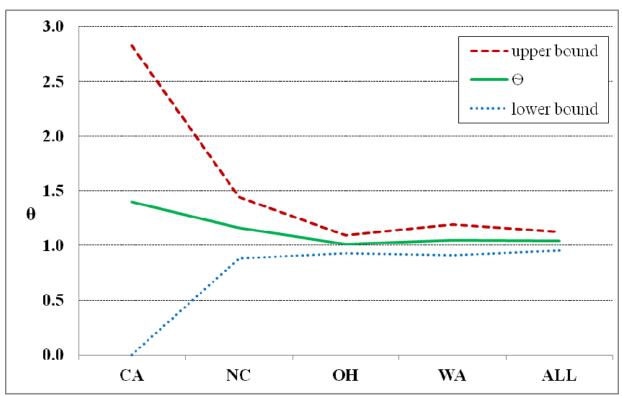


Figure 6. The safety effectiveness index and the 95 percent confidence interval for each state (multi-vehicle crashes)

The results for single-vehicle crashes are presented in Figure 7. The overall results are the similar: there are no statistically significant safety impacts from digital signs, except for California. The California results for single-vehicle crashes indicate a statistically significant decrease in crash frequency in the after period. Although the before-after results of California show a decrease in the after period, it does not affect the overall result because the low sample

size (6 sites) makes it more difficult to establish statistical significance in the analysis results. It is also worth noting that the North Carolina data has the largest confidence interval, due to the variability in the North Carolina single-vehicle crash data.

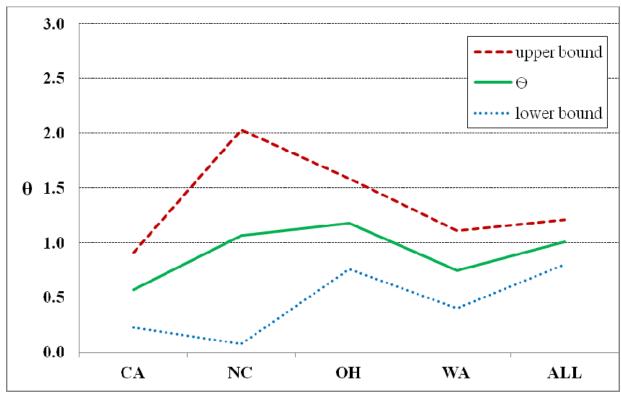


Figure 7. The safety effectiveness index and the 95 percent confidence interval for each state (single-vehicle crashes)

RESULTS FOR CRASHES RELATED TO DIFFERENT TYPES OF SIGNS

The research team also conducted an analysis to investigate the impacts of specific on-premise digital sign characteristics on the safety impacts of those signs. Specific sign characteristics that the research team evaluated included color (single or multi-color), size (small, medium, or large), and type of business. The research team used the analysis of variance (ANOVA) analysis method to evaluate whether the means of the safety index (θ) among the different characteristics of signs are equal.

An ANOVA is one of the most common statistical methods used to compare two or more means in the analysis of experimental data. In short, ANOVA provides a statistical test of whether or not the means of multiple groups are all equal, while a t-test is suitable only for the two-group case because doing multiple two-sample t-tests would increase the risk of a Type I error (for datasets containing more than 30 observations). In addition, when there are only two means to compare, the t-test and the ANOVA are equivalent. As a result, the research team chose the one-way ANOVA as the study tool to simplify the methodology, although some digital sign characteristics, such as sign color, have only two subgroups (i.e., single color and multi-color).

The theory of an ANOVA test is to separate the total variation in the data into a portion due to random error (sum of squares for error [SSE]) and portions due to the treatment (total sum of squares [SST]). Table 6 shows the typical form of a one-way ANOVA table. If the calculated F value (= treatment mean square [MST] / error mean square [MSE]) is significantly larger than F (k-1, N-k), the null hypothesis is rejected. F (k-1, N-k) is the critical value when the means of each group are equal. Most statistic software will also provide the corresponding p-value for researchers making their decisions in different confidence intervals.

Table 6. The typical form of a one-way ANOVA table

Source	SS	DF	MS	F	P(>F)
Treatments	SST	k-1	SST / (k-1)	MST/MSE	
Error	SSE	N-k	SSE / (N-k)		
Total (corrected)	SS	N-1			

es: SS = sum of squares, DF = degrees of freedom, MS = mean of sum of squares, F = F-distribution (because the test statistic is the ratio of two scaled sums of squares, each of which follows a scaled chisquared distribution), P(>F) = the p-value when the F value (= MST/MSE) is larger than F (k-1, N-k), k = number of treatments, and N = total number of cases.

There are three data assumptions for applying the ANOVA method:

- 1. Independence: The study data are independently, identically, and normally distributed.
- 2. Normality: The distributions of the data or the residuals are normal. This assumption is true when the sample size is larger than 30.
- 3. Homogeneity of variability: Equality of variances the variance of data between groups should be the same.

If the above conditions do not exist, the ANOVA results may not be reliable. However, if the sample size of each group is similar, one can usually ignore independence and homogeneity problems. Or statisticians may transform data (such as into the logarithmic form) to satisfy these assumptions of the ANOVA.

Based on the existing sign dataset, the research team focused on three digital sign characteristics: color (single color or multi-color), sign dimension (small, medium, or large), and business type (restaurants, pharmacies and retail stores, hotels, gas stations, auto shops, or others). The definitions of sign dimension level are based on the balance principle (making the sample size of each group equal). Figure 8 shows the distribution of signs as a function of different dimensions, and the research team defined signs with an area less than 10 ft² as small signs. The medium sign size had an area of at least 10 ft² but no more than 15 ft², and the large sign size had an area greater than 15 ft². The sign size represents the area of the electronic display, not the overall size of the complete sign. It was estimated from the Street View image in Google Maps and may not be an accurate assessment of the sign dimensions.

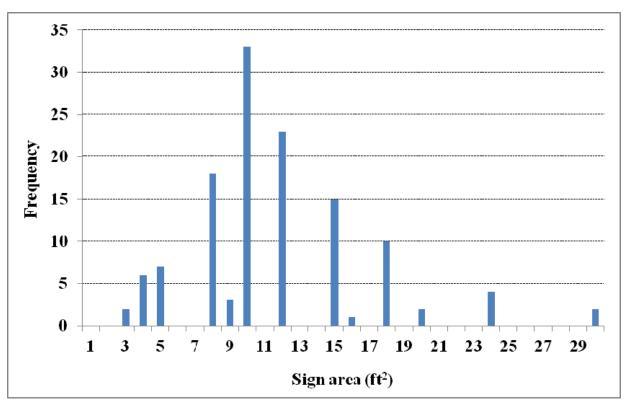


Figure 8. The histogram of digital signs for each sign dimension

Using the ANOVA method to analyze crash data related to specific design characteristics of the sign led to the conclusion that there is no statistically significant difference among the population means of the safety effectiveness index. The following descriptions provide more detail for each of the digital sign characteristics:

• Color: According to images obtained from the Street View feature of Google Maps, 89 signs are single-color signs, and 37 signs are multi-colored signs. Table 7 shows the ANOVA results. The test statistic (F value) is 2.07, and its p-value is 0.1527. Because the probability is larger than the critical value (0.05 for 95 percent confidence interval), the null hypothesis of equal population means cannot be rejected. In other words, the ANOVA table shows no significant difference between the mean of safety index (θ_{EB} = crash mean in the before period/crash mean in the after period) among signs having a single color or multiple colors.

Table 7. Analysis of variance table (color)

	Df	Sum Sq	Mean Sq	F value	Pr (> F)
Group	1	4.464	4.4640	2.0704	0.1527
Residuals	124	267.352	2.1561		

• **Sign dimensions:** In the final sign dataset, 36 signs have a sign area less than 10 ft², 56 signs have a sign area 10–15 ft², and 34 signs have a sign area greater than 15 ft². In Table 8, the F value is 0.7767, and its p-value is 0.4622. Because the probability is larger

than the critical value (0.05 for 95 percent confidence interval), the null hypothesis of equal population means cannot be rejected. Accordingly, researchers conclude that there is no (statistically) significant difference among the population means.

Table 8. Analysis of variance table (sign dimension)

Tuble of Third years of variables table (Sign anneals)									
	Df	Sum Sq	Mean Sq	F value	Pr (> F)				
Group	2	3.39	1.6950	0.7767	0.4622				
Residuals	123	268.43	2.1823						

• **Business type:** In the final sign dataset, 7 signs are for restaurants, 18 for pharmacies and retail stores, 3 for hotels, 3 for gas stations, 7 for auto shops, and 84 for other business types. Based on Table 9, the F value is 0.5401, and its p-value is 0.7455. As with the above types, the null hypothesis of equal population means cannot be rejected because the p-value is much larger than the critical value (0.05). The sample size of some business type groups is less than 30, so the research team combined all categories of business types with less than 20 samples into one large group, the "other" category. The resulting ANOVA analysis (Table 10) provides similar results: there is no significant difference among the population means.

Table 9. Analysis of variance table (six business types)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	5	5.983	1.1966	0.5401	0.7455
Residuals	120	265.833	2.2153		

Table 10. Analysis of variance table (two business types)

	Df		Sum Sq Mean Sq		Pr(>F)	
Group	1	0.728	0.7289	0.333	0.5649	
Residuals	123	271.088	2.18619			

IMPACT OF SIGN HOLD TIME

As an additional effort for this research effort, the research team worked with members of the SFI advisory panel to identify the potential impact of hold time on the relationship between onpremise digital signs and traffic safety. One of the advantages of digital signs is the ability to change the displayed message. The minimum length of time that a message must be displayed is often an element of local sign codes because some believe that frequent changing of sign messages can increase driver distraction and lead to increased crashes. Because the researchers were working with a large number of individual sites and crash records for the after period that spanned two years, it was not possible within the available resources of this project to determine what message(s) were displayed at the time of a crash or the hold time used at a particular site at the time of a crash.

As a surrogate for including hold times as part of the individual site characteristics, the research team acquired information for the hold time regulations in the jurisdictions where the signs were

located. The 135 sign sites were located in 108 jurisdictions. A member of the SFI advisory panel contacted these jurisdictions and was able to identify hold time regulations for 66 of them. The hold time regulations of these 66 jurisdictions are summarized in Table 11. Input from the advisory panel indicated that when a jurisdiction has no statutory language regarding digital sign hold times, it most often means that sign users are able to program their sign to change messages as often as they see fit. In some cases, it could mean that the state standard for digital signs applies, which ranges from 6 to 8 seconds in the four states included in the analysis.

Table 11. Summary of sign hold times

Table 11. Dullillar	y of sign flora times
Minimum Hold Time	Number of Jurisdictions
2–6 seconds	14
7–10 seconds	12
20 seconds	3
1–60 minutes	2
24 hours	2
Variance required*	4
No specific restriction	29
Total	66

^{*} Hold times were established by variance on a case-by-case basis.

CHAPTER 6: SUMMARY AND CONCLUSIONS

While there have been significant amounts of research devoted to the safety impacts of geometric design features and other aspects of the publicly owned transportation infrastructure, the same cannot be said about research on the safety impacts of privately owned signs that are directed to users of public roads. This research effort focused on addressing the safety impacts of onpremise digital signs. Previous research by others has documented the safety effects of on- and off-premise digital signs and their potential influence on crash risk to some extent. However, the results of recent crash studies are not consistent, and most studies have some important weaknesses, such as neglecting biases related to the regression-to-the-mean effects, low statistical power, and analysis results based on erroneous assumptions. In addition, Molino et al. (2009) report that the results from these studies are not comparable because of their different study methods, statistical powers, and cares of execution, which affected the quality of the research.

The research effort described in this report examined the safety impacts of on-premise digital signs using a large sample size of data and advanced statistical methods that provide more accurate results than previous studies. With the help of sign data provided by sign-manufacturing companies and crash data obtained from the Federal Highway Administration Highway Safety Information System, the research team obtained extensive datasets for signs and crashes in four states. The research team began the safety analysis with 1,120 potential study sites, but only 135 sites were usable due to limitations related to the individual signs or the related crash data. Although the yield of usable data was only 11.3 percent, the final sample size of 135 sites was much higher than the sample size of other published papers and reports related to on- and off-premise signs, indicating the results of this research are more robust and accurate.

The research team used the empirical Bayes (EB) statistical analysis method, which is the method recommended in the *Highway Safety Manual*, to conduct the safety analysis described in this report. The *Highway Safety Manual* is a recently published document that is recognized within the transportation profession as the authoritative document for analyzing the safety impacts of various transportation improvements or treatments. The EB analysis procedure uses a before-after approach, with the before and after values modified to address local safety characteristics, regression to the mean, and other factors. The EB method reports the safety impacts through the use of a safety index indicator (represented by θ). A value greater than 1 indicates an increase in crashes, and a value less than 1 indicates a decrease in crashes from the before to the after period. However, for the results to be statistically significant, the θ value must be outside the limits of the 95 percentile confidence interval.

For the entire sample size of 135 sites, the results from the EB method show that there is no statistically significant change in crash frequency associated with installing on-premise digital signs because the safety effectiveness index (θ) is determined to be 1.00, and the 95 percent confidence interval is equal to 0.93 to 1.07 (which includes 1.00, indicating no statistically significant change). The research team also conducted the analysis for each of the four individual states and obtained the same results: there are no statistically significant safety impacts from

installing on-premise digital signs. In addition, the researchers analyzed the safety impacts related to both single- and multi-vehicle crashes. The results for these analyses were also the same: there is no statistically significant increase in crashes associated with the installation of on-premise digital signs. Chapter 5 includes plots that illustrate the safety index values and confidence intervals for all of these results. As a final analysis, the research team performed an ANOVA to evaluate whether the means of the safety index (θ) varied as a function of sign factors (color, size, and type of business). The color analysis evaluated whether there was a difference in the means of the safety index for single- and multi-colored signs, and the results did not find a difference. The size analysis divided the signs in the study into three categories (<10 ft², 10–15 ft², and >15 ft²), and the results did not find a difference. Signs were also categorized by the type of business (restaurants, pharmacies and retail stores, hotels, gas stations, auto shops, and others). Once again, there were no differences in the means. Overall, the ANOVA analysis did not identify any factor that led to an increase or decrease in traffic safety for the subcategories evaluated in the ANOVA.

Based on the analysis performed for this research effort, the authors are able to conclude that there is no statistically significant evidence that the installation of on-premise signs at the locations evaluated in this research led to an increase in crashes.

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APPENDIX A: STEP-BY-STEP INSTRUCTIONS FOR STUDENTS TO RECORD SIGN DATA

- 1. Open one SFI sign dataset (e.g., "Washington_2006-2007.xls"). This dataset includes about 150 signs located in the state of Washington during 2006–2007.
- 2. Input the address information (such as Primary Street Address, City, ZIP Code, County Name, and State) of each sign in Google Maps and use the Street View function to identify the target signs. Please see this link, http://maps.google.com/help/maps/starthere/index.html#streetview&utm_campaign=en&utm_medium=et&utm_source=en-et-na-us-gns-svn&utm_term=gallery, for a demo about how to use the Street View. If you did not find any on-premise digital signs near this site, please make a note in Table 12. Check the characteristics of each sign (including colors, dimensions, and business types) and fill out Table 12. Then, use the "Print Screen" button to copy each sign's picture, and paste it in this document (such as Figure 9). The different business types are classified as (1) Restaurant, (2) Pharmacy and Retail Store, (3) Hotel, (4) Gas Station, (5) Auto Shop, and (6) Other.

Table 12. Example work table of site data collection procedure

				Goo	gle Maps			Goog	le Earth		
Sign ID	Address	Installation Date		Color (Single/ Multi.)	Dimension (Estimated)		County ID	Route #	Distance	Mile- post	Note
79016	19330 N US	2006/9/15	Fig 2	S	$3 \text{ ft} \times 6 \text{ ft}$	6	Mason	101	19.3	335.72	
	HIGHWAY						(23)				
	101 Shelton										
	98584										
	Mason										
	County, WA										

- 3. Then, use Google Earth to determine the county and route number, and to measure the distance between the closet county boundaries and sign location along the route (recorded in the distance column). The corresponding ID for county and route number is based on the HSIS data manual (file name: guidebook_WA[1].pdf). Then, estimate the milepost value of the sign by the distance and the milepost of the route in the boundaries (based on the HSIS road file, such as wa04road.xls). Take Figure 10; for example, the end mile point of Highway 101 in the county boundary is 355.18, and the distance between the sign and the county boundary is 19.3; so, the milepost of our sign is 335.72. Generally, the milepost value increases from south to north and from west to east. However, the best way to check it is to compare the value of the milepost of adjusted counties. For example, the milepost of US 101 in Mason County is 313.96~355.18, and the milepost of US 101 in Thurston County (located south of Mason) is 355.18~365.56. So, it is known that the mileposts increase from north to south in Mason County. The above variables will be used in the R software to select target crashes from HSIS crash datasets.
- 4. Write down any questions or comments in the note column. Feel free to ask us if you have any questions.

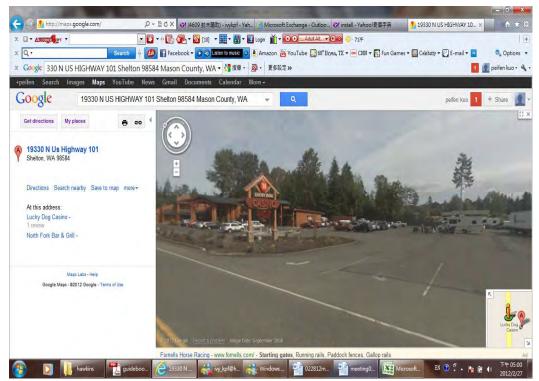


Figure 9. Example screenshot of Google Maps

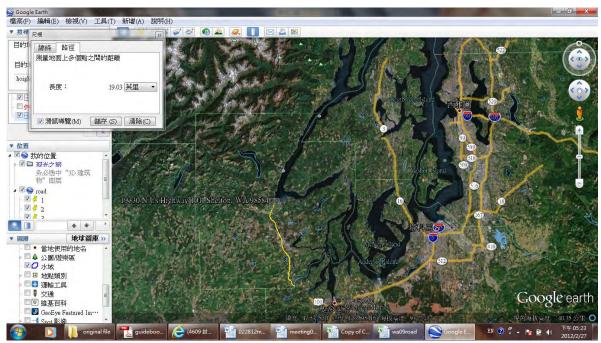


Figure 10. Example screenshot of Google Earth

APPENDIX B: STATISTICAL SYMBOLS

The following statistical symbols are used throughout this report.

 θ = the safety effectiveness, $0 < \theta \le 1$ (can be theoretically higher, but not in this study).

n = the sample size.

 α = the dispersion parameter (of the negative binomial model).

t =the time period.

 $\hat{\theta}_{CS}$ = the estimate of safety effectiveness by using the CS method.

 $\hat{\theta}_{naive}$ = the estimate of safety effectiveness by using the naïve method.

 $\hat{\theta}_{CG}$ = the estimate of safety effectiveness by using the control group method.

 $\hat{\theta}_{EB}$ = the estimate of safety effectiveness by using the EB method.

 $\hat{\lambda}$ = the estimated number of crashes for the treatment group in the after period.

 $\hat{\pi}$ = the estimated number of crashes for the treatment group in the before period.

 \hat{v} = the estimated number of crashes for the control group in the after period.

 $\hat{\mu}$ = the estimated number of crashes for the control group in the before period.

 N_{ij1}^T , N_{ij1}^C = the observed responses for site i (T = treatment group and C = control group) and year j (in the before period).

 N_{ij2}^T , N_{ij2}^C = the observed responses for site i (T = treatment group and C = control group) and year j (in the after period).

 M_{ii1} = the expected responses for site i for the EB method,

$$M_{ij1} = W \times (\hat{\Lambda}_1) + (1 - W) \times (\sum_{j=1}^{t} N_{ij1})$$

W= the weight for sites for the EB method, $W=\frac{1}{1+\hat{\Lambda}_1\times\hat{\alpha}}$.

 $\hat{\Lambda}_1$ = the estimate for the average crash rate of all sites in the before period.

 $\hat{\alpha}$ = the estimate of the dispersion parameter (from the negative binomial model).



AGENDA

Meeting Location: Virtual Meeting (via Zoom)

Phone: 541-682-5481 www.eugene-or.gov/pc

The Eugene Planning Commission welcomes your interest in these agenda items. Feel free to come and go as you please at any of the virtual meetings. For the hearing impaired, FM assistive-listening devices are available, or an interpreter can be provided with 48-hour notice prior to the meeting. Spanish-language interpretation will also be provided with 48-hour notice. To arrange for these services, contact the Planning Division at 541-682-5675.

**Due to Governor Kate Brown's Stay Home, Save Lives Executive Order to combat the spread of Covid-19, this meeting will be held remotely using virtual meeting technology. Information about online or other options for access and participation is available on the reserve side of this agenda. **

TUESDAY, JULY 21, 2020 - REGULAR MEETING (5:30 p.m. to 7:30 p.m.)

A. PUBLIC COMMENT

The Planning Commission reserves 10 minutes at the beginning of this meeting for public comment. The public may comment on any matter, except for items scheduled for public hearing or public hearing items for which the record has already closed. Generally, the time limit for public comment is three minutes; however, the Planning Commission reserves the option to reduce the time allowed each speaker based on the number of people requesting to speak.

B. WORK SESSION: Digital Sign Code Amendment (CA 20-2)

Staff: Mike McKerrow, MMckerrow@eugene-or.gov, 541-682-5288 Jenessa Dragovich, JDragovich@eugene-or.gov, 541-682-8385

C. ITEMS FROM COMMISSION AND STAFF

a. Other Items from Staff

b. Other Items from Commission

c. Learning: How are we doing?

Commissioners: John Barofsky; Ken Beeson; Tiffany Edwards (Chair); Lisa

Fragala (Vice Chair); Dan Isaacson; Chris Ramey; Kristen Taylor

HOW TO ACCESS THE MEETING

- To watch the meeting live (non-participant): Visit https://www.eugene-or.gov/2109/Planning-Commission-Webcasts to view the live webcast or tune in to Local Comcast Chanel 21
- To join/watch the meeting from your computer, tablet or smartphone (allows participation in Public Comment):

https://eugene-or-gov.zoom.us/j/93513516584

- **To join by phone** (allows participation in Public Comment): Dial one of the below numbers and enter the **Webinar ID**: 935-135-16584
 - +1 971 247 1195
 - +1 669 219 2599
 - +1 669 900 6833
 - +1 720 928 9299
 - +1 206 337 9723
 - +1 213 338 8477

For higher quality, dial a number based on your current location.

International numbers available: https://eugene-or-gov.zoom.us/u/acwmw8uOfC

To sign-up to speak for Public Comment:

- For those viewing the meeting on a computer, laptop, or other device, click once on the blue "hand" icon
- o For those listening to the meeting on a phone, press *9 (Star-9)

AGENDA ITEM SUMMARY July 21, 2020

To: Eugene Planning Commission

From: Mike McKerrow, Associate Planner and Jenessa Dragovich, Senior Planner,

Building and Permit Services Division

Subject: Work Session: Digital Sign Code Amendments (City File #CA 20-2)

ACTION REQUESTED

This work session is an opportunity for the Planning Commission to receive an overview of and ask questions about a proposed land use code amendment to modify existing sign standards to allow various digital signs, in advance of the July 28, 2020 public hearing.

BACKGROUND

Eugene's Sign Code (which is part of the Eugene land use code, Chapter 9) was originally adopted in 1968. The last major change to the sign code occurred in the late 1980's and minor amendments were passed in 2001 and 2013. Electronic sign technology has changed significantly in that period and the sign code has not been changed to accommodate the new technology. Digital signs use an electronic display system, such as a light-emitting diode (LED) screen, to deliver multiple messages at a single location. Images are often static and held for a specified amount of time.

Eugene's current sign code prohibits flashing signs and most digital or electronic signs except for electronic message centers, which are limited in size and location. Most existing electronic message centers in Eugene are digital time and temperature displays (three square feet in area and five display characters) except for a few cases where variances were approved to allow larger digital signs.

Eugene has few examples of existing digital signs. They include signs for the Lane County Fairgrounds, the Hult Center, Matthew Knight Arena, and The Shedd which were allowed either as public signs or through sign variances as mentioned above.

Proponents assert several benefits from the technology, including reduced waste compared with traditional copy materials, lower energy consumption, the ability to serve the advertising needs of more businesses, making advertising less expensive for small businesses and non-profits, and allowing for usage by law enforcement agencies to provide public warnings such as Amber Alerts.

Billboard industry representatives contacted City Councilor Chris Pryor to request a

modification to the sign code standards to allow for electronic (digital) billboards. Councilor Pryor polled the council and in response, a work session to discuss the proposal was held on September 18, 2019. The meeting agenda is provided as Attachment A. Please note that the original date of the work session was September 9, 2019; however, due to time constraints, the work session was bumped to the following week. After staff presented information about what would be needed to allow digital signs, the City Council initiated the current code amendment process with the following motion:

MOTION AND VOTE: Move to initiate land use code amendments to allow digital billboards and digital readerboards within the city and to implement changes to the sign regulations identified by staff that are legally required or necessary to clarify the current regulations. The motion passed 4:2, with Councilors Taylor and Semple voting in opposition.

DRAFT LAND USE CODE LANGUAGE

The proposed modifications to the existing sign code are primarily focused on allowing digital billboards as well as limited digital signage for drive-through signs, service stations and institutional uses. The other proposed changes in the draft are clarifications recommended by staff. The draft land use code language is provided in Attachment B and the following is a summary of the proposed changes:

- Provides new definitions for digital billboards, cutouts and digital signs and modifies existing definitions for electronic message centers and flashing signs.
- Provides ability to convert existing billboards into digital billboards when proposed standards are met:
 - Minimum spacing of 1,200 feet (4 blocks) between digital billboards
 - Minimum 10 seconds between messages
 - No video, animations, scrolling, or other similar effects.
 - Auto-dimming to prevent glare, especially at night
- Allows one digital sign (maximum 20 square feet) for each institutional use such as schools, religious institutions and community centers.
- Allows up to six small digital sign components (totaling not more than 20 square feet) for service stations.
- Allows up to two digital signs (maximum 7-foot high and not more than 40 square feet) for each drive-through use.

Eugene's sign code defines a billboard as any sign with a sign face of 200 square feet or greater in surface area. The sign code limits billboards to certain areas in Eugene (such as along portions of Beltline Road, Franklin Boulevard, Coburg Road, 7th and 11th Avenues, and I-105). City Councilors have expressed concern in the past about smaller "billboards" on commercial properties that have non-premise advertising messages (such as the one located at 18th Avenue and Willamette Street).

These are not true billboards (because of their size and location) and can only be approved at locations if they otherwise meet the sign standards. Since sign codes must be content neutral by law, signs standards cannot distinguish between on-premise and off-premise advertising. The proposed code amendments would only allow digital billboards and allow digital signs with a maximum size of 20 square feet for institutional uses. This approach is responsive to Council direction to allow some of the existing "traditional" billboards to be converted to digital billboards without causing a proliferation of digital signage throughout the City.

Today, there are approximately 120 billboards within Eugene's jurisdiction. About 40 percent are on major or minor arterials that are also regulated by Oregon Department of Transportation (ODOT). Nearly 20 percent have legal nonconforming status for at least one billboard standard such as sign area, sign height or proximity to other billboards. Digital sign technology has been operating in Hillsboro, Milwaukee, Salem, Springfield and Medford for some time. Staff researched the digital sign standards for these jurisdictions prior to creating the proposed draft standards. Attachment C includes a summary of that research for reference – the column headings indicate common areas of concern related to digital signs.

PUBLIC OUTREACH

Consistent with Eugene Code requirements, notice of the public hearing was mailed to Springfield, Lane County, and all active Eugene neighborhood groups on June 26, 2020 and a legal ad ran in the Register Guard on July 6, 2020. In addition, staff also notified sign companies that regularly obtain sign permits in the City of Eugene on July 14, 2020. Staff have also met with billboard industry representatives regarding the proposed regulations. The City's Land Use Code Amendments website is updated regularly with information about where we are in the process as well as available resources: https://www.eugene-or.gov/764/Land-Use-Code-Amendments. To date, no written testimony has been received. Any testimony received in advance of the public hearing will be forwarded to the Planning Commission for their consideration.

NEXT STEPS

A public hearing before the Planning Commission regarding the proposed Digital Sign Code Amendments is scheduled for July 28, 2020. Following the public hearing, the Planning Commission will deliberate on the proposed code amendments and provide a recommendation to the City Council. Deliberations are scheduled for August 11, 2020. Planning Commission will make a recommendation to City Council at that time, and then City Council will hold a public hearing on September 21, 2020, with City Council action scheduled for October 12, 2020.

ATTACHMENTS

- A. City Council Work Session Agenda Item Summary, September 9, 2019
- B. Draft Land Use Code Language
- C. Digital Sign Standards Research Summary

FOR MORE INFORMATION

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EUGENE CITY COUNCIL AGENDA ITEM SUMMARY



Work Session: Digital Signs

Meeting Date: September 9, 2019

Department: Planning and Development

www.eugene-or.gov

Agenda Item Number: 3

Staff Contact: Jenessa Dragovich

Contact Telephone Number: 541-682-8385

ISSUE STATEMENT

At this work session, City Council will be provided with an overview of Eugene sign code regulations pertaining to digital signs. This work session is in response to Councilor Pryor's request and was initiated through a poll, provided as Attachment A. This is an informational item and no council action is requested.

BACKGROUND

Eugene's sign code (which is part of the Eugene land use code) was originally adopted in 1968. Minor amendments to the sign code were passed in 2001 and 2013, however, the last major change occurred in the late 1980s. Electronic sign technology has changed significantly in that period. Digital signs use an electronic display system, such as an LED screen, to deliver multiple signs at a single location. Images are often static and held for a specified amount of time; however, the technology is capable of slide presentation effects, including frame transitions, scrolling, animation and videos. With a push to convert traditional billboards to digital, many communities are being asked to allow electronic signage.

At this work session, council will be presented with an overview of:

- Eugene's existing sign code pertaining to digital signs
- Digital sign information
- Common concerns related to digital signs
- Examples of how other communities regulate digital signage

Eugene's current sign code prohibits flashing signs, except electronic message centers (which are considered digital signs). However, because electronic message centers are limited to three square feet in area and five display characters, they are effectively prohibited with the exception of small displays that show time and temperature. A 2007 Land Use Board of Appeals decision affirmed the City's interpretation that LED displays meet the City's definition of electronic message centers and are subject to the size, character and message interval limits prescribed by the sign code. To allow digital signage in Eugene, the sign code would need to be amended to remove prohibitive language and add specific regulations to address common concerns associated with digital signage. Excerpts from the sign code are provided as Attachment B.

There are only a few existing examples of digital signs in Eugene—the Lane County Fairgrounds, the Hult Center, Matthew Knight Arena, and The Shedd. The Eugene land use code generally does not allow digital signs. The examples listed were allowed because two are public signs that are exempt from sign standards and two, Matthew Knight Arena and The Shedd's electronic message centers, received a variance to the sign code standards.

Proponents of digital signage assert several benefits from the technology, including reduced waste compared with traditional copy materials, lower energy consumption, the ability to serve the advertising needs of more businesses, and usage by law enforcement agencies to push public warnings such as Amber alerts.

Concerns over the use of digital signage are primarily focused on driver distraction and visual pollution. Several factors that contribute to these concerns include: flashing effects, moving images, or videos; frequency of image changes; size and location; and brightness/glare.

Digital sign technology has been operating in Portland, Salem, and Springfield for several years. At the work session, staff will provide some examples of how these cities and others regulate such signage.

Allowing digital signs in Eugene would require an amendment to Eugene's land use code. Such changes would require the City Council to initiate the process. The formal adoption process for an amendment to the land use code includes notice to the state and interested parties, a public hearing before the Planning Commission who provides a recommendation to City Council, a public hearing before the City Council, and action by the City Council. In some cases, notice must also be sent to affected property owners. Prior to the formal adoption process, the Building Permit Services Division would engage stakeholders in a public process to identify key issues and possible solutions, and to review draft code language.

In addition to the work session request regarding digital signs, there have been two other questions asked by councilors related to sign standards. One question was about signs that advertise off-premise businesses and whether the City can require that signs be for on-premise, or "proximate" businesses, or limited to businesses located within the city. The City cannot require that signs only advertise proximate businesses or businesses located in the city. Such a requirement would violate the Oregon Constitution because it would prohibit certain speech based on the content of that speech. *See Outdoor Media Dimensions, Inc. v. Department of Transportation*, 340 Or 275 (2006).

The second question is related to mobile advertising signs (e.g., a sign on the flat bed of a truck that is driven around town). The current sign code already prohibits any sign placed on a motor vehicle with the primary purpose of providing a sign not otherwise allowed by the sign standards. See land use code section 9.6615(2) on page 1 of Attachment B.

PREVIOUS COUNCIL DIRECTION

This is the first work session on this topic.

COUNCIL OPTIONS

Informational item. No action requested.

CITY MANAGER'S RECOMMENDATION

No recommended action.

SUGGESTED MOTION

No recommended action.

ATTACHMENTS

A. Work Session Request

B. Eugene Sign Standards Excerpts

FOR MORE INFORMATION

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Digital Sign Amendments Ordinance

Proposed Land Use Code Changes DRAFT – June 9, 2020

Language to be added is shown in **bold italics**. Language to be removed is show by strikeout.

Definitions:

Cutout. A supplemental design element attached to or superimposed upon a billboard.

Digital Billboard. Any billboard that changes messages by any electronic process.

Digital Sign. Any sign with a sign face of 20 or fewer square feet in surface area that changes messages by any electronic process.

Electronic Message Center. A sign, or portion of a sign, that conveys information through a periodic automatic change of message on a lampbank, through the use of fiber optics, or through mechanical means. A sign on which any portion less than an entire sign rotates shall be considered an electronic message center. A sign component that utilizes a computer or other electronic means to change the digital message displayed.

Flashing Sign. A sign or sign structure *that is not a digital billboard, digital sign, or electronic message center,* where some part of the display is provided by light-emitting elements which abruptly change color or intensity of illumination, including intermittent periods of illumination and non-illumination, or where the effect of flashing is achieved through mechanical means, including rotation.

Sign Standards:

9.6610 <u>Exemptions to Sign Standards</u>.

(2) Except as provided in subsection (3) of this section, the following signs are exempt from the requirements of EC 9.6600 through 9.6680, and are exempt from the requirement to obtain a sign permit if they are located on private property outside of vision clearance areas:

* * *

<u>Building Directories</u>. For buildings with multiple tenants, one wall-mounted sign up to 12 square feet in area for the purpose of communicating to persons already on the development site.

* * *

Message Boards *Drive-through Signs*. One sign per business for the purpose of communicating to persons on the development site, such as a drive through menu sign or building directory. Such a sign may be up to 6 feet in height and up to 40 square feet in area.

Two drive-through signs for each drive-through lane. Each drive-through sign may be up to 7 feet in height and up to 40 square feet in area. Drive-through signs may be digital signs if the sign display is static and the copy is not changed more than once per hour, except for a portion of the digital display not to exceed 2 square feet may change copy more frequently.

* * *

Residential Property Signs. Two signs for each development site used primarily for a single family dwelling or duplex. The signs are limited to the following types: freestanding sign or banner. A freestanding sign may not exceed 12 square feet in size per face, with a maximum of two faces; a banner may not exceed 15 square feet in size. The maximum height of a freestanding sign under this exemption is 6 5 feet (from grade), and it must be separated by at least 8 feet from any other freestanding sign on the same development site.

* * *

9.6615 Prohibited Signs. Except where qualified as a nonconforming sign, the following signs are unlawful and are declared to be nuisances:

* * *

- (5) Decorative laser signs, search lights, and flashing signs, except electronic message centers;
- 9.6620 Nonconforming Signs.

* * *

(3) Except as provided in EC 9.6675(7) or Except where only a change in display copy is made, any nonconforming sign which is structurally altered or has illumination installed shall be brought into compliance with all applicable provisions of the sign standards within 90 days and shall thereafter be kept in compliance with the sign standards.

* * *

(5) The provisions of subsection (6) of this section and subsection (2) of EC 9.6635 Approval of Permit Application do not apply to signs in existence pursuant to a validly issued sign permit as of July 1, 1990, along Goodpasture Island Road from a point 300 feet north of the intersection with Valley River Way to a point 1400 feet north of the intersection. The provisions of subsection (2) of this section shall apply except that restoration of a damaged

- sign shall be allowed where a sign is damaged to the extent of 100 percent of its value. All other provisions of this section shall apply.
- (6) All signs with a surface area of 200 square feet or greater shall be removed or brought into compliance with this land use code by April 1, 2003.

9.6630 Permit Application.

(1) An application and related information shall be submitted by the applicant, in a manner prescribed by the city, together with a fee established by the city manager as provided by EC 2.020 <u>City Manager - Authority to Set Fees and Charges</u>. When a person begins construction of a sign requiring a sign permit before the permit is issued, the permit fee shall be doubled. Payment of a double permit fee shall not otherwise exempt the person from liability for other penalties prescribed for a violation of the sign standards.

* * *

9.6635 Approval of Permit Application.

* * *

(8) A decision granting or denying a sign permit may be appealed to a hearings official. Appeals are processed according to other Type II applications beginning at EC 9.7200 General Overview of Type II Application Procedures. The decision of the hearings official is final.

9.6640 General Provisions.

* * *

(4) Location Standards.

(a) <u>Setbacks</u>. All signs shall comply with the setback requirements beginning at EC 9.2000 through EC 9.3980 and EC 9.6745 <u>Setbacks - Intrusions Permitted</u>. Signs may be installed up to 5 feet into the required front yard setback except that freestanding signs up to 5 feet in height in the E-1 zone may be installed at least 5 feet from the front property line.

* * *

<u>Projecting Over the Public *Right-of-*Way</u>. Except as specified in EC 9.6670 <u>Central Commercial Sign Standards</u>, no privately owned sign may project over any public right-of-way.

* * *

(5) Construction Standards.

* * *

(f) Wall Signs. Wall signs shall may project up to a maximum of 12 inches from the wall, except that wall signs shall project no more than 4 inches from the wall when the sign is less than 8 feet above a sidewalk or public way. when the wall sign is more than 8 feet above

grade and a maximum of 4 inches when the wall sign is less than 8 feet above grade.

(6) Illumination Standards.

* * *

(d) Illumination From Signs on Residentially Zoned Property. No internally illuminated sign shall be allowed on property in a residential zone. Lighting from all light sources operated for the purposes of sign illumination on property in a residential zone shall be shielded from other property in the residential zone and shall not be more than 2 foot candles at any point along the boundary of the development site closest street or property line. Externally illuminated signs shall be shielded.

* * *

- (9) Electronic Message Centers. Except electronic message centers operated as public signs by governmental agencies, no electronic message centers are subject to the following limitations:, or
 - (a) Except as provided in subsection (b) of this section, that portion of any sign used as an electronic message center shall be larger than limited to 3 square feet in area, may display-a message containing no more than 5 characters, erand must not change the displayed message at intervals of less than once every 3 seconds. No electronic message center, except for temporary construction use, shall exceed a maximum one-hour equivalent A-weighted sound pressure level of 50 dBa at the receiving property line when the receiving property is occupied by a dwelling, hospital, school, library or assisted care center.
 - (b) Each service station may include up to 6 rectangular digital signs, constructed a minimum of 3 inches from each other, limited to 20 square feet in area cumulatively, and must not change the displayed message at intervals of less than once every 24 hours.
- (10) Digital Signs. One digital sign up to 20 square feet in area is permitted per institutional use on a development site. Digital signs must be located a minimum of 50 feet from the property line of any residentially zoned property.

All digital signs shall be subject to the following standards:

- (a) The change from one message to another message shall be no more frequent than once every 10 seconds.
- (b) The change from one message to another message shall be instantaneous.
- (c) Animation, scrolling or other perceived movement is not allowed.
- (d) The digital sign shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 45 feet perpendicular to the sign face
- (e) The digital sign shall be equipped with a light sensor that automatically adjusts the intensity of the digital display according to the amount of ambient light.

9.6645 Applicability of Sign Standards.

- No sign permit shall be issued for any sign unless specifically identified as an allowed sign use under the terms of the applicable sign standards or otherwise allowed a permit under EC 9.6620 Nonconforming Signs or exempted from the requirement for a permit under EC 9.6610 Exemptions to Sign Standards.
- (2) Except as otherwise specified, signs located on property zoned S Special Zone shall be subject to the provisions of:

- EC 9.6680 Employment and Industrial Sign Standards, if employment or (b) industrial. or
- EC 9.6660 General Commercial Sign Standards-, or (c)
- (d) EC 9.3970(11) if the property is zoned S-WS Walnut Station Special Area Zone.

9.6650 Residential Sign Standards. The residential sign standards are hereby created and applied to all land zoned as set forth below. Signage is limited to preserve the character of the area by allowing signs only for residential purposes and for nonresidential uses allowed in the applicable zone.

- Permitted Sign Types. Signs allowed under residential sign standards are (2) limited to the following types:
 - Awning signs;
 - (b) Digital signs;
 - (bc) Freestanding signs;(ed) Readerboards; and

 - (de) Wall signs.

9.6655 General Office Sign Standards. The general office sign standards are hereby created and applied to all land as set forth below. Signs are regulated to accommodate the office buildings and other public uses that are commonly located within these zones and because of the proximity of residential areas.

- Permitted Sign Types. Signs allowed under general office sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;

- (fg) Under-marquee signs; and
- (gh) Wall signs.

General Commercial Sign Standards. The general commercial sign standards are hereby created and applied to all land as set forth below. Sign limitations reflect the commercial nature of the area and the amount of vehicular traffic.

* * *

- (2) Permitted Sign Types. Signs allowed under these standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Roof signs;
 - (gh) Under-marquee signs; and
 - (hi) Wall signs.

* * *

Shopping Center Sign Standards. The shopping center sign standards are hereby created and applied to all land as set forth below. Sign limitations in these standards accommodate the special commercial character of these areas and the residential areas which are close to most shopping centers.

* * *

- (2) Permitted Sign Types. Signs allowed under the shopping center sign standards shall be limited to the following types:
 - (a) Awning signs:
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Readerboards;
 - (fg) Roof signs;
 - (gh) Under-marquee signs; and
 - (hi) Wall signs.

* * *

9.6670 <u>Central Commercial Sign Standards</u>. The central commercial sign standards are hereby created and applied to all property within the central commercial zones as set forth below. Signs are restricted in recognition of the high density usage of these areas, where pedestrian traffic is heavy and vehicular traffic is commonly limited.

- (2) **Permitted Sign Types.** Signs allowed under the central commercial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Digital signs;
 - (bc) Electronic message centers;
 - (ed) Freestanding signs;
 - (de) Marquee signs;
 - (ef) Projecting signs:
 - (fg) Readerboards;
 - (gh) Roof signs;
 - (hi) Under-marquee signs; and
 - (ij) Wall signs.
- (3) Maximum Number of Signs. The number of signs central commercial sign standards allow shall be limited to no more than 1 electronic message center, freestanding, projecting sign, readerboard, or roof sign per development site street frontage and 1 projecting sign per business occupant. The number of allowed awning, marque, under-marque and wall signs is not limited.

* * *

- **9.6675**Highway Commercial Sign Standards. The highway commercial sign standards are hereby created and applied to all land as set forth below. Signs in this area are regulated to accommodate the mixed uses of the areas and the presence of major streets with high traffic volumes.
 - (1) Corresponding Zones. The provisions of this section apply to that property within the S-RP Riverfront Park Special Zone located within 200 feet of the Franklin Boulevard center line and to property within the C-1, C-2, C-3, or any employment and industrial zone with frontage along the following named streets:
 - (a) Beltline Road from 11th Avenue to Roosevelt Boulevard;
 - (b) Broadway from Mill Street to Franklin Boulevard;
 - (c) Coburg Road from 6th Avenue to 200 feet north of Frontier Drive;
 - (d) Franklin Boulevard east from Broadway, including the north-south segment;
 - (e) Garfield Street from 11th Avenue to 5th Avenue;
 - (f) Goodpasture Island Road from Valley River Drive to 1,700 feet north;
 - (g) Highway 99 North;
 - (h) I-5 **on the south side only** from Henderson Avenue to 300 feet north of Laurel Hill Drive;
 - (i) I-5 on the north side only, from 720 feet east of Henderson Avenue to 1,330 feet east of Henderson Avenue;
 - (ji) I-105 from the Coburg interchange to Scout Access Road;
 - (kj) Mill Street from Broadway to Coburg Road;
 - (lk) Railroad Boulevard;
 - (ml) 6th Avenue east of conjunction with Highway 99 North;
 - (nm) 7th Avenue east of conjunction with Highway 99 North; and
 - (en) 11th Avenue from 200 feet east of the centerline of Chambers Street to Terry Street.

- **(2) Permitted Sign Types.** Signs allowed under the highway commercial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Billboards;
 - (c) Digital Billboards;
 - (d) Digital Signs;
 - (ee) Electronic message centers;
 - (df) Freestanding signs;
 - (eg) Marquee signs;
 - (fh) Projecting signs;
 - (gi) Readerboards:
 - (hj) Roof signs;
 - (ik) Under-marquee signs; and
 - (jl) Wall signs.

- (6) Billboards. Billboards shall be subject to the following standards:
 - (a) Billboards located along the streets named in subsection (1)(b) through (1)(g) and (1)(jk) through 1(ne) of this section shall not exceed 250 square feet in surface area.
 - (b) Billboards located on developed property along streets named in subsection 1(a), and (1)(h) and through (1)(ij) of this section shall not exceed 300 square feet in surface area.

* * *

- (7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:
 - (a) Minimum spacing between digital billboards shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards.
 - (b) The change from one message to another message shall be no more frequent than once every 10 seconds.
 - (c) The change from one message to another message shall be instantaneous.
 - (d) Animation is not allowed.
 - (e) The digital billboard shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 150 feet perpendicular to the sign face.
 - (f) The digital billboard shall be equipped with a light sensor that automatically adjusts the intensity of the billboard according to the amount of ambient light.
 - (g) The digital billboard shall be designed to either freeze the display in one static position, display a full black screen or turn off in the event of a malfunction.
 - (h) Cutouts are not allowed.

- (i) Notwithstanding EC 9.1230, legal nonconforming billboards may be removed and replaced by digital billboards if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet and all other standards in this section must be met.
- (j) Digital billboards are allowed at the locations identified at EC 9.6675(1) except for (b), (e), (f), (j) and (k).
- 9.6680 Employment and Industrial Sign Standards. The employment and industrial sign standards are hereby created and applied to all property zoned for employment and industrial use as set forth below. Signs are regulated to accommodate the minimal street frontage of most parcels and the general proximity to highways and arterial streets.

- (2) **Permitted Sign Types.** Signs allowed under the industrial sign standards shall be limited to the following types:
 - (a) Awning signs;
 - (b) Billboards;
 - (c) Digital Billboards;
 - (d) Digital signs;
 - (ee) Electronic message centers;
 - (df) Freestanding signs;
 - (eg) Marquee signs;
 - (fh) Projecting signs;
 - (gi) Readerboards;
 - (hj) Roof signs;
 - (ik) Under-marquee signs; and
 - (il) Wall signs.

* * *

- (5) Maximum Height. All billboards, freestanding signs and roof signs shall be no more than 30 feet in height except freestanding signsup to 5 feet in height are allowed in the E-1 zone at a minimum of 5 feet from the front property line.
- **(6) Billboards.** Billboards regulated by the employment and industrial sign standards shall be subject to the following:
 - (a) Billboards shall be permitted only along property which abuts the following named streets:
 - 1. Garfield Street north of 5th Avenue to the intersection of Roosevelt Boulevard.
 - Seneca Street north of 11th Avenue to the intersection of Roosevelt Boulevard.
 - 3. Bertelsen Road north of 11th Avenue to the intersection of Roosevelt Boulevard.
 - 4. Obie Street north of 11th Avenue to the end of the street, but no further north than the intersection of Stewart Road.
 - 5. West 11th Avenue from 200 feet east of the centerline of Chambers Street to Terry Street.

- (b) No billboard shall exceed 250 square feet in area.
- (c) Notwithstanding the required connection between perimeter wall size and billboard size established in (4)(b) of this section, a billboard not to exceed 200 square feet may be located on an otherwise vacant lot abutting any street designated in this section.
- (d) The provisions of EC 9.6675(6)(d) to (i) shall apply to all billboards in areas regulated by the employment and industrial sign standards.
- (7) Digital Billboards. In addition to the standards in EC 9.6680(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:
 - (a) Minimum spacing between digital billboards shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards.
 - (b) The change from one message to another message shall be no more frequent than once every 10 seconds.
 - (c) The change from one message to another message shall be instantaneous.
 - (d) Animation is not allowed.
 - (e) The digital billboard shall operate at an internal illumination intensity level of not more than 0.3 foot-candles over ambient light levels as measured from a distance of 150 feet perpendicular to the sign face.
 - (f) The digital billboard shall be equipped with a light sensor that automatically adjusts the intensity of the billboard according to the amount of ambient light.
 - (g) The digital billboard shall be designed to either freeze the display in one static position, display a full black screen or turn off in the event of a malfunction.
 - (h) Cutouts are not allowed.
 - (i) Notwithstanding EC 9.1230, legal nonconforming billboards may be removed and replaced by digital billboards if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet and all other standards in this section must be met.
 - (j) Digital billboards are only allowed at the location described in EC 9.6680(6)(a)5.

Attachment C

Digital Sign Code Amendment Research

Sign Attribute	Animation	Auto Shut Off	Auto- dimming	Brightness	Conversions	Dwell Time	Height	Legal Nonconforming (LNC)	Locations	Max Size	Min Size	Mitigation	Spacing (between billboards)	Transitions	Fuel Prices	Readerboards /EMCs in R-1	Drive-Thru Boards
АРА	Promotes static images	None found	Use photocell for auto dimming	Max .3 foot candles over ambient light (Use FC over nits.)	Strategy of trading in 2 static boards for one digital.	Typ. 6-8 seconds. Use longer so only one message seen	Varies	No draft code found	Usually major arterials	Varies	No examples found	strategy of "trading in" 2-3 static boards for one digital boards	Varies	Max. 2 seconds	no info found	no info found	no info found
Hillsboro	11.32.150 Boards 11.32.230 EMCs No animation except 4 sec. scroll	None	None	8000 nits or equiv. for daylight, 1000 nits or equiv. dusk to dawn	None	8 seconds min.	45' in industrial	Consolodations: 2 under 300 sq. ft. into one less than 700 sq. ft.	Board-Hwy 26 and Tualitin Valley Highway	300 sq. ft. EMCs- 25% or 50%	None	None	Min. 150' from Res. Zoned property	4 seconds max Horizontal or vertical scroll allowed	Allowed by Use	In Res. Use traditional readerboard	Com. 50% ground mounted can be EMC
Medford	10.1700ff Com. No text scrolling. Animated movement allowed	example of glitch 1/2 screen showing	Required to match ambient light at all times	Glare standard	None	5 secs min. Billb. 10 secs EMCs	20' (50' for freeway)	Prohibits Legal Nonconforming conversion to digital sign	Com and Man.	150 sq. ft. Com and 20' height. 250 sq. ft. and 50' height Freeway	None	None	Min. 150' from Res. Zoned property	None	EMC standards	EMC - denied since facing freeway	Max 1, 32 sq. ft., max 6' high
Milwaukee	14.24.020g.2.b. Not Allowed	None	None	14.24.020 Digital signs	None	10	25'	Must comply with existing standards	Major Arterials	250 sq. ft.	None	None	Min. 150' from Res. Zoned property	Max. 2 seconds	Per Electronic Display Standards	In Res. Zones must obtain Sign Adjustment (tough standards)	
ODOT	No motion whatsoever - including scrolling etc. static only	Requirement ability to shut down if awry. Emergency shut off.	No distinction on day/night brightness - enforce if glare issue	foot candles standard to be emailed	None	5 sec. min.	Doesn't regulate. Local jurisdictions	All new must conform with new standards. No wood to steel.		672 sq. ft. (14x48)	None	relocation credits program - remove some static boards to get digital sign	100' if in city limits.	Max. 2 seconds	Meets standards if no video board with movement	Meets standards if no movement.	
Salem	900.090 Elec. displ 900.155 Out. Adver None, static only	None	Yes ***	Max. # of nits day with lesser max. at night.	No provisions	min. 8 seconds Time/Temp min 3 seconds	35'	Has to meet existing standards	Major Arterials where billboards are currenlty allowed	300 sq. ft.	None	None	500'	2 seconds max. (ODOT)			
Springfield	Section 8.260 None	None	None	ODOT	No provisions	5 sec. ODOT	I-5 and I-105=45' to bottom of sign	Has to meet existing standards	I-5 and I-105	672 (14' x 48' max)	200'	None	500'	2 seconds (ODOT)	Treat as static sign. No special standards. If issue will enforce	Treat as static sign. No special standards. If issue will enforce	2 exempt signs per drive-up, each 40 sq. ft., 8' High.
Eugene (Proposed)	None	No regulation recommended	Yes	Max .3 foot candles over ambient light (N1) (Use FC over nits.) ODOT Standard	No provisions	Min. 10 seconds	30' (existing limit) consider exception for exising LNC	Recommend some exceptions vs. a blanket allowance to replace LNC	Major Arterials where billboards are currenlty allowed	Same as for billboards except that LNC reduce to 300 sq. ft.	200 sq. ft.	Not Required	Keep existing (6(f)) limits and 1200' between any two digital billboards (Stanard Arterial block is 400')	Instantaneous	ID by use and select average community standard	ID by use and select average community standard	Allow two per drive through lane

DRAGOVICH Jenessa L

From: DRAGOVICH Jenessa L

Sent: Monday, July 27, 2020 6:09 PM

To: DRAGOVICH Jenessa L **Subject:** RE: Please no electronic signs.

From: Christopher L < ctm_logan@yahoo.com>

Sent: Sunday, July 26, 2020 11:58 AM

To: MCKERROW Mike J < MMcKerrow@eugene-or.gov>

Subject: Please no electronic signs.

Greetings, Mr. McKerrow!

You seem to be the lead staff on this question of allowing commercial exploitation of our visual environment, by huge electronic billboards. Come on, really. Can you even *consider* this intrusive, for-profit ugliness?

First of all, there's way too much advertising already. It's not a matter of alerting consumers to a supposedly worthwhile option. That can be done in newspapers, online, and in small, carefully regulated traditional signs. **There's no social need for electric signs**.

The reason they are employed is the same reason drugs are used in athletics - to give an advantage over competitors. And the same effects are to be expected: then **everyone has to use electric signs or they can't compete**. If you allowed these things, we'd see more and more, and the techniques will become ever more intrusive.

I was an English teacher in Taiwan but brought my family back to Oregon, where I was born, in 2002. We returned to Taiwan a couple of years ago, and I had plenty of opportunity to observe a society awash in electronic billboards. There's a huge open hall for the Taipei Railway Station, and four main pillars holding up the roof. On all for sides of all four pillars, the screens the size of a sheet of plywood, arranged just above eye level, blasted the same commercial message. In order to be sure you couldn't look away, dramatic and colorful images flashed constantly. With no place to rest one's eyes, the effect was quite enervating. There are also electronic commercial messages along the escalators, and if you go out in the street, there are plenty more.

This is **not good for human beings**. We need to rest our eyes, think our own thoughts and pay attention the scenery and the action around us. The "value" of these signs is mostly to the sign *manufacturers*, and to the *larger companies* who can afford this kind of advertising.

Most competitors will be no better off for using electronic billboards, than if they had been prohibited. That is, it's not good for business (as in, general prosperity) because, like weaponry, each side has to top the other in the quest just to remain viable. If electronic billboards are allowed, *they will become necessary for anyone wanting to compete* with those who do use them. That **increases business costs**, working to the advantage of businesses already successful enough to use them.

Also, at a time when energy use is being called into question, you would be adding an **unnecessary use of electricity**. Our electricity is famously produced by hydropower. But we also use **nuclear and coal** (and a wee bit of wind and solar). Any added energy burden, not compensated for by additional clean energy production, means more use of fossil fuels and nuclear. If allowed, these things will become normal, and the culture of influencing consumers with these energy users will significantly raise the amount of non-personal

energy use. I doubt new windmills will be built to accommodate the proposed new trend; they should be built anyway, but this represents a new demand on a system that can only increase energy production by other means.

Think of the way Eugene is advertised to the world: Livability! We're not like Chicago, we're green and beautiful! There's absolutely no question about it, this technology **would degrade the beauty of the**City. Eugene should keep its high standards, even as much of the world caves in to much worse technologies, coming in waves.

Also, they're **distracting to motorists**. They scream "LOOK AT ME!", *up in the air*, when drivers should be looking for pedestrians and bicyclists *down on the ground*. Add this to the many other disadvantages, and I just can't believe you'd even consider allowing these things.

Please prohibit electronic billboards and other similar advertising in the City of Eugene.

Sincerely, Christopher Logan River Road

DRAGOVICH Jenessa L

From: Aaron Noteboom <aaron@noteboomlaw.com>

Sent: Tuesday, July 28, 2020 1:27 PM

To: DRAGOVICH Jenessa L; MCKERROW Mike J

Cc: John Fitzmaurice; Hill, Christie D; Brian Casady; Todd Torrey; Chris Zukin; Mike Reeder; Valencia,

Mary; Hoobler, Rob; Mike Zukin; Rick Smith

Subject: Eugene Sign Code Amendment

Attachments: LTR PLANNING COMMISSION 7.28.2020.pdf

[EXTERNAL ⚠]

Jenessa/Mike,

Would you kindly forward the attached correspondence to the Planning Commission and include a copy in the record in this matter.

Yours truly,

Aaron Noteboom | Attorney at Law

Noteboom Law LLC

375 W 4th Ave, Ste 204 | Eugene, Oregon 97401

Ph: (541) 513-2298 | aaron@noteboomlaw.com

NOTEBOOM LAW LLC

July 28, 2020

Via Email

Eugene Planning Commission c/o: Jenessa Dragovich & Mike McKerrow City of Eugene

Re: Eugene's Sign Code Amendment

Dear Commission:

I represent Meadow Outdoor Advertising ("Meadow"). Meadow has been working with a consortium of Eugene's billboard providers and the City through its stakeholder outreach to update the City's sign code to allow for digital billboards. Overall, the industry believes the City has done a good job at crafting changes to the code to accommodate digital billboards. Meadow has been asked to relay to the Planning Commission the industry's comments and proposed modifications to the draft code language and to provide information responsive to the issues raised by the Planning Commission.

Below are comments addressing the billboard industry's concerns related to the proposed code language namely: allowance for continuation of certain non-conformities, clarifying spacing requirements, digital Ad "dwell" time, adding an ODOT billboard permit requirement, and including a process to ensure even and fair distribution of digital billboards. Also included are brief comments from the industry in response to several issues raised during the planning commission's July 21st work session, namely: on the environmental aspects of digital billboard advertising and comments on the digital institutional signs allowed under the proposed code.

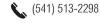
I. DRAFT CODE LANGUAGE.

"9.6620 <u>Nonconforming Signs</u>.

(3) Except as provided in EC 9.6675(7) and EC 9.6680(7) or Except where only a change in display copy is made, any nonconforming sign which is structurally altered or has illumination installed shall be brought into compliance with all applicable provisions of the sign standards within 90 days and shall thereafter be kept in compliance with the sign standards."

See 9.6675

(i) Notwithstanding EC 9.1230, legal nonconforming billboards may be if the location, area and height of the sign do not change and if the building permit is issued within 365 days of the 1st day of demolition. However, no digital billboard shall be larger than 300 square feet



and all other standards in this section must be met.

Issue: Allows for certain non-conformity to continue, but only on a portion of signs identified for conversion to digital.

Recommended Change: Add language allowing for certain non-conformity to remain on signs converted to digital in both: (a) Highway Commercial are (EC 9.6675(7)) <u>and</u> (b) Employment and Industrial signs areas (EC 9.6680(7)). Does not allow for expansion of non-conformity; All new digital billboards would be subject to the 300 sq ft size limitation and 1,200 spacing standards.

"9.6675(7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:

(a) Minimum spacing between digital billboards facing the same direction shall be 1200 feet. The distance between digital billboards shall be measured along the centerline of the street designated to be a location for digital billboards."

<u>Issue</u>: Ambiguity as to how the spacing requirement is intended to apply.

Recommend Change: Add language clarifying spacing limitation applies to signs facing same direction consistent with Staff discussion and industry norm. Apply changes to both EC 9.6675(7) and EC 9.6680(7)).

"9.6675(7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:

(b) The change from one message to another message shall be no more frequent than once every 40 8 seconds."

Issue: 10 second dwell time is "non-standard" within the industry. Creates difficulties in marketing and selling space especially to regional and national advertisers purchasing a campaign based on a standard 8 second dwell. 8 second dwell also creates opportunity for additional messaging including opportunities for non-profits and local government.

Recommended Change: Change to State and national standard of 8 seconds to create uniformity with other markets. Apply changes to both EC 9.6675(7) and EC 9.6680(7)).

"9.6675(7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:

(j) Digital billboards must have a permit from the Oregon Department of Transportation issued pursuant to ORS 377.725are allowed at the locations identified at EC 9.6675(1) except for (b), (e), (f), (j) and (k)."

<u>Issue</u>: Industry agrees with Staff that digital billboards should be located on "major arterials" and not "minor arterials." Difficulty is that proposed language removes portions of major arterials from allowed locations. See attached map.

Recommended Change: Change to allow digital billboards on all portions of major arterials. Add requirement to have state sign permit. Prevents digital on billboards without state permits. Imposes state regulations including state enforcement mechanisms and requirement to obtain electricity from renewable resources where available. Creates consistency with the State and national standards. Apply changes to both EC 9.6675(7) and EC 9.6680(7)).

"9.6675(7) Digital Billboards. In addition to the standards in EC 9.6675(6), Digital Billboards shall be subject to the following standards. Where standards conflict, the standards for Digital Billboards in this subsection (7) shall control:

(k) During the five year period following [enactment date], the City shall approve a permit for a digital billboard at the locations stated in this EC 9.6675(7)(k) notwithstanding any spacing standards which may otherwise prohibit the digital billboard, and the City shall not approve a permit for a digital billboard, other than those listed in this EC 9.6675(7)(k), that would violate any spacing standards with respect to the digital billboard locations identified and allowed herein. Except as specifically provided herein, this provision shall not act to prohibit or restrict digital billboards otherwise allowed by the code. This provision shall not apply to digital billboard permit applications submitted after the expiration of the five year period and will not act as a basis to approve or deny such applications."

E. Broadway North Line 200' W/O Hilyard. East Face
Franklin Blvd North Line 230' E/O Hilyard St. West Face
Coburg Rd West Line 190' N/O Frontier Drive. South Face
Coburg Rd East Line 270' N/O Oakmont. North Face
Coburg Rd East Line 350' S/O MLK. North Face
6th Ave North Line 150' E/O High St. East Face
W. 7th South Line 100' E/O Jefferson. West Face
W 7th North Line 20' W/O Blair Blvd. West Face
Chambers East Line 133' S/O 6th Ave. South Face
W 7th South Line 250' E/O W 5 th . West Face

Issue: Allowance of digital billboard (combined with proposed and existing restrictions) could create fairness/access issues amongst industry. This issue was identified by Commissioner Barofsky during the Planning Commission work session.

Recommended Change: Add language proposed by industry above. Ensures access to market by small (e.g. Torrey), medium (e.g. Meadow) and national (e.g. OUTFRONT, Lamar) billboard companies operating

in Eugene market. Prevents "claim jumping." Prevents permanently "camping" on a site (i.e. not putting to use). Use it or lose it. Believed that all signs exceed the 1,200 ft spacing requirement. Creates distribution of signs throughout market. Gives companies reasonable time to raise capital and development signs.

II. PLANNING COMMISSION COMMENTS.

a. Environmental Benefits.

- Currently, vinyl copy is recycled or repurposed. Allowing digital billboards would go a step further and eliminate the need for vinyl copy altogether for those converted signs. Over the life of a digital billboard, this will result in a significant environmental benefit especially taking into consideration the greater number of advertisers that can be accommodated on a single sign thereby reducing the pressure to frequently change copy on standard signs.
- The digital sign faces are recycled after their useable life.
- Digital signs eliminate vehicle miles driven to change copy. Over the life of a digital sign, this will result in thousands of miles not driven thereby reducing consumption and greenhouse gas emissions.
- It is anticipated that around 10 signs will convert to digital in the initial 5 years following enactment. That equates to a go forward reduction in vehicles miles drive of over 8% for billboards in Eugene (10/120). Similarly, that results in a go forward reduction in vinyl of over 8%.
- State law requires digital billboards to use renewable energy where available.
- LED technology continues to improve and reduce the consumption of electricity. It is in sign industries best interest to reduce energy consumption and thereby reduce associated cost.

b. Advertisement on Digital Signs.

While possible, the industry believes that it is not likely that there would be widespread usage of digital signs for paid commercial advertising by third parties for the following reasons.

- Limitation on changing message once per hour reduces likelihood of selling advertising space.
- Advertising someone else's products to your customer/target market, is less appealing than advertising your own products/message to your own customer.
- 20 sq. ft. limitation makes them an unattractive option for paid advertising space.
- 20 sq. ft. limitation makes them less effective in reaching off-premises persons making them ineffective at reaching large numbers of passersby.
- State law prohibits paid advertisements within 600 ft of highway unless they acquire a state billboard permit. Even then, such signs are only allowed on commercial or industrial zoned property.

- Institutional users are often IRC 501(c)(3) tax exempt non-profits, who risk losing their exemption by engaging in for profit activities including generating unrelated business income from paid commercial advertising.
- Digital billboards will be a more attractive market for paid advertising.

OUTFRONT!

Cc:

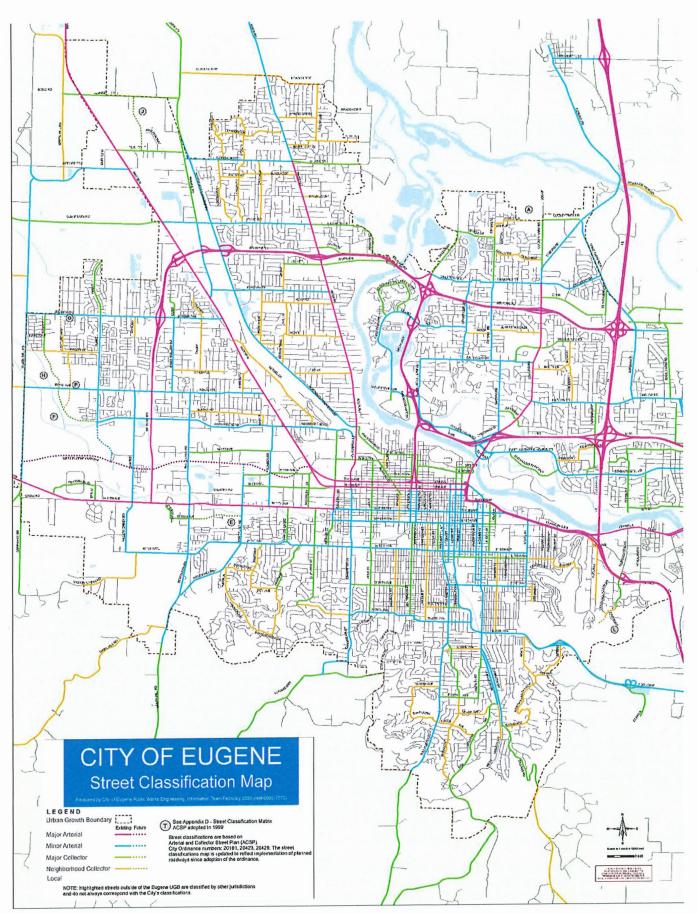
Signees

Yours truly,

/s/ Aaron J. Noteboom

Aaron Noteboom

	O O D O O K AD VERNOUNC
/s/ Christie Hill	/s/ Chris Zukin
Christie Hill	Chris Zukin
(LAMAR)	Torrey Outdoor Advertising, LLC
/s/ Rick Smith	/s/ Todd Torrey
Rick Smith	Todd Torrey
Enclosure	





Memorandum

Date: 8/5/2020

To: Jenessa Dragovich and Mike Mckerrow

From: Logan Telles, Public Works Engineering

Subject: Digital Billboards and Traffic Safety

Overview

At the request of the Planning and Development Department, Public Works has compiled a summary of key research relevant to the regulation of digital billboards in Eugene. The research highlighted in this brief memorandum does not represent the entirety of literature on the subject. The studies listed here do, however, fit in well with a broader field of research that documents concern about the traffic safety impacts of digital billboards. This memorandum also discusses the possibility of piloting digital billboards in Eugene prior to wider-scale installation. This document goes on to list roadway characteristics that may be of interest in developing digital billboard regulations and discusses the subject of cycle length briefly.

Research Summaries

Crash Studies

Definitively determining causality of a crash can be challenging, however, crash study research around digital billboards aims to identify increases, decreases, or consistencies in the occurrence of documented crashes that may be correlated with the installation of digital billboards. Some key research within this area includes:

Nation Center for Transportation Systems Productivity and Management: The United States Department of Transportation (USDOT) funded research into the effect of digital billboards on traffic safety with several university based research teams. It is important to note that the contents of the report reflect the conclusions of its authors and do not represent a formal position from USDOT on digital billboards. Some key findings from the consolidated report include:

The Safety Assessment of Digital Billboards in Florida: The USDOT consolidated report includes findings from a crash study out of Florida (see Chapter 3) that compared crash data at several digital billboard sites to control sites with similar roadway conditions. Researchers concentrated on high speed, low access facilities and found that, "it can be concluded that the difference in the crash rates between DBB influence areas and control sites in Florida varies

from site to site but overall there is a 25% increase (approximately) in crash rates in DBB influence areas". The study also found that fixed-object, sideswipe, and rear-end collisions were overrepresented in digital billboard influenced areas compared to control sites.

The Safety Assessment of Digital Billboards in Alabama: The USDOT consolidated report also includes crash study findings from researchers using a similar methodology in Alabama (see Chapter 4). The Alabama research team found that, "the presence of digital billboards increased the overall crash rates in areas of billboard influence compared to control areas downstream of the digital billboard locations by 29% in Alabama". Like the Florida research team, they found an overrepresentation of sideswipe collisions and rear end crashes. The sample size of severe crashes was too small to make conclusive determinations, but the research team stated that they believed there may be a relationship between crash severity and digital billboard influence for further exploration.

Eye-Tracking Studies

Eye-tracking studies take a different approach to identifying the impact of digital billboards on traffic safety. Research teams using this method seek to identify changes in driver behavior through direct observation, opposed to changes in documented crash history. To accomplish this, researchers use eye-tracking cameras that identify the number and duration of off-road glances a driver makes. Once fitted with the appropriate equipment, driver participants in eye-tracking studies are directed to takes routes past existing (and sometimes temporary) digital billboard installations. Some key research within this area includes:

Swedish National Road and Transport Research Institute: This 2012 study based in Stockholm observed the eye movement behavior of 41 drivers at four locations with digital billboard installations. These digital billboards did not include video and changed messages every seventh second (resulting in two to three messages as drivers passed). The drivers were not informed that digital billboards were the subject of the study until after the 40 minute drive was completed. The research team concluded that, "drivers had a significantly longer dwell time, a greater number of fixations and longer maximum fixation duration when driving past an electronic billboard". This means that drivers were observed spending more total time looking away from the road (across one or more glance), taking more glances away from the roadway and taking longer glances away from the road when passing a digital billboard. The study declined to take a formal position on whether digital billboards should be considered a traffic safety hazard by roadway authorities.

Simulator Studies

Simulator studies take yet another approach to evaluating the safety of billboards. While the body of literature around this method hasn't focused in on digital billboards specifically, multiple research teams have used computer simulated scenarios to demonstrate that there is an observable reduction in driver reaction time when presented with a traffic scene that includes billboard messaging. Some key research within this area includes:

Monash University Accident Research Center: This 2011 study based in Australia used computer simulation to measure differences in reaction time when inexperienced and elderly drivers were confronted with transportation environments that include billboards. These demographics were chosen due to the role age and experience can play in limiting reaction time. The researchers found that, "billboards can automatically attract attention when drivers are engaged in other tasks, delaying their responses to other aspects of the environment". Moreso the team's research indicates that, "the effect of billboards was particularly strong in scenes where response times are already lengthened by high levels of built or designed clutter". In this context, the term built clutter refers to, "factors such as shopfronts along the road and high buildings on each side", and the term designed clutter, "refers to the number of road signs and markings". Conversely, "in the low clutter scenes, billboards did not impair response times" in the context of this study.

Regulatory Options

Pilot Study

Selecting pilot locations to evaluate the effect of digital billboards on traffic safety in Eugene may be a preferable alternative to introducing the new installations at a city-wide scale. Based on available research and the professional opinions of transportation staff, the selection of a roadway with low-access density and low active transportation volumes was identified as preferable. HWY 99 was identified as the most likely candidate location for a prospective pilot evaluation. Furthermore, selecting locations along HWY 99 that are offset from onramps and other merge points by 300 to 500 feet would be ideal. Given research findings on rear end and sideswipe collisions in digital billboard influenced areas, transportation staff would also like to select locations without a prevalent history of these types of collisions. Locations with a documented history of sever and fatal injuries should also be avoided in the selection of a study area. Transportation staff are available to conduct further analysis to identify specific locations along HWY 99 that meet this criteria. To provide comparison data an "upstream" portion of HWY 99 should be left without digital billboard installation during the duration of the prospective pilot.

Location Restriction

Based on available research and the professional opinions of transportation staff, there is particular concern around the effect digital billboards will have in denser urban areas. Urban areas with high bicycle volumes, high pedestrian volumes, access density, busy intersections, and on-ramps/off-ramps already have high attention demand for drivers.

The potential impact of digital billboards on driver attention and reaction time in these environments may warrant restricting the installment of digital billboards in areas with:

- Moderate to high pedestrian activity and demand
- Moderate to high bicycle activity and demand
- High density of residential and commercial driveways
- Areas with existing transportation equity concerns
- Corridors that have been identified as high crash streets in the Vision Zero Action Plan Furthermore, offset requirements of 300 to 500 feet may be appropriate for:
 - High volume intersections
 - Intersections identified as high crash intersections in the City's Vision Zero Action Plan
 - Existing mid-block pedestrian crossings

- Freeway and highway on-ramps and off-ramps
- Lane merge points

Public Works staff is available to assist in identifying locations that meet this criteria.

Cycle Length

Based on the available information, transportation staff believe that longer cycle lengths are safer than shorter cycle lengths. Digital billboards with longer cycle durations present fewer messages as a driver advances through the area, theoretically prompting fewer glances away from the road. Less frequent image change on a digital billboard also means less activity in the driver's peripheral vision. While Public Works was unable to identify research comparing the safety of different cycle lengths, transportation staff would encourage PDD to consider cycle length requirements longer than the 8-10 second billboard industry standard.

Further Conversation

Public Works Engineering staff is available and happy to discuss research, regulation, and the idea of piloting implementation of digital billboard installations in greater detail.

NOTEBOOM LAW LLC

August 18, 2020

Via Email

Eugene Planning Commission c/o Mike McKerrow City of Eugene

Re: Response to Public Work's Memorandum dated August 5, 2020

Dear Planning Commission:

I represent Meadow Outdoor Advertising. We have reviewed Public Work's memorandum and do not see a need for any change to the currently proposed sign code amendments. The studies cited and relied on by Public Works staff do not address the issue of whether the conversion of an existing billboard to a digital billboard results in an increased safety risk. This letter if offered to provide additional research in order to provide a more complete and comprehensive review of research related to digital billboards and potential impacts on traffic safety. While the studies cited by Public Works do not address the question at hand (conversion of static to digital), there are, however, studies that have looked at this issue. Those studies have concluded that conversion has not been shown to result in increased safety risk. Those studies are attached and discussed below. Moreover, a pilot program is not needed to confirm the safety of digital billboards in light of their proven safety track record in Eugene covering many years and over one hundred million vehicle trips. Additionally, we have reviewed the area along Mill/Broadway/Franklin Blvd (currently proposed for exclusion from conversion) and as discussed below, do not see any added safety issues that would arise from converting existing static billboards to digital warranting their prohibition in this area. Finally, we would like to clarify that the industry is not asking to be able to build new billboards where they are not already permitted under the existing code (i.e. no expansion/proliferation). Rather, the industry is requesting to be able to convert existing billboards for those areas identified in the draft code amendments to include the three small segments of major arterials that were inadvertently omitted by staff (the "fuchsia area"). For ease of reference and comparison we have used the headings contained in Public Work's memorandum in the order provided therein.

1. Response to Public Works Memorandum

a. "Crash Studies"

The Public Work's memorandum correctly notes that, "Definitely determining causality of a crash can be challenging." The memorandum cites a project by that summarized two related studies of digital billboards in Florida and Alabama. The studies use historic traffic data comparing selected digital billboard sites versus alternate nearby "control" sites without any billboards and purported to

find a correlation between digital billboards and an increase in traffic accidents at digital billboard sites. However, the study notes that the findings are finally inconclusive partly because of the small sample size and especially because "individual site data showed mixed results with crash rates decreases (sic) at half the study locations." (p.43). In fact, for the Alabama study, 4 of the 8 digital billboard sites saw fewer accidents than at the "control sites" (p. 41) and in Florida seven 7 of the 10 digital billboard sites saw fewer traffic accidents than the control sites. (p. 29) The findings of the study purporting to correlate an overall increase in traffic accidents at the site of digital billboards may be accounted for by the fact that at some of the locations either the traffic volume at the digital billboard sites was higher or the study area was larger than at the control sites in both the Alabama and Florida studies, indicating a greater likelihood of potential crashes simply because there was higher traffic volume or larger study area at the digital billboard than at the "control site". Critics of the study note that the actual cause of the crashes (e.g. drunk driving, texting, weather, traffic jam, etc.) at the sites were not analyzed and no adjustments were made to account for differing road conditions, suggesting that any purported correlation between the digital billboards and increased incidences of accidents may have been further overstated. If the purported correlation between digital billboards and increase crash rates were in all cases true, then one would have logically expected to see increased crash rates at all 10 of the 10 sites studied in Florida and all 8 of the 8 cites studied in Alabama. That did not happen. Instead 70% of the digital sites in Florida proved to have lower crash rates and 50% of the digital sites in Alabama had lower crash rates than comparable areas without digital billboards. Unfortunately, the cited studies do not explain the discrepancy between their collected data and purported finding of correlation calling into question the completeness of the studies and their findings.

A study conducted in 2009-2010 in association with Massachusetts DOT as a pilot study for safety in the vicinity of digital billboards along state routes in Massachusetts found there was a decrease in accidents at some digital billboard sites and an increase at other sites. MassDOT published a memorandum at the end of the study stating, "the Traffic Safety Engineering Section believes the Digital Advertising Board pilot program was successful and did not create an adverse safety condition on Massachusetts Highways." These findings, that digital billboards do not create adverse safety conditions, are reflected in multiple studies conducted between 2007 and 2010 by a transportation consulting firm engaged by a national advertising company in New Mexico, Ohio, Pennsylvania, Virginia and Minnesota. (See attached studies) These studies looked at sites where digital billboards had been installed and analyzed between 5 and 8 years of historic crash data from before and after the installation/conversion of digital billboards. The findings at each site, while varying in specifics, found "no statistically significant increase in accident rates" near digital billboards and, the studies note, in some cases there is a decrease in the accident rates recorded at some digital billboard sites.

b. "Eye Tracking Study"

The Public Works' memorandum cites a Swedish study that, according to the memorandum, found that, "drivers had a significantly longer dwell time, a greater number of fixations and longer maximum fixation duration when driving past electronic billboards" though the study "declined to take a formal position on whether digital billboards should be considered a traffic safety hazard by roadway authorities." A Consumer Usage Laboratories' review of the study found, "[the authors] present no evidence that the electronic signs compel viewing. In fact their data are more readily interpreted to show, as they point out, that the signs can actually be ignored, whether purposefully or because they were not looked at for other

reasons associated with controlling a vehicle on a highway with other vehicles close by." The review of the study concludes by quoting the study's authors that their study, "clearly indicates that they (electronic billboards) do what they are built for. Whether they attract too much attention, that is, whether they are a traffic safety hazard, cannot be answered conclusively based on the present data."

In contrast, a US Federal Highway Administration Eye Tracking study employing similar methodology to the Swedish study states conclusively that, "the results [of the study] did not provide evidence indicating that CEVMS (digital billboards) were associated with long glances away from the road that may reflect an increase in risk." (p. 64). The FHWA study found that, in the presence of both static and digital billboards, "the present data suggest that the drivers in this study directed the majority of their visual attention to the areas of the roadway that were relevant to the task at hand (i.e. the driving task)" and "When billboards were present the drivers in this study sometimes looked at them but not such that overall attention to the forward roadway decreased." (p.65)

c. "Simulator Study"

The 2011 Australian simulator study entitled "Advertising billboards impair change detection in road scenes" cited by the Public Work's memorandum is not a study of digital billboards. Rather, it studies the reaction time of drivers in different age categories and in different built environments. The study hypothesizes that "drivers would have more difficulty detecting changes in scenes with billboards present" and "it was hypothesized that the inexperienced and older drivers would take longer to find changes than the comparison drivers." The study found that "when both built and designed clutter were high, adding billboards did not have significant effect on time to detect change.... When built clutter was high but designed clutter was low or vice versa, drivers took longer to detect changes in scenes with billboards than in scenes without billboards...When both built and designed clutter were low, drivers were faster to detect changes in scenes with billboards." In other words, the study's first hypothesis, that "drivers would have more difficulty detecting changes in scenes with billboards present" was shown to not be the case in two of the three scenarios examined. Regarding the second hypothesis, that "inexperienced and older drivers would take longer to find changes than the comparison drivers," the data presented in figure 4 of the study shows that indeed older drivers took longer to find changes in a scene though the hypothesis regarding inexperienced drivers was not born out in the data, which indicates that younger/inexperienced drivers were actually faster at detecting changes in the scene. Though the results of the study were inconsistent with the study's hypotheses, it appears that the Public Work's memorandum infers in their section on "Regulatory Options: Pilot Study, Location Restriction and Cycle Length" that Eugene should regulate location and cycle length using the study's hypotheses as justification.

As noted elsewhere in this letter there have been numerous studies examining the question of the impact of digital billboards on traffic safety. The FHWA study on the impact of digital billboards on driver attention included driver volunteers from across the age spectrum between the ages of 18 and 65 and their findings indicate no evidence that the presence of CEVMSs "reflect an increase in risk." (p.64) Similarly, a study conducted by Virginia Tech on digital billboards and driver performance had 36 participants between the ages of 18 and 71 and found that "changes in driver performance in the presence of digital billboards...are on par with those associated with everyday driving..." (p. 73) Several studies specifically examine the question of whether digital billboards have an adverse impact on older and inexperienced drivers and find "that the age of drivers [is a] neutral factor which shows no significant increase in accident rates near the digital billboards...." Tantala's Richmond VA study p. 33.

d. "Regulatory Options" - "Pilot Study"

As noted above, Massachusetts DOT's Traffic and Safety Engineering Division conducted a pilot study similar to that being proposed by Public Works, with the exception that the MassDOT study did not focus on "low-access roadways" as proposed by Public Works, which are not feasible candidates for a digital billboard. Instead, the MassDOT study looked at economically viable, high traffic digital billboard sites for the pilot study. MassDOT published a final memorandum summarizing the findings of the pilot study, stating, "The traffic engineers preparing the reports found *no detrimental safety impacts* of the DABs (digital advertising boards) in any of the eight study locations." (emphasis added).

An alternative to an expensive and time-consuming pilot study, could be for Public Works to look at traffic data in Oregon cities where digital billboards have been allowed since 2011 (such as Salem and Springfield). Better yet, the City of Eugene could simply look at available data for the existing digital signs already located in the City. Of the existing digital signs, the sign located at Matthew Knight Arena is most similar or representative of the type of sign that would be constructed, understanding, however, that the proposed digital signs would be required to comply with state standards for brightness, dwell time, spacing, etc. A review of the data available shows no uptick in traffic accidents since its placement in 2011.

Matthew Knight Arena:

i. Installation.

Installed on or around January 11, 2011 (Official opening of Arena).

ii. Description of Sign and Surrounding Areas.

Located at the south east corner of Franklin and Villard St, Eugene, OR. Double-sided sign with faces oriented to eastbound and westbound traffic on Franklin. Commercial advertising for sporting events, concerts and shows. Eastbound traffic has limited view of sign during summer months due to street trees. Located at intersection of bifurcated major arterial with neighborhood collector. Complex intersection with 20 traffic lanes, 7 permitted turning directions, a dedicated bus rapid transit lane, designated bike lane (eastbound), 5 pedestrian cross walks and 5 commercial driveway aprons within 100 feet of the intersection. Zoned C-2 to SW of intersection. Zoned Special Areas to NW, NE and SE of intersection. Adjacent uses include 12,000+ seat arena, commercial grocery store (Market of Choice, drive through Starbucks, automotive repair, hotel (Days Inn), restaurants (House of Chen, Café Seoul, Subway).

iii. Traffic Count.

Traffic information obtained from LCOG – City of Eugene 2013 Traffic Flow Map. Presumably, traffic counts have increased since then and the total number of trips below is underinclusive of the actual vehicle trips.

<u>Eastbound Franklin</u>: 13,900 per day, 48,733,400 vehicles trips between January 11, 2011 and August 17, 2020.

Westbound Franklin: 14,800 per day, 51,888,800 vehicles trips between January 11, 2011 and August 17, 2020.

Total Vehicle Trips: 100,622,220 vehicles trips between January 11, 2011 and August 17, 2020.

iv. Crash Data.

In over 100,000,000 vehicles trips there were NO fatal or serious injuries resulting from the digital billboard at Matthew Knight Arena. Information was obtained online from Eugene Vision Zero Crash Data for crashes occurring after installation of the digital billboard on or about January 11, 2011.

Fatal and Serious Crashes: None

<u>Crashes Involving People Walking</u>: Not available

<u>Crashes Involving People on Bikes</u>: 1 crash was noted at the intersection of Franklin and

Walnut in 2013 involving a bike. It is not stated whether this crash involved a vehicle. The crash was almost certainly not connected with the digital billboard given its distance from the billboard (approximately 970 ft). At that location the billboard, is barely visible and largely obscured by existing obstructions (e.g. telephone poles, traffic light poles, transformer boxes, cars, Market of

Choice Sign and Hiron's sign). See attachment.

e. "Regulatory Options" – "Location Restriction"

Public Work's memorandum states that "based on the available research" they recommend restricting the location of digital billboards due to the "potential impact of digital billboards on driver attention." Given the foregoing additional information provided here, which Public Works may not have been aware of at the time of the memorandum, there is ample evidence that digital billboards do not represent a distraction leading to decreased traffic safety and warranting location restrictions beyond those already being considered by Planning Commission. Further, such overly broad restrictions will significantly reduce the available locations to areas which cannot support the increased costs of a digital billboard (e.g. to low of traffic volume, outskirts of town) while offering no appreciable gain in safety. In short, those types of restrictions would undercut the Council's direction and purpose in amending the sign code leaving few, if any, locations where digital billboards could or would actually be employed.

f. "Regulatory Options" – "Cycle"

Public Work's memorandum notes that "based on available information transportation staff believe that longer cycle lengths are safer than shorter cycle lengths" because longer cycle lengths "theoretically prompt fewer glances away from the road." Public Works notes that they were "unable to identify research comparing the safety of different cycle lengths" but nevertheless suggest that Planning Commission "consider cycle length requirements longer than the 8-10 second industry standard." However, the billboards that were the subject of the FHWA's study and the Virginia Tech study and the crash studies noted above used the industry standard "cycle length", which is 8 seconds, and concluded that there is no increased risk to traffic safety due to the presence of digital billboards, demonstrating that the industry standard is a safe standard. The Virginia Tech study notes that an analysis of longer glances in their study did not show that drivers "maintained longer glances toward digital billboards in the hopes of catching the next message." (p. 73) Lengthening cycle time between flips is inconsistent with state law, makes it difficult

to market and sell regional or national add spaces, reduces the availability of ad space including PSA's and would not result in any appreciable increase to safety.

4. No Additional Safety Issue on Mill St, Broadway, Franklin Blvd.

Planning Commission raised some concerns about digital billboards in the vicinity of the Federal District Courthouse and asked for additional information. This was the "fuchsia area" identity by staff and which were inadvertently left out for conversion of billboards. Although the precise boundaries of this area are not clear, there are potentially 3 billboard that fall within this segment. The first is located across from Whole Foods on the on the east side of Mill St approximately 175 feet south of 8th Ave. The sign generally faces north towards vehicles traveling south on Mill or stopped at the intersection of Mill and 8th and facing south. There is only one pedestrian cross walk here which is deconflicted with traffic on Mill through signalization. The second billboard in on the south side of Broadway approximately 150 feet east of the intersection of Broadway and Mill. The sign is doubled sided facing traffic moving east and west on Broadway. There are no bike paths in this area. There is a deconflicted signalize pedestrian cross walk approximately 150 feet west of the sign at the intersection of Broadway and Mill. The third sign, which has been identified for conversion (east face), is a double faced sign located on the north side of Broadway approximately 100 ft west of the intersection of Broadway and Hilyard and faces traffic driving east and west on Broadway. There are two signalized and deconflicted pedestrian crosswalks on Broadway and Hilyard. There are no bike paths in this area. Overall, there are minimal potential distractions/conflicts in the vicinity of these signs.

Digital billboards have been in operation in communities across the country and the state of Oregon for over a decade during which time they have proved themselves as safe both in practice and through numerous studies. Their real world application and track record coupled with the proposed code language is adequate to ensure the continued safety of all users of Eugene's streets and is consistent with the City's Envision Zero goals.

Sincerely,

NOTEBOOM LAW, LLC

/s/ Aaron J. Noteboom

Aaron J. Noteboom



Franklin Blvd looking east. Digital billboard is completely obstructed by street tree during foliage.



Intersection of Franklin Blvd and Walnut looking west towards Mathew Night Area. Digital billboard is generally not visible from crash site.



DOT study finds digital billboar don't distract drivers

BY KEITH LAING - 01/07/14 02:57 PM EST

7 SHARES SHARE TWEET

Just In...

More than a dozen states sue Postal Service over delays

COURT BATTLES - 4M 29S AGO

Fauci says he does not see US mandating COVID-19 vaccination for general public

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BLOG BRIEFING ROOM
— 19M 45S AGO

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ADMINISTRATION — 23M 6S AGO

Watch live: Trump speaks on immigration during Arizona visit

ADMINISTRATION — 29M 37S AGO

Funding the removal of Huawei in our networks is smart investment

OPINION — 29M 39S AGO

Ardern: Trump claim of 'big surge' in coronavirus cases in New Zealand is 'patently wrong'

INTERNATIONAL — 35M 35S AGO

24 people contract COVID-19 following

Drivers are not distracted by digital billboards alongside roads, according to a study conducted by the Department of Transportation (DOT).

The study, which was released by the Federal Highway Administration (FHA), found that drivers are not any more likely to be distracted by digital billboards than stationary signs.

"On average, the drivers in this study devoted between 73 and 85 percent of their visual attention to the road ahead for both [Commercial Electronic Variable Message Signs] and standard billboards," the study said. "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."

The study surveyed drivers in Richmond, Va. and Reading, Pa. and found that the average length of time drivers spent looking at digital billboards was 379 milliseconds, compared to 335 milliseconds for standard signs.

The results were both well below the "currently accepted threshold of 2,000 milliseconds," the study said.

"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," the study said. "When dwell times longer than the currently accepted threshold of 2,000 [milliseconds] occurred, the road ahead was still in the driver's field of view. This was the case for both CEVMS and standard billboards."

The results were cheered by the Washington, D.C.-based Outdoor Advertising Association of America (OAAA), which has pushed the transportation department to relax its rules regarding digital billboards.

"Studies have long shown that digital billboards do not cause distracted driving," the outdoor advertising agency said in a statement. "The new federal study released on Dec. 30 comes to the same conclusion."

TAGS BILLBOARDS ADVERTISING

SHARE TWEET



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Traffic and Safety Engineering **MEMORANDUM**

TO:

Edward Farley, Director MassDOT Office of Outdoor Advertising

THROUGH:

Neil Boudreau, State Traffic Engineer, and Thomas F. Broderick, P.E., Acting Chief Thomas F. Berelical

Engineer Neil & Barber

FROM:

DATE:

Bonnie Polin, Chief Safety Analyst わかん

November 22, 2011

RE:

Digital Advertising Board – Pilot Program

In 2008, the MassDOT Highway Division (then MassHighway) Traffic and Safety Engineering Section worked closely with the Office for Outdoor Advertising (OOA) and established a pilot program to evaluate the safety impacts of Digital Advertising Boards (DAB) in Massachusetts. The program consisted of a diverse selection of DAB locations (selected by OOA) and a "pre-installation study" (scope of work is attached), a 30-day post installation and a "post-installation study" one year following the DAB installation. This memo summarizes the findings of the pilot program.

In 2008, the OOA met with the Traffic and Safety Engineering Section to discuss the DAB pilot program. Together, we drafted scopes of work for the pre- and post-installation studies and then presented it to several potential DAB owners to explain the process. We worked with Massachusetts State Police to obtain copies of one full year of crash data, within the study areas. The crash reports were received at MassDOT in April 2009. Personal information was then redacted from the crash reports and copies of the crash reports were provided to the potential DAB owners. Over the next year, pre-installation reports were received and reviewed for a number of locations.

Generally, the pre-installation studies identified the areas along the roadway in which the DAB would be visible, the existing crash data were summarized and the geometry and traffic operations within the area of visibility were described. The pre-installation studies were reviewed and the DAB owners were directed to proceed with the installation of the DABs. In some cases (based on existing crash data or traffic operations within the visibility of the proposed DAB), the owners were directed to proceed with caution. In some cases, cities or towns did not grant approval for DAB installation so those pilot locations had to be dropped.

Ultimately, eight DABs were all installed between June 2, 2009 and June 30, 2010 and the 30-day post-installation studies were submitted shortly after each installation. The 30-days installation report covered a search through local/ regional media regarding the DABs and a conversation with the State Police barracks to learn if the installation of the DAB put the location on the radar screen. In no cases was there an outcry of safety concerns and the police barracks were not aware of any issues. A summary of the DAB locations is listed in the following table.

Subsequent to that, the State Police were once again requested to gather and submit one-year post crash data for the eight study area locations. The crash data was received at OOA in September 2011 and distributed to each DAB owner (after the personal information was redacted). Post-installation reports were submitted between September 2011 and November 2011.

DAB - Post Installation Evaluation Final 11-22-11

1 of 2

11/23/2011

		DAB		Company of	Date DAB		
District	City/Town	Route	Address of DAB	DAB	Operational	Latitude	Longitude
				Catahoula Realty			_
5	Fall River	I-195	240 Hartwell St	Trust	6/30/2010	41.69743	71.15168
	_			Clear Channel			
4	Stoneham	I-93	21 Manison St	Outdoor	10/23/2009	42.47765	71.11269
				Clear Channel			
4	Lawrence	I- 495	8 Commonwealth Dr	Outdoor	12/8/2009	42.35743	71.14210
				Clear Channel			
4	Medford	I-93	162 Mystic Ave (Rear)	Outdoor	4/30/2010	42.41020	71.10399
				Clear Channel			
4	Medford	I-93	282 Mystic Ave (Rear)	Outdoor	5/30/2010	42.40478	71.09903
5	New Bedford	I-195	2031 Purchase St	Murray Outdoor	5/1/2010	41.65378	70.93069
				Carroll			59
5	Foxboro	Route 1	29 Washington St	Advertising	6/2/2009	42.10186	71.25943
2	Chicopee	I-90	374 Montgomery St	D'Auria Series	4/30/2010	42.17019	72.58509

The post-installation studies described the existing conditions, the one year post-installation crash summary and a general finding with regard to the safety impacts of the DAB. As one would expect, crash data fluctuates so in some cases crashes increased and in other cases the number of crashes decreased when comparing pre-and post-installation conditions. The role of the study was to gain a better understanding around the circumstances of the crashes. In cases where the number of crashes increased between pre and post-installation, much of this was able to be attributed to work zones within the area or in areas immediately outside the visibility of the DABs. The traffic engineers preparing the reports found no detrimental safety impacts of the DABs in any of the eight study area locations.

Therefore, the Traffic and Safety Engineering Section believes the Digital Advertising Board pilot program was successful and did not create an adverse safety condition on Massachusetts' Highways. The MassDOT Office of Outdoor Advertising can move forward with permitting the installation of additional DABs on a regional basis. However, Traffic & Safety Engineering believe that guidelines should be established to direct the placement of DABs in safe areas (as an example: not in the immediate vicinity of lane drops, merge / diverge points and other areas in which a driver needs to make a decision in travel) and not obstructing other guide, regulatory and warning signs on the highway. Finally, we believe that the DAB's have been a tremendous benefit to MassDOT through the agreement to allow a portion of the broadcast time for Public Service Announcements (PSA). This program should continue as part of the standard OOA permitting process for Digital Billboards,

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

SEPTEMBER 2012



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

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Message Signs (CEVMS)	6. Performing Organization Code		
7. Author(s) William A. Perez, Mary Anne Bertola Molino	8. Performing Organization Report No.		
9. Performing Organization Name and SAIC	l Address	10. Work Unit No. (TRAIS)	
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15. Supplementary Notes The Contracting Officer's Technical I	Representatives (COTR) were Christ	opher Monk and Thomas Granda.	
billboards, and control areas with no of freeways in the day and nighttime. Fire but there were differences in the road conditions; however, the CEVMS and control conditions (roadways not control conditions differed from e billboard conditions showed that gaze maximum fixations to CEVMS and st times were found (sequential and mul freeway in the day time, two were to to one was to a standard billboard on an CEVMS or standard billboards in day control of gaze behavior in natural en regulation of gaze behavior.	e with an eye tracking system was us off-premise advertising were selected eld studies were conducted in two cit way visual environment. The gazes to billboard conditions resulted in a locaining off-premise advertising) with each other. Examination of where dries away from the road ahead were not andard billboards were similar across tiple fixations) that were greater than the same standard billboard on a free arterial at night. In Richmond, the rest night; however, in Reading the driver and night. The results of the study a	ed. Roads containing CEVMS, standard I. Data were collected on arterials and ies where the same methodology was used to the road ahead were high across the wer probability of gazes as compared to the the exception of arterials in Richmond where vers gazed in the CEVMS and standard trimarily to the billboards. Average and sall conditions. However, four long dwell 2,000 ms. One was to a CEVMS on a way once in the day and once at night; and sults showed that drivers gazed more at ers were equally likely to gaze towards re consistent with research and theory on the ring task tend to affect the driver's self-	
17. Key Words Driver visual behavior, visual environ system, commercial electronic variable complexity		18. Distribution Statement No restrictions.	

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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. 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. 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. 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 headmounted 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. 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. 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. 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. 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. 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. 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. The surrogates are real environments.

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' eve 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. 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
ОН	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/m²) 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. 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. 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. 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. 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

Eve Tracking Measures

The Multiple-Analysis of Psychophysical and Performance Signals (MAPPSTM) software was used to reduce the eye tracking data. 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.

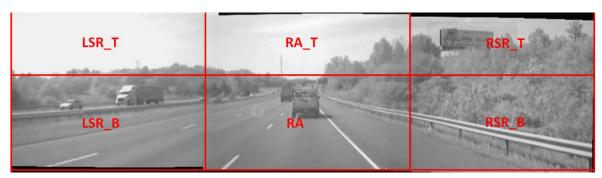


Figure 9. Screen capture showing static ROIs on a scene video output.

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/m²) and contrast (Weber ratio) measurements.

	Luminance (cd/m²)		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.

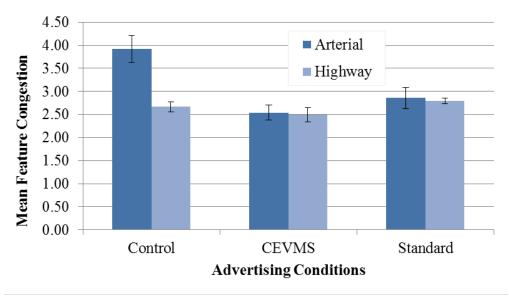


Figure 10. Mean feature congestion as a function of advertising condition and road type (standard errors for the mean are included in the graph).

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. 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 nonroad 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.

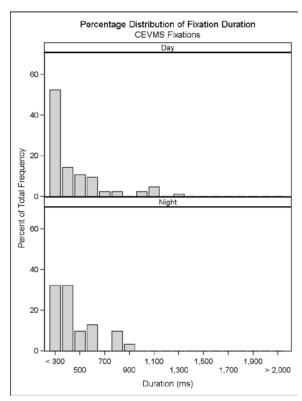


Figure 11. Distribution of fixation duration for CEVMS in the daytime and nighttime.

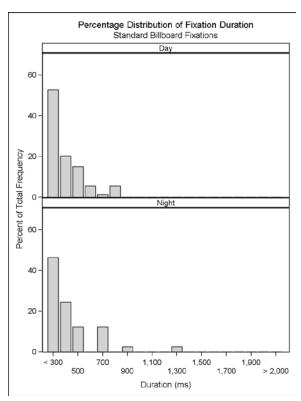


Figure 12. Distribution of fixation duration for standard billboards in the daytime and nighttime.

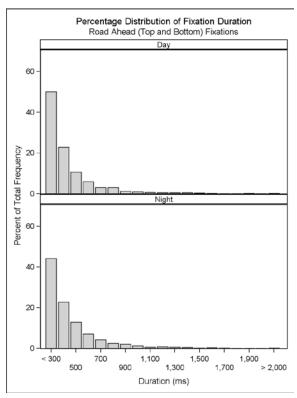


Figure 13. Distribution of fixation duration for road ahead (i.e., top and bottom road ahead ROIs) in the daytime and nighttime.

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.

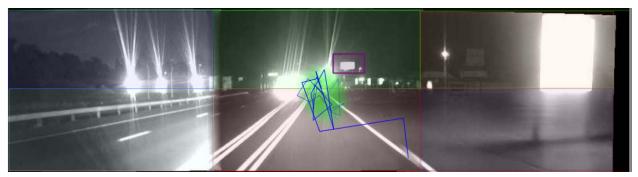


Figure 14. Heat map for the start of a DCZ for a standard billboard at night on an arterial.

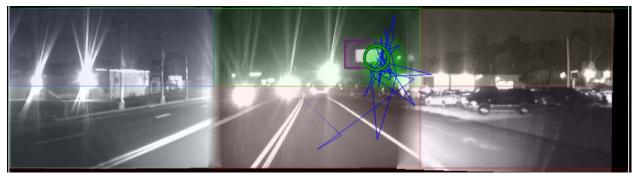


Figure 15. Heat map for the middle of a DCZ for a standard billboard at night on an arterial.



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.

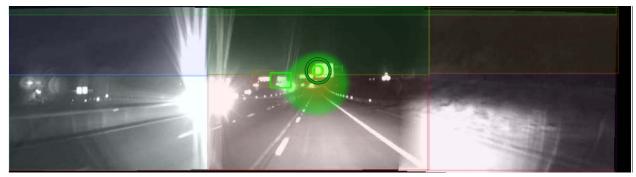


Figure 17. Heat map for start of a DCZ for a standard billboard at night on a freeway.

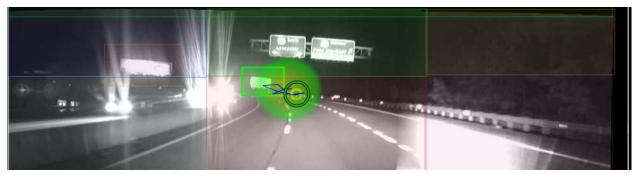


Figure 18. Heat map for middle of a DCZ for a standard billboard at night on a freeway.

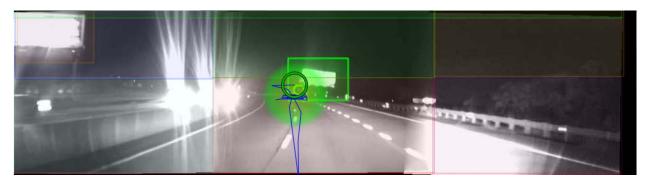


Figure 19. Heat map near the end of a DCZ for a standard billboard at night on a freeway.

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).

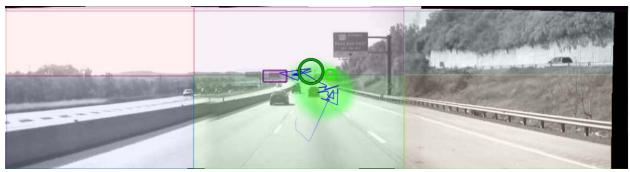


Figure 20. Heat map for the start of a DCZ for a standard billboard in the daytime on a freeway.

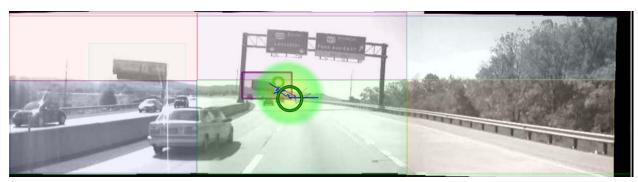


Figure 21. Heat map near the middle of a DCZ for a standard billboard in the daytime on a freeway.

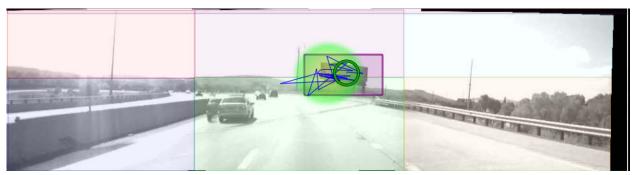


Figure 22. Heat map near the end of DCZ for standard billboard in the daytime on a freeway.

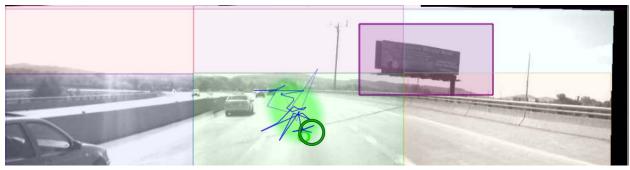


Figure 23. Heat map at the end of DCZ for standard billboard in the daytime on a freeway.

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). 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.

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.

	Art	erial	Freeway		
	Day	Night	Day	Night	
Control	В	A	С	В	
CEVMS	C	A	В	A	
Standard	A	A	В	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. 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. 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.

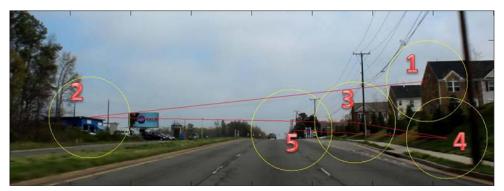


Figure 24. Example of identified salient areas in a road scene based on bottom-up analysis.

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 invehicle information systems and other devices (e.g., for texting) where the driver is indeed looking completely away from the road ahead. 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/m²) and contrast (Weber ratio) measurements.

	Luminance (cd/m²)		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.

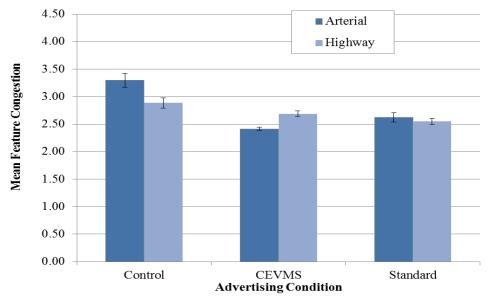


Figure 31. Mean feature congestion as a function of advertising condition and road type.

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.

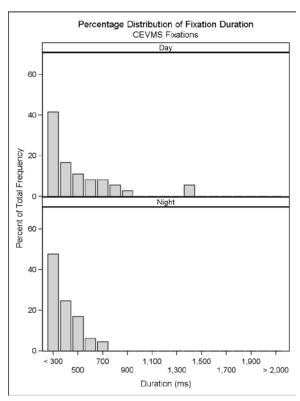


Figure 32. Fixation duration for CEVMS in the day and at night.

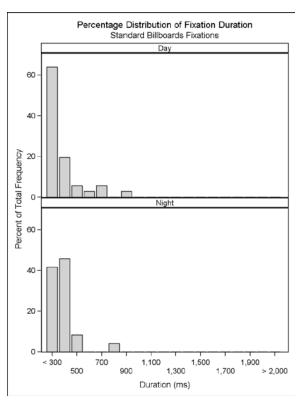


Figure 33. Fixation duration for standard billboards in the day and at night.

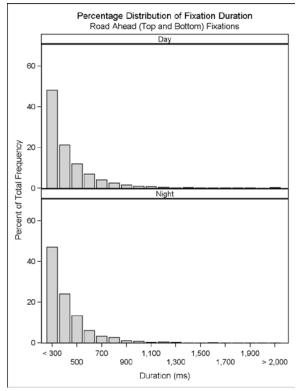


Figure 34. Fixation duration for the road ahead in the day and at night.

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.

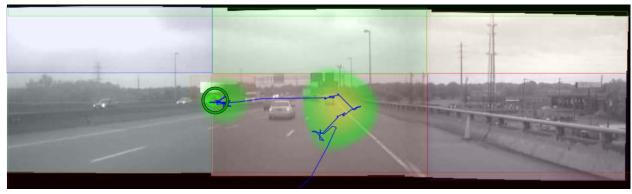


Figure 35. Heat map for first fixation to CEVMS with long dwell time.



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

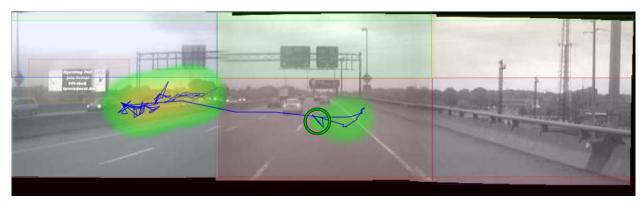


Figure 37. Heat map at end of fixations to CEVMS with long dwell time.

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.

	Art	erial	Freeway		
	Day Night		Day	Night	
Control	В	A	С	В	
CEVMS	В	A	В	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. 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. However, useful information for reading can be extracted from parafoveal vision, which encompasses the central 10 degrees of vision. More recent research on scene gist recognition has shown that peripheral vision (beyond parafoveal vision) is more useful than central vision for recognizing the gist of a scene. 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. 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. 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/m² 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/m² 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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FHWA Final CEVMS Report Summary

Key Points regarding the FHWA Research

- The Federal Highway Administration (FHWA) contracted the Science Applications
 International Corporation (SAIC) to study the effects of digital billboards on driver attention
 and distraction in 2007
- This study was aimed at determining if digital billboards posed an unsafe driver distraction and was based on how long drivers took their eyes off the road when in the presence of digital billboards.
- FHWA emphasized that the study employed highly accurate state of the art research methodology and eye tracking equipment, which ensures a high level of confidence in the eventual findings.
- The study was completed in early 2010, and a draft report was subjected to peer review in 2012.
- On December 30, 2013, FHWA released its final report

The FHWA conducted its research on digital billboards based on an eye-glance analysis in two test markets: Reading, PA, and Richmond, VA.

In both cities, digital billboards were located on freeways and local arterials.

Results from the FHWA study indicate the following:

- 1. The presence of digital billboards does not appear to be related to a decrease in looking toward the road ahead, which is consistent with earlier industry sponsored field research studies (VTTI).
- 2. The longest fixation to a digital billboard was 1.34 seconds, and to a standard billboard it was 1.28 seconds, both of which are well below the accepted standard.¹
- 3. When comparing the gaze at a CEVMS versus a standard billboard, the drivers in this study were more likely to gaze at CEVMS than at standard billboards.
- 4. The researchers were careful to note the FHWA study adds to the knowledge base of digital billboard safety, but does not "present definitive answers" to the questions investigated.

Bottom Line:

Digital billboard glances are well within federal safety standards concerning driver distraction.

The full report is available on the FHWA website http://www.fhwa.dot.gov/real_estate/practitioners/oac/



DOT study finds digital billboards don't distract drivers

f 190 💆 63 💥 🚅 28 💌

Drivers are not distracted by digital billiboards alongside roads, according to a study conducted by the Department of Transportation (DOT).

The study, which was released by the Federal Highway Administration (FHA), found that drivers are not any more likely to be distracted by digital billboards than stationary signs.

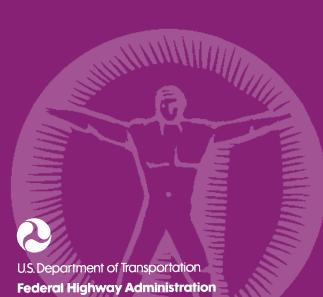
¹ According to the National Highway Traffic Safety Administration (NHTSA), safety concerns arise when a driver's eyes are diverted from the roadway by glances that continue for more than 2.0 seconds.

The Effects of Commercial Electronic Variable Message Signs (CEVMS) on Driver Attention and Distraction:

An Update

PUBLICATION NO. FHWA-HRT-09-018

FEBRUARY 2009



Research, Development, and Technology Turner-Fairbank Highway Research Center 6300 Georgetown Pike McLean, VA 22101-2296

FOREWORD

The Highway Beautification Act of 1965 outlined control of outdoor advertising, including removal of certain types of advertising signs, along the Interstate Highway System and the existing Federal-aid primary roadway system. Since that time, most States have evolved a body of legislation and/or regulations to control off-premise outdoor advertising (billboards), and many local governments have developed similar rules.

The advent of new 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 (DBB) and Electronic Billboards (EBB).

The present report reviews research concerning the possible effects of CEVMS used for outdoor advertising on driver safety, including possible attention and distraction effects. The report consists of an update of earlier published work, an investigation of applicable research methods and techniques, recommendations for future research, and an extensive bibliography. The report should be of interest to highway engineers, traffic engineers, highway safety specialists, the outdoor advertising industry, environmental advocates, Federal policy makers, and State and local regulators of outdoor advertising.

Michael F. Trentacoste Director, Office of Safety Research and Development Gerald Solomon
Director, Office of Real Estate
Services

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FHWA Contracting Officer's Technical Representative (COTR): Thomas M. Granda, Safety Research and Development, FHWA

16. Abstract

The present report reviews research concerning the possible effects of Commercial Electronic Variable Message Signs (CEVMS) used for outdoor advertising on driver safety. Such CEVMS displays are alternatively known as Electronic Billboards (EBB) and Digital Billboards (DBB). The report consists of an update of earlier published work, a review of applicable research methods and techniques, recommendations for future research, and an extensive bibliography. The literature review update covers recent post-hoc crash studies, field investigations, laboratory investigations, previous literature reviews, and reviews of practice.

The present report also examines the key factors or independent variables that might affect a driver's response to CEVMS, as well as the key measures or dependent variables which may serve as indicators of driver safety, especially those that might reflect attention or distraction. These key factors and measures were selected, combined, and integrated into a set of alternative research strategies. Based on these strategies, as well as on the review of the literature, a proposed three stage program of research has been developed to address the problem.

The present report also addresses CEVMS programmatic and research study approaches. In terms of an initial research study, three candidate methodologies are discussed and compared. These are: (1) an on-road instrumented vehicle study, (2) a naturalistic driving study, and (3) an unobtrusive observation study. An analysis of the relative advantages and disadvantages of each study approach indicated that the on-road instrumented vehicle approach was the best choice for answering the research question at the first stage.

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		<u> </u>	RSION FACTORS	
		MATE CONVERSIONS		
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
n	inches	25.4	millimeters	mm
t .	feet	0.305	meters	m
/d	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
2		AREA	700	2
n² t²	square inches	645.2	square millimeters	mm² m²
ι ⁄d²	square feet	0.093 0.836	square meters square meters	m ²
ic	square yard acres	0.405	hectares	ha
ni ²	square miles	2.59	square kilometers	km ²
	oquai o i i i i o	VOLUME	equal o miemetero	
loz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
3	cubic feet	0.028	cubic meters	m ³
rd ³	cubic yards	0.765	cubic meters	m ³
		mes greater than 1000 L shall		
		MASS		
Σ	ounces	28.35	grams	g
b	pounds	0.454	kilograms	kg
Γ	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		MPERATURE (exact de	egrees)	- '
F	Fahrenheit	5 (F-32)/9	Celsius	°C
		or (F-32)/1.8		
		ILLUMINATION		
c	foot-candles	10.76	lux	lx
1	foot-Lamberts	3.426	candela/m ²	cd/m ²
	FOR	CE and PRESSURE or	STRESS	
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
	APPROXIM/	ATE 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
··· κm	kilometers	0.621	miles	mi
arr	Kilomotoro	AREA	1111100	
nm²	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
km²	square kilometers	0.386	square miles	mi ²
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
	cubic meters	35.314	cubic feet	ft ³
	cubic meters	1.307	cubic yards	yd^3
		MASS		
			ounces	oz
m ³ m ³ g	grams	0.035		
m ³	grams kilograms		pounds	lb
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n ³ J sg Mg (or "t")	kilograms megagrams (or "metric ton")	0.035 2.202	short tons (2000 lb)	
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1.0 INTRODUCTION

The present report reviews research concerning the possible effects of Commercial Electronic Variable Message Signs (CEVMS) used for outdoor advertising on driving safety. The report consists of an update of earlier published work by Farbry et al., which consists of an investigation of applicable research methods and techniques, recommendations for future research, and an extensive bibliography. The Federal Highway Administration (FHWA) has evaluated possible safety effects of CEVMS in two previous studies. The first study was completed in 1980 and the second in 2001. Since then, CEVMS technology has evolved, in particular the expanded use of digital Light Emitting Diode (LED) arrays, as well as the implementation of new programmable formats and messages. The present report concentrates on identifying potential factors that may contribute to determining whether there are any significant safety concerns or distraction effects with regards to CEVMS used for outdoor advertising. Throughout the present report, the acronym CEVMS will be employed to refer to both the singular and plural case.

1.1 BASIC RESEARCH QUESTION

The basic research question being addressed in this report is whether the presence of CEVMS along the roadway is associated with a reduction in driving safety for the public. Increases in vehicle crashes along a certain portion of the roadway are generally regarded as an indication of a possible safety concern. Thus, the measurement of crash rates in the vicinity of CEVMS in comparison with crash rates at matched control locations without CEVMS is one possible way to determine possible safety impacts. But, the crashes are rare multicausal events which are difficult to measure. Therefore, measurements of driving behavior in near-crash situations are sometimes taken as a substitute for crashes. These safety surrogate measures may then be generalized to other driving behaviors that represent possible precursors of crashes—like sudden braking, sharp swerving, or traffic conflicts—even though no crash occurs. Usually, because these safety surrogate measures are more frequent and easier to measure, they are often employed instead of or in addition to crashes. Thus, determining the frequency of occurrence of certain relevant safety surrogate driving behaviors in the vicinity of CEVMS in comparison with the frequency of occurrence of such behaviors at matched control locations without CEVMS is another possible way to determine possible safety impacts. The validity of using such safety surrogate measures rests on the assumption that they are related to actual vehicle crashes, which seems intuitively reasonable but has not been conclusively demonstrated.

There is another approach to determining the possible safety impact of CEVMS. This approach is based upon the abstract psychological constructs of driver attention and distraction. A driver must devote a certain amount of attention to the driving task at hand, and sufficient distraction from that driving task could be associated with the higher risk of a crash. The measurement of driver eye glance behavior is often taken as an indirect indicator of attention. Thus, the driver's eye glances should be concentrated in the region of the roadway ahead, and any frequent or long eye glances away from this region toward other objects, including CEVMS, could be regarded as an indication of possible driver distraction. If the eye glances toward a certain object and away from the roadway ahead are sufficiently frequent or sufficiently long to exceed criteria established for safe driving, this outcome can be taken as an indication of a possible safety impact. The validity of using eye glance behavior measures in this manner rests on two

assumptions: that eye glances are related to attention and/or distraction and that there are generally accepted safety criteria for excessive eye glances away from the roadway ahead. These assumptions are not universally accepted.

In summary, the basic research question is whether the presence of CEVMS along the roadway is associated with a reduction in driving safety for the public. The three fundamental methods for answering this question include if there is an increase in crash rates in the vicinity of CEVMS, if there is an increase in near-crashes or safety surrogate measures in the vicinity of CEVMS, and if there are excessive eye glances away from the roadway ahead in the vicinity of CEVMS.

1.2 SCOPE

In this report, a CEVMS will be defined as a self-luminous advertising sign which depicts any kind of light, color, or message change which ranges from static images to image sequences to full motion video. The CEVMS may also be referred to as an Electronic Billboard (EBB) or a Digital Billboard (DBB). The present report concentrates on the possible effects of CEVMS on driver attention, driver distraction, and roadway safety. The report is divided into 10 sections: Introduction, Literature Review Update, Key Factors and Measures, Research Strategies, Future Research Program, Recommended First Stage Study, Conclusions, References, Bibliography, and Appendices.

Investigating the possible safety effects of CEVMS is sufficiently complex so that no single experiment will answer all of the relevant scientific and engineering questions. The present report outlines a top-level broad program of potential future research, and it defines in greater detail three possible studies, any one of which could serve as a possible first step. After these discussions, a course of action is recommended. Although off-premise advertising signs constitute the main focus of FHWA attention, the influence of on-premise advertising signs will also be considered to create a more comprehensive and consistent research approach.

In parallel with the present project, a related study is being performed under National Cooperative Highway Research Program (NCHRP) Project 20-7 (256), titled "Safety Impacts of the Emerging Digital Display Technology for Outdoor Advertising Signs." Both the present project and the NCHRP study begin with the understanding that, despite years of research, there have been no definitive conclusions about the presence or strength of adverse safety impacts from CEVMS. The two projects differ in three significant ways. First, the NCHRP study is undertaking a broad, critical review of the research literature in this field. The present project is more focused on literature update oriented toward the identification of suitable independent and dependent variables for future research. Second, the NCHRP study is reviewing current regulations and guidelines for the control of roadside advertising that may exist in foreign countries to assess their applicability to U.S. highways and streets. Aside from mention in the literature review update portion, the present report does not directly address regulations and guidelines. Third, the NCHRP study will synthesize current research results and current regulations and guidance to recommend how State and local governments might enact reasonable temporary guidance for the control of CEVMS within their own jurisdictions. Such guidance may be applicable on an interim basis pending the outcome of future, more conclusive research outlined in the present project. As a result, such interim guidance may need to change as new

technical information is developed control of CEVMS.	. The present repo	ort does not provid	e guidance to Sta	tes on the



2.0 LITERATURE REVIEW UPDATE

2.1 BACKGROUND

The research that addresses the possible safety and distraction effects of outdoor advertising billboards has been extensive and long standing. Dating back to the 1930s, this research reached a peak in the 1950s and 1960s. Research continued at low ebb through the 1980s, and then all but ceased. With the advent of newer billboard technologies (e.g., lamp matrix, rotating disc, trivision, and, most recently, LED) and with the corresponding questions raised by regulators, safety researchers, and the public, research has increased again since the turn of the century. These newer billboard technologies, especially the LED technology, ushered in the increasing use of CEVMS for on-premise and off-premise advertising. The current research focuses on information that has become available since the publication of the most recent FHWA report, but it also includes earlier relevant studies not previously identified. The present review is organized into five major categories according to the research context for the study: post-hoc crash studies, field investigations, laboratory investigations, previous literature reviews, and reviews of practice. The categories that contain empirical data have a brief discussion of potential methodological problems inherent in the types of studies characteristic of that category.

2.2 POST-HOC CRASH STUDIES

Post-hoc crash studies review police traffic collision reports or statistical summaries of such reports 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.

A number of studies have been conducted over the years using the crash methodology. Three such studies were not reviewed in prior FHWA studies. In a study similar to that conducted in the 1970s in Massachusetts, the Freeway Operations Unit of the Wisconsin Department of Transportation (WisDOT) analyzed bidirectional crashes on I-94 near an electronic billboard with a 5.0 s message dwell time. (3,4) Crash rate data were collected for 3 years prior to and 3 years after sign operation began. For eastbound traffic, total crashes increased 36 percent over the 3 year post operational period compared to the baseline preoperational condition. In addition, side-swipe crashes increased 8 percent, and rear-end crashes increased 21 percent. For westbound traffic, total crashes increased 21 percent, sideswipe crashes increased 35 percent, and rear-end crashes increased 35 percent. The authors of the WisDOT study concluded that, "it is obvious that the variable message sign has had an effect on traffic, most notably in the increase of the side-swipe rate" (p. 3). (4)

Stutts et al. conducted an analysis of several crash data reporting systems to identify major sources of driver distraction and the relative importance of different types of distraction as contributing factors in motor vehicle crashes. Distraction was described as one form of inattention, and it has been implicated as a factor in more than half of the police reported inattention crashes identified by the National Highway Transportation Safety Administration. In this study, 8.3 percent of drivers involved in police-reported crashes were identified as distracted, but 35.9 percent of these crashes were coded as "unknown." For this and other

reasons, it is believed that the reported percentage of distraction-related crashes substantially under-represents the true statistics. Among the types of distractions coded in the database, the largest contributor (29.4 percent) was "outside person, object, or event," and the second largest (25.6 percent) was "other."

Smiley et al. studied the relationship between video advertising signs and motor vehicle crashes at downtown intersections and on the freeway. (7) Crash data were analyzed from three intersections before and after the introduction of video advertising signs. When the three intersections were evaluated individually, two demonstrated increases in both total and rear-end crashes; the third showed no significant increase in such crashes. The authors believe that the lack of statistical significance may be due to the small number of crashes identified. For the freeway environment, crash data on the video approach was compared to crash data for three non-video approaches, one of which was deemed the most comparable (control) segment. For this comparison, the authors report a negligible increase in injury collision crash frequencies on the video approach.

Following the design of their earlier study on conventional billboards, Tantala and Tantala analyzed police accident reports in the vicinity of seven digital billboards on interstate highways near Cleveland, OH. Both their current and earlier studies were sponsored by the outdoor advertising industry. Reported crashes were analyzed for a period of 18 months prior to and after the conversion of these billboards from conventional to digital. They found essentially no statistically significant differences in crash rates before and after the conversion.

Unfortunately, all post-hoc crash studies are subject to certain weaknesses, most of which are difficult to overcome. For example, the vast majority—more than 80 percent in one study—of accidents 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, researchers need to collect comparable data in such studies before and after the change and in the after phase at equivalent but unaffected roadway sections. Last, 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. For a more specific analysis of some possible design and methodological concerns with the study by Tantala and Tantala, see Wachtel. (8,9)

2.3 FIELD INVESTIGATIONS

The spectrum of field investigations related to roadway safety is broad. It includes unobtrusive observation, naturalistic driving studies, on-road instrumented vehicle investigations, test track experiments, driver interviews, surveys, and questionnaires. Klauer et al., in one of several papers to emerge from a National Highway Traffic Safety Administration (NHTSA) project known as the "100-Car Naturalistic Driving Study," provides preliminary information about the role of driver inattention in crashes and near-crashes. (10) Although the study did not specifically address CEVMS, it represents an important methodology for investigating driver distraction. Their results show that 78 percent of crashes and 65 percent of near-crashes included driver

inattention and/or distraction as a contributing factor. This contribution from inattention and distraction is larger, by a factor of three, than previous research has indicated. The authors believe that the "100-Car Naturalistic Driving Study" provides the first direct link (i.e., without reliance on crash surrogate measures) showing distraction/inattention as a contributing factor to motor vehicle crashes. In another variant of the "100-Car Naturalistic Driving Study," Klauer et al. identifies four specific unsafe behaviors that contributed to crashes and near-crashes. (11) One of these, inattention and/or distraction, is of direct relevance to the present project. This term is operationally defined by Klauer et al. as a driver looking away from the forward roadway for greater than 2.0 s. Under these conditions, the odds of a crash or near-crash are nearly twice those than when the driver attends to the forward roadway. The study stresses the importance of including near-crashes in the database for two reasons. First, the kinematics of crashes and near-crashes are similar, meaning they involved comparable levels of driver emergency actions, such as swerving and hard braking. Second, 83 percent of the crashes in this study were not reported to the police. Thus, the study indicates that relying on crash statistics alone will substantially underreport crashes due to inattention and/or distraction.

Lee, McElheny, and Gibbons undertook an on-road instrumented vehicle study on interstate and local roads near Cleveland, OH. (12) The project, conducted on behalf of the outdoor advertising industry, looked at driver eye glance behavior toward digital billboards, conventional billboards, comparison sites (sites with buildings and other signs, including digital signs), and control sites (those without similar signage). Performance measures, such as speed maintenance and lane keeping, were also recorded. Although the major data collection was done in daylight, a small pilot study was conducted at night. One of the key questions that the study sought to answer was whether longer glances consisting of over 1.6 s were associated more with any of the event types. (12) This question is based on findings from various studies, including the "100-Car Naturalistic Driving Study," which indicates that longer glances away from the road are associated with higher crash rates. (13) In discussing their results, the authors state, "...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" (p. 59). (13) The findings from the nighttime pilot study led to, "the overall conclusion, supported by both the eye glance results and the questionnaire results, 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 these billboards" (p. 10). (13) However, in view of the small number of participants, these data were not analyzed. The authors suggest that at least some of these findings, "would show statistical significance" if a larger study were to be conducted (p. 64). (13)

Beijer, Smiley, and Eizenman, working on behalf of the Government of Toronto, Canada, evaluated driver eye glances toward four different types of roadside advertising signs on roads in the Toronto, Canada area. The study employed an on-road instrumented vehicle approach with a head-mounted eye-tracking device. Active signs—all but traditional billboards—consistently received longer glances and more total glances than fixed signs. The study found that 22 percent of all glances were defined as long or greater than 0.75 s. Since 22 of the 25 subjects made at least one long glance at an advertising sign, the authors conclude that, "distraction...was not just an isolated incidence" (p. 101). The authors suggest that active signs may result in greater distraction than past studies of the effects of commercial signing might indicate.

After a previous study raised concerns about the number and duration of glances made to video advertising signs along an expressway in Toronto, Canada, Smiley et al. conducted another study at the request of the city government. Five different measures were taken, including eye movements, traffic conflicts, traffic speed and headway, crash data, and public surveys. The crash data results were described earlier. The results from the other measures were mixed. All of the video signs attracted attention; the probability of a driver's looking at such a sign upon approach was nearly 50 percent. The average glance duration was 0.5 s, similar to those for official traffic signs. However, one-fifth of the video sign glances lasted longer than 0.75 s, and some lasted as long as 1.47 s, which were considered unsafe amounts of time. About 38 percent of glances at the video billboards were made when headways were 1.0 s or less, and 25 percent of the glances took place when the signs were more than 20 ° off the line-of-sight. These glances were also considered to be unsafe. According to the study, glances at static billboards and bus shelter ads were made at even greater angles and shorter headways.

It is noteworthy that the earlier study that led to this research, also evaluating a video billboard on an expressway in Toronto, Canada, produced dramatically different results. This study found five times the number of glances per subject and three times the glance duration than did the later 2004 study. Smiley et al. attribute these differences to the longer sight distance available for the sign in the earlier study, the uninterrupted view, and the location of this sign on a curve.

Smiley et al. also employed safety surrogate measures of conditions which might be precursors of a possible crash. The study measured these safety surrogate indicators by means of the unobtrusive observation method. The drivers of the vehicles were not aware that they were being observed. In this context, the study measured traffic conflicts, vehicle speed, and vehicle headway. When comparing video and non-video approaches at the same intersection, at one intersection the authors found no differences in traffic conflicts; however, at the other, they found a significant increase in drivers who applied their brakes without cause on the video approach. Given the comparability of sites, they concluded, "the only reason that could be found for increased braking...was the presence of the video sign" (p. 108). The speed and headway data were inconclusive.

In addition, Smiley et al. employed a "public" survey method to determine whether video advertising might be considered to have "a negative effect on traffic safety" (p. 110). (7)
Participants in the survey were approached at three intersection sites which had video advertising. Of the 152 persons surveyed at the 3 locations, 65 percent felt that video advertising signs had a negative effect on the ability of a driver to attend to pedestrians and cyclists. Furthermore, 59 percent of the people said that as drivers, their attention was drawn to such signs, while 49 percent of those felt that such signs had a negative effect on traffic safety. A surprisingly large number of people—9 out of 152—stated that they personally had experienced near-crashes, and 2 had experienced actual rear-end crashes that they associated with video advertising signs. In addition, 86 percent of the respondents suggested that restrictions should be placed on those types of signs, such as their locations and brightness.

Three of the field investigations of CEVMS effects mentioned earlier employ indirect measures of driver attention (eye glances) in the context of an on-road instrumented vehicle experimental approach. Although CEVMS stimuli are real, the experimental approach suffers from a degree of artificiality in its implementation. The research participants usually drive in an experimental

vehicle along a route which is contrived for experimental purposes, and the route does not serve a useful purpose in their daily lives. The research participants sometimes drive with an experimenter present in the instrumented vehicle, and they sometimes wear a head-mounted eye-tracking device. Two of the three studies cited used a somewhat intrusive but more accurate head-mounted eye-tracking device. One study used a less obtrusive but also less accurate vehicle-mounted eye-tracking device, where cameras were mounted in the vehicle cab. Although the research participants were not told the purpose of the investigation, the participants were definitely aware that they were participating in a driving experiment of some kind, and they may not have exhibited entirely natural behaviors as a result. Furthermore, eye glance behavior is difficult to measure, and it is not easy to relate directly to attention and distraction. For a more specific analysis of some further design and methodological concerns with the Lee et al. study cited above, see Wachtel. (12,9)

The unobtrusive observation method employed in the field by Smiley et al. to collect safety surrogate measures of potential crashes (e.g., sudden braking, inadequate headway, etc.) does not create an artificial environment for the driver. ⁽⁷⁾ Usually, the sensing devices (loop detectors, remote cameras, or posted human observers) are hidden in the environment, and they are not noticed by the drivers. There is no problem of artificiality; the drivers in the study are not even aware that they are part of a study. However, the safety surrogate variables being measured are usually infrequent, often multicausal, comparatively subtle, and difficult to measure. For CEVMS, these variables can also occur over great distances, adding to the difficulty in accurately and reliably capturing data relating to these variables.

Finally, the public survey method employed by Smiley et al. collected the opinions, attitudes, and feelings of passersby at intersections with video advertising signs. (7) The results, while interesting as a measure of public sentiment, are difficult to relate to the basic research question of determining whether there are any significant distraction effects or concrete safety concerns with regards to CEVMS used for outdoor advertising.

2.4 LABORATORY INVESTIGATIONS

Laboratory investigations related to roadway safety can be classified into several categories: driving simulations, non-driving simulator laboratory testing, and focus groups.

For one such investigation, a non-driving simulator laboratory testing environment was used. For this study, researchers filmed a 27 minute drive and had 200 licensed drivers view the film while their eye movements were recorded. Billboards generated greater levels of visual attention than suggested by measures of recall. Billboards were viewed by individuals whether they were in the "target" audience or not and regardless of whether the billboard was of high or low interest. In addition, billboards located close to official highway signs received more attention than those that were farther away.

In a driving simulation laboratory, Crundall et al. compared street level advertisements (SLAs), such as those on bus shelters, to raised level advertisements (RLAs), which include elevated ads on poles or streetlights. The study was based on the understanding that, in undemanding situations, drivers have spare attentional capacity; however, when cognitive demands increase, spare capacity diminishes. As a result, eye movements must focus on the driving task at hand.

Based on their prior research, Crundall et al. believe that if an advertisement is within the driver's visual field during a search for hazards, it will attract visual fixations and distract attention needed to safely perform the driving task. Because the most relevant information for hazard detection is distributed along a horizontal plane, the authors believe that the majority of visual fixations will fall within this plane when the driver is looking for driving-relevant information. Thus, if an advertisement is located within this window, it will receive more fixations than will advertisements located outside this window. The principal research hypotheses tested were that during conditions when drivers were looking for hazards, SLAs would receive the most attention. When spare capacity was greater, the attention given to RLAs would increase. The results supported these hypotheses. A post-drive survey showed that SLAs were judged more hazardous than RLAs.

Young and Mahfoud used a driving simulator in which subjects drove three routes in the presence and absence of billboards. The presence of billboards adversely affected driving performance in terms of lateral control and crashes. Billboards also had an adverse impact on driver attention in terms of the number of glances made to them, and they were associated with a higher subjective mental workload. In addition, the recall of official road signs was adversely affected by billboards, which the authors interpreted to mean that drivers were attending to billboards instead of relevant road signs. The authors reached a "persuasive overall conclusion that advertising has adverse effects on driving performance and driver attention" (p. 18). (18)

In a recent study using a driving simulator, Chan and her colleagues compared the impacts of invehicle versus external-to-vehicle distractors on performance of inexperienced versus experienced drivers. The authors were particularly concerned with young, novice drivers because of the elevated crash risk for this segment of the driving population. They were also concerned because the researchers believed that distraction could adversely affect the novice drivers' poorly developed hazard detection and avoidance skills. Chan et al. theorized that external distraction may be more harmful than internal distraction because when drivers are looking within the vehicle, it should be obvious to them that they are not processing relevant roadway information. However, when drivers are looking at sources outside the vehicle, it is likely that the forward roadway is still somewhere within the field of view. Thus, it may not be obvious to drivers (particularly inexperienced drivers) that this important information is not being fully processed since it is peripheral, unattended, or both.

Chan et al. were primarily interested in the longest glances away from the forward roadway since these have been implicated in prior studies (e.g., Horrey and Wickens⁽²⁰⁾) as major contributors to crashes. Thus, they used as their dependent measure the maximum time that drivers spent continuously looking away from the forward roadway during a specific distraction task. In terms of in-vehicle distractors, as hypothesized, inexperienced drivers showed a consistent pattern of looking away from the roadway for longer periods of time than experienced drivers. However, the findings about external distractions were quite different and unexpected in two key ways. There was very little difference in the duration of distraction episodes between the experienced and inexperienced drivers, and the maximum distraction durations were significantly longer for the out-of-vehicle tasks than for the in-vehicle tasks. The two experience groups showed little differences in the percentage of distraction episodes longer than 2.0 s, 2.5 s, and 3.0 s, in all cases longer for the external than for the in-vehicle distractors. The study also demonstrated that, "drivers are more willing to make extended glances external to the vehicle than internal to the

vehicle" (p. 17).⁽¹⁹⁾ Chan et al. conclude that, "it is likely that our out-of-vehicle tasks (which not only engage attention but also draw the eyes and visual attention away from in front of the vehicle) would have quite significant detrimental effects on processing the roadway in front of the vehicle" (p. 22).⁽¹⁹⁾

Three of the laboratory investigations of possible distraction effects mentioned above employ indirect measures of driver attention (eye glances) in the context of a driving simulation experimental approach. The interactive driving simulator approach offers considerable experimental control over stimulus parameters, like the size, number, proximity, and change rate of CEVMS or other advertising display. The simulator is also well suited for executing parametric studies of the effects of these variables on possible driver distraction. However, the approach suffers from all of the sources of artificiality found in the on-road instrumented vehicle approach for conducting field research mentioned earlier. Also, the approach adds the important source of virtual driving as opposed to real driving. Although the vehicle cab of the driving simulator may have certain degrees of motion (pitch, roll, heave, etc.) to enhance the sense of virtual driving, the vehicle cab does not move down the roadway. The visual scene passes by while the driver and vehicle remain stationary. This degree of artificiality requires considerable adaptation on the part of the research participants, most of whom need some amount of training to become accustomed to the differences between driving in a simulator and driving on a real road. Moreover, in the case of CEVMS, 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 on a natural background scene.

One laboratory investigation had research participants watch films of driving scenes containing billboards while their eye movements were being recorded. This study represents an example of a non-driving simulator laboratory method. It suffers from all of the aforementioned limitations of laboratory CEVMS or billboard research. In addition, it does not measure the participants' response while engaged in a driving task.

2.5 PREVIOUS LITERATURE REVIEWS

Garvey summarizes the literature on sign visibility, legibility, and conspicuity on behalf of the advertising industry. One of his recommendations bears on the issue of distraction from billboards. He suggests that signs need not be detectable at distances greater than the minimum required legibility distance. Specifically, he states, "if a sign is detected before it is legible, the driver will take numerous glances at the sign in attempts to read it" before it becomes legible, and "these momentary diversions are inefficient and potentially dangerous" (p. 1). (21)

Cairney and Gunatillake, working on behalf of the Government of Victoria, Australia, undertook a review of the literature with the goal of generating recommendations for guidelines for the control of outdoor advertising in that State. They cited two prior reviews by Wachtel and Netherton in the United States and by Andreassen in Australia as the basis of their review. Since these earlier studies, the technology used for the display of roadside advertising and the addition of in-vehicle distractors has changed. Cairney and Gunatillake conclude that the principal concern remains the effects that a sign may have on a driver's visibility of other road users, the roadway, and traffic control devices, particularly at high-demand locations, such as interchanges. They suggest several research approaches, including case studies, site

investigations, and laboratory simulations to address these newer technologies. They conclude that the best of the studies conducted to date demonstrate that when all confounding variables are controlled statistically, sites with advertising signs have higher crash rates than sites without them. However, large, well-controlled studies will be required to detect significant effects because the effect size is small. They further conclude that changeable message signs may have a more direct bearing on crash rate than static signs. The findings of the study suggest that unregulated roadside advertising has the capability of creating a significant safety problem. The conclusions from their review run counter to Andreassen's conclusion that, "there is no current evidence to say that advertising signs, in general, are causing accidents" (p. 4). (23)

On behalf of the Scottish government, Wallace undertook the most extensive and critical review of the literature since the two earlier FHWA studies. (24) The study concludes that driver distraction from attention-getting sources can occur even when the driver is concentrating on the driving task. Furthermore, there is abundant evidence that billboards can function as distractors, particularly in areas of visual clutter. Billboards can distract in "low information" settings, and distraction from external factors is likely to be underreported and underrepresented in crash databases.

The Dutch National Road Safety Research Institute reviewed the recent literature for the Dutch authorities and emphasized some of the stronger, more consistent points made in other studies, such as billboards should not be placed near challenging road settings, especially at or near intersections. Also, they should not resemble official traffic signs in pattern or color. (25) Furthermore, dynamic signs that display motion or include moving parts should not be permitted. A key conclusion was that, "precisely in a dangerous situation it is important for the driver to have his attention on the road; an advertising billboard can slow the driver's reaction time, which increases the chance of a crash" (p. 2). (25)

The WisDOT sponsored a study which summarizes available information about the safety impacts of outdoor electronic billboards and tri-vision signs. Similar to Crundall, et al. and Wallace, the authors of this study determined that greater visual complexity associated with a high-volume location, such as intersections, required drivers to search the environment more than at lower-volume locations. The authors stated, it can be conjectured that additional visual stimuli such as billboards may add additional demand to driver workload in high-volume intersections (p. 6).

Bergeron, on behalf of the Government of Quebec, Canada, re-reviewed many of the studies originally examined by Wachtel and Netherton and added reviews of several studies conducted subsequent to 1980. (2,27) His findings and conclusions, similar to those of other researchers, indicate that attentional resources needed for the driving task are diverted by the irrelevant information presented on advertising signs. This distraction leads to degradation in oculomotor performance, which adversely affects reaction time and vehicle control capability. The study concludes that when the driving task imposes substantial attentional demands that might occur on a heavily traveled, high-speed urban freeway, billboards can create an attentional overload that can have an impact on micro and macroperformance requirements of the driving task.

2.6 REVIEWS OF PRACTICE

Bergeron also performed a site review at a major elevated expressway in Montreal, Canada, which was proposed for two future billboards. By reviewing the scene and considering various parameters such as traffic volumes, road geometry, and traffic control devices, Bergeron concludes that this 1.1 km section was already causing excessive cognitive demands, particularly for the many unfamiliar drivers. He concluded that the billboards would be inadvisable for several reasons. First, the location creates a substantial demand on drivers' mental workloads because of its complex geometry, heavy traffic, high traffic speeds, merging and diverging traffic, and the presence of signs and signals that require drivers to make rapid decisions. Also, at the perceptual level, the billboards would add confusion to the visual environment, thus impairing drivers' visual search, tracking, and reaction time. In addition, at an attention level, billboards could distract drivers. Last, the billboards could add to a driver's mental workload in a setting where workload is already quite high. In a road situation such as this one, Bergeron concludes that the billboard is a "useless drain on limited attentional resources" (p. 5), and it could lead to reduced performance through inattention errors by overloading the driver's information processing abilities. (28)

du Toit and Coetzee address the current regulatory process for advertising signs visible from national roads. The authors report that the South African government engages in careful scrutiny of proposed advertising signs before they are approved for use. All applications receive a desktop review followed by a site visit. If a decision cannot be made at this point, the authorities evaluate crash statistics for the proposed location to determine that if it is hazardous. Key questions asked as part of the review include the following:

- Will the proposed sign obscure the view of an official road sign?
- Will the sign cause a disruption of information flow to the driver?
- Will the sign's location distract the driver's attention at merge/diverge areas, curves, and interchanges?

A clear system exists in South Africa that requires certain spacing between road signs, particularly those that are close to interchanges; proposed advertising signs must fit within the parameters. This system, as codified in the South African Road Traffic Signs Manual (SARTSM), is intended, "to allow adequate time for the driver to read, interpret and react on the information on the road sign" (p. 7). (29) The authors report that for a recent review period, 86.7 percent of all applications were rejected. Of those, 40.8 percent were rejected because the advertisement was too close to existing road signs, 20 percent were rejected because the sign disrupted the flow of information to the driver, and 7.5 percent were rejected because the sign was too close to a ramp gore.

As a result of his work cited immediately above, Coetzee reviewed literature, performed a regulatory analysis, and recommended changes to regulations for outdoor advertising control in South Africa. Although superficially similar to regulations in the United States, billboard control in South Africa goes much further, regulating the design and amount of information (in bits) that can be displayed on a given sign, as well as the proximity of two or more advertising

signs to one another and to road features, such as official signs and interchanges. In South Africa, message sequencing, visual clutter, and sign size are restricted for different display technologies. This document includes a description of the terms *critical event* and *critical zone*, and it demonstrates how regulations would control advertising signs in these applications. Coetzee finds support from the earlier work of Ogden and the experiments of Johnston and Cole, concluding that, whereas drivers may be able to ignore advertisements when the driving task requires attention, it is possible that an attention-getting sign can assume primary importance and interfere with not only any spare capacity that a driver might have but also the information processing capacity reserved for primary task performance. The danger arises, according to Coetzee, when processing the information on the advertisement interferes with the driver's principal vehicle control task in situations that demand attention and rapid reactions. The Coetzee report is the only work in the present review of the literature that has attempted to establish the parameters of billboard location and content based on theories of information processing and cognitive demand.

2.7 CONCLUSIONS FROM LITERATURE REVIEW

2.7.1 Basic Research Question

The basic research question being addressed in the present report is whether the presence of CEVMS used for outdoor advertising is associated with a reduction in driving safety for the public. When regarded from a scientific perspective, the present literature review does not provide an adequate answer to this question. The studies reviewed are inconclusive.

The present literature review reveals a disjointed array of isolated studies revealing sometimes contradictory and inconclusive results. Some studies show statistically significant driver safety concerns or distraction effects, but not all levels of distraction have negative safety impacts. Some studies go one step further and compare a statistically significant distraction with a criterion level of distraction claimed to represent the threshold of negative safety performance. This approach represents a substantial improvement, but it depends heavily upon the veridicality of the chosen criterion level of distraction. Other studies show no statistically significant safety or distraction effects at all, or they show mixed results. Some studies which show no statistically significant safety or distraction effects have been demonstrated to have serious flaws in their experimental and/or statistical designs. These studies are often plagued with two intrinsic methodological problems. First, they may not have sufficient measurement accuracy and precision to distinguish CEVMS distraction from noise in the data. Second, they may not have sufficient statistical power to reveal a small but important distraction effect which may really exist; i.e., they have not sampled enough events, drivers, or conditions to demonstrate an effect which may be obscured by variability due to sampling. In summary, from the perspective of strict statistical hypothesis testing, the present literature review is inconclusive with regard to demonstrating a possible relationship between driver safety and CEVMS exposure. From this perspective, the more stringent restrictions on the placement of billboards found in other countries might be regarded as a conservative precautionary measure, erring on the side of protecting public health from a possible but unproven threat and not as a response to an established driving safety hazard. That is not to say that such a conservative approach is inappropriate, but it should be acknowledged as such.

The present literature review does reveal a preponderance in the number of studies (5:1) which show some driver safety effects due to traditional billboards and CEVMS in comparison with the number of studies that show no driver safety effects at all due to these stimuli. In addition, four other studies show mixed results. Three lists were prepared below to demonstrate this outcome. These lists included only empirical research studies, regardless of the methodology employed. Studies that reviewed literature or practice were not included unless they also contained an original research component. Studies previously reviewed in the earlier FHWA projects were also not included.

The following research studies reported potential adverse safety effects for all dependent measures:

- Wisconsin Department of Transportation. (4)
- Young. (16)
- Crundall, et al. (17)
- Young and Mahfoud. (18)
- Chan, et al. (19)

The research study by Tantala and Tantala⁽⁸⁾ reported no adverse safety effect on any dependent measure.

The following research studies reported potential adverse safety effects using some dependent measures and no effects using other dependent measures:

- Lee, McElheny, and Gibbons. (12)
- Beijer, Smiley, and Eizenman. (14)
- Beijer. (15)
- Smiley et al.⁽⁷⁾

Such an outcome could lead one to conclude that there is more evidence for a possibly meaningful negative safety impact than evidence against such an impact. This conclusion is not warranted for at least two reasons. First, a simple tally of the number of studies which support a given research hypothesis compared with the number of studies which do not support the hypothesis may be misleading. Such a tally neglects to weight the various studies for their intrinsic strength of experimental design, statistical power, and care of execution. One strong landmark study with a robust experimental design and a sufficiently large sample of cases or drivers can topple a host of weaker investigations with fewer credentials. Yet, credentialing and weighting studies can become a subtle and subjective matter. It is difficult to judge studies on their relative strengths because it requires experience and judgment. While it may be relatively

easy to identify the champion study and give that study a strong weighting, it is more difficult to evaluate the weaker studies at the middle and bottom of the list.

Second, there is a strong propensity in scientific research to search for differences. The current Western model of reductionist scientific inquiry, coupled with its reliance on the paradigm of parametric statistics, is aligned against supporting the null hypothesis. This hypothesis states that there are no observed differences between two or more different treatments, i.e., that matters under scientific scrutiny are due to chance. This propensity to search for differences is so strong that when anticipated results are small or subtle, researchers often seek out conditions in nature that are worst case examples to find any affect at all. This causes the results to suffer from a lack of generalization when the entire population becomes the frame of reference. Thus, the present literature review acknowledges a possible natural and intrinsic bias toward including more studies that show a possible distraction effect of CEVMS exposure than studies that do not. Once these two considerations are recognized—a lack of weightings for comparing studies and a propensity to emphasize differences—the present literature review realigns to its original inconclusive outcome. In summary, present scientific techniques are not adapted to providing proof that CEVMS do not distract drivers; they only afford opportunities to demonstrate that they do distract drivers and possibly to what extent. If the demonstrated extent of distraction is minor and below the accepted criterion to interfere with safe driving, then the safety impact may be considered negligible.

2.7.2 Methodological Implications

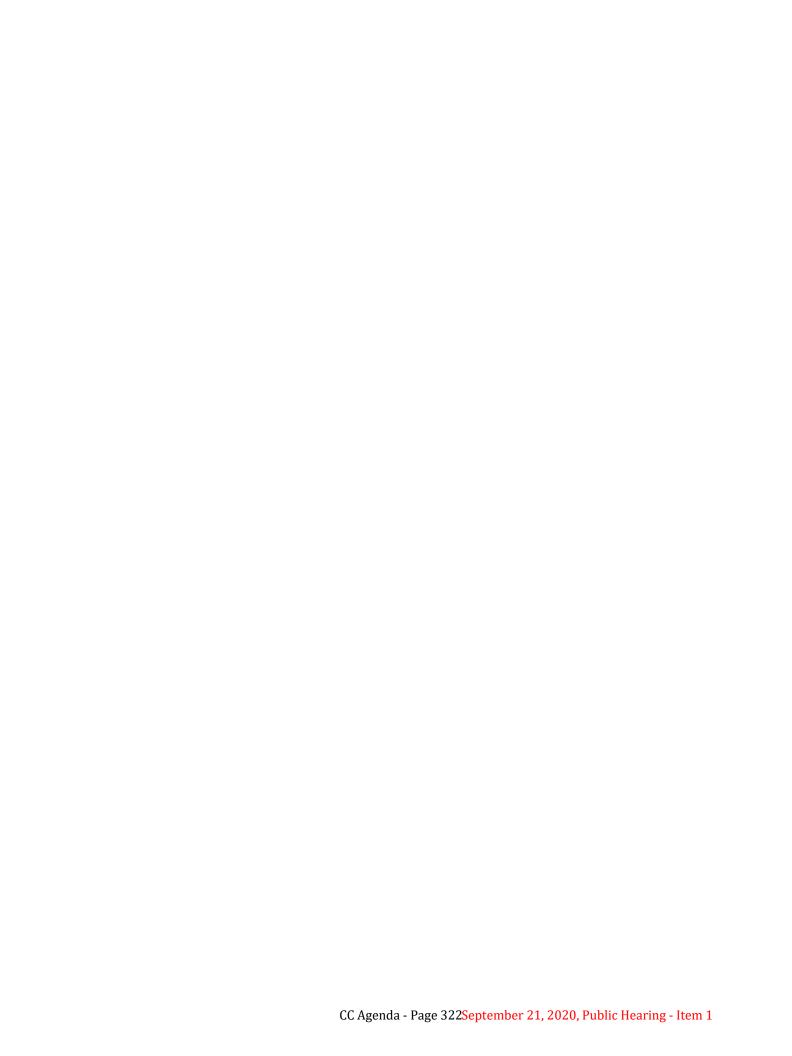
The inconclusive literature review findings suggest the need for carefully controlled and methodologically sound investigations of the relationships between CEVMS, driver distraction, and safety. The review also suggests several factors that need to be considered in future research. One plausible model posits that drivers often have spare attentional capacity, and they can afford to divert their visual attention away from the driving task to look at objects irrelevant to the driving task, such as CEVMS. According to this model, when driving demand increases because of fixed hazards (such as dangerous roadway geometry or complex interchanges) or transient hazards (such as slowing traffic, vehicle path intrusion, or adverse weather), spare capacity is reduced or eliminated, and the driver devotes more capacity to the driving task. In this model, driver workload emerges as an important issue. By applying this model, in some countries, outdoor advertisements are not allowed in areas where known fixed hazards exist. Such locations include, but are not limited to, sharp horizontal or vertical curves and areas where high cognitive demand is imposed by the roadway, traffic, or environment, like intersections, interchanges, and locations of merging or diverging traffic. In some countries, billboards are also not allowed where they might interfere with the processing of important information from official road signs. These prohibitions do not in themselves prove that distraction is worse in high driver workload situations. However, they do point to the need to consider conditions of differing driver workload in an effective future research program on possible safety effects from CEVMS exposure.

When scanning for hazards, drivers' eye movements tend to fall within a horizontal window centered on the focus of expansion in the forward view. This focus of expansion is related to the visual flow of the moving scene where points and objects all emerge from a single point. Because an attention-getting billboard may be able to attract a driver's glance even unintentionally, a CEVMS that falls within this scanning pattern can interrupt the pattern and

cause a distraction at an inopportune time. Furthermore, research suggests that the distraction from a roadside billboard may be unconscious. Consequently, drivers may not be aware that they are being distracted, and they are unable to verbalize that any distraction occurred. Although where someone's eyes look may not be the same as where his or her attention is focused, a theoretical connection may be implied. Through this connection, measurements of eye glance behavior permit the researcher to gain potential entrance into this realm of unconscious allocation of attention. This allocation of attention should play an important role in an effective program for future research.

In addition, it cannot be assumed that all CEVMS are equal, even those of the same size, height, and LED technology to display their images. The impact of a CEVMS in an undeveloped area with relatively low levels of nighttime ambient lighting may be quite different from that of a CEVMS in a more urban context among other buildings and structures in an area with high nighttime illumination levels. Furthermore, characteristics of the CEVMS displays may, in and of themselves, lead to measurable differences in distraction, such as information density, colors of figure and background, character size and font, and message content. These characteristics cannot be assumed to be equivalent for purposes of comparisons. One possible solution to this problem may be for future research studies to exercise a certain degree of experimental control over the CEVMS message itself. This may require a deeper level of cooperation with the billboard industry than has been encountered in previous studies. Such increased cooperation could be beneficial in establishing a collaborative research environment among industry, government, and university stakeholders.

Finally, a frequently changing CEVMS, which can generally be seen long before it can be read, raises a particular concern for distraction. This is because drivers may continue to glance at the CEVMS to observe changes in varying content with various sizes of lettering until the sign content can be read. The implication here is that future studies may need to embrace longer viewing distances.



3.0 KEY FACTORS AND MEASURES

The study of possible CEVMS effects on driver safety represents a complex research endeavor. There are numerous key factors affecting a driver's response to CEVMS. Many of these influential factors may be designated as independent research variables in need of specification or control within a given research design. Likewise, there are numerous inferred measures of driver safety which may serve as possible dependent variables for observation and measurement. Depending upon the specific research design, some of these independent and dependent variables may swap places.

3.1 KEY FACTORS (INDEPENDENT VARIABLES)

For classification purposes, the key factors, or major independent variables, may be categorized into various types. The list of key factors shown below gives some of the independent variables which might be considered in the study of possible safety effects of CEVMS. These key independent variables were selected from a more comprehensive analysis by means of a process to be described later. This analysis grouped all of the independent variables into five major categories according to source as follows:

- Billboard.
- Roadway.
- Vehicle.
- Driver.
- Environment.

After this initial analysis, a subsequent evaluation selected only the most important, or key, factors or variables. Each category lists the key independent variables which belong to that category. The lists below contain independent variables from four of the five above mentioned categories. The vehicle category is missing because all of the variables belonging to that category were eliminated in the selection process. For cross reference purposes, the decimal number shown in brackets to the right of each variable gives the outline number from the more detailed analysis upon which the selection was based (see table 1 in appendix A). In parentheses to the right of certain variables are given some examples and explanations which serve to clarify that particular variable.

The following are the key factors relating to the billboard:

- Location [1.1] (lat./long., GPS, mile marker, survey location, reference location).
- Sight distance [1.1.3].
- Resolution [1.2.3] (dpi, LEDs/inch, crispness).

- Luminance [1.2.4] (brightness).
- Contrast ratio [1.2.4].
- Day/night settings [1.2.4].
- Change rate [1.3.2] (image changes).
- Dwell time [1.3.2].
- Change time [1.3.2].
- Sequencing [1.3.2] (apparent motion).
- Full motion video [1.3.4].
- Engagement value [1.3.5] (ability to hold attention).
- Message [1.4].

The following are the key factors relating to the roadway:

- Category [2.1.1] (two-lane rural, collector, arterial, freeway).
- Geometry [2.2.2] (curve radius: horizontal, vertical).
- Intersection [2.2.3] (signalized, stop controlled).
- Interchange [2.2.4].
- Exit [2.2.4].
- Entrance [2.2.4].
- Merge [2.2.4].
- Gore [2.2.4].
- Traffic [2.3] (average daily traffic, peak traffic, level of service).

The following are the key factors relating to the driver:

- Age [4.1].
- Gender [4.1].
- Demographics [4.1].

- Years driving [4.2].
- Route familiarity [4.2].
- State [4.3] (alert, fatigue, alcohol, drugs).

The following are the key factors relating to the environment:

- Visual clutter [5.1.1].
- Nearby billboards [5.1.1].
- Ambient lighting [5.1.1].
- Official signs [5.2] (illuminated, luminous (VMS), retro-reflective).
- On-premise signs [5.3] (conventional, tri-vision, digital, full motion video).

The combined list of key factors given above represents a subset of the most influential independent variables in terms of importance to a future program of research. This subset of variables was selected from a more extensive list of the major independent variables which might play a role. As mentioned previously, the list of all major independent variables may be found in outline form in table 1 in appendix A. The bracketed decimal numbers in the list of key factors refer to the corresponding outline numbers in table 1. In addition, the table cites some of the advantages and disadvantages of employing that particular variable. The combined list of key factors presents the 32 variables which were judged to be the most influential variables from table 1.

The more comprehensive and detailed analysis represented in table 1 identifies considerably more possible independent variables. The approximately 60 types of variables listed in the table are further broken down into 185 specific subtypes or levels of independent variables which could play an important role in studying the possible effects of CEVMS on driver distraction and roadway safety. It is encouraged to carefully examine the many independent variables and their advantages and disadvantages, as described in table 1 in appendix A, to gain a greater appreciation of the complexity of the research problem. With such a profusion of important factors affecting the study of CEVMS effects, no single experiment could possibly answer all of the relevant scientific or engineering questions.

The key independent variables were selected from the expanded list represented in table 1 by three senior research psychologists, all coauthors of the present report and familiar with CEVMS research. The criterion for selection was the importance of that factor in conducting research on CEVMS effects. Thus, the list of key factors indicates critical independent variables which need to be considered in any proposed program of research. The brightness and crispness, or photo realism, of the CEVMS images are extremely important. Any image changes, apparent motion or video motion in the CEVMS, and location parameters are also critical factors. The next level of importance relates to environmental factors. Two distinct classes of variables must be taken into account: general visual clutter and the presence of other off-premise commercial CEVMS

(nearby billboards). In particular, compelling information from CEVMS used for advertising may conflict with important roadway safety information conveyed by nearby traffic control devices (official signs). The question should also be raised concerning possible enhanced distraction caused by the urgency of Amber Alerts and other public safety messages displayed on CEVMS. Any contextual links among the messages from several sequential CEVMS, as well as any specific user interactions with the CEVMS must be taken into account. Factors to consider for drivers include their familiarity with the driving route and the expected presence or absence of CEVMS. Lastly, the complexity of the roadway geometry and the volume of traffic are likely to play significant roles.

3.2 KEY MEASURES (DEPENDENT VARIABLES)

The study of driver safety is a complex area of investigation. There are numerous objective, inferred, and subjective measures of driver behavior which might serve as dependent variables in a program of proposed research on the possible safety effects of CEVMS. As demonstrated in the discussion concerning independent variables, the key measures or dependent variables may be categorized into types. The list of key measures shown below gives 28 key measures, or dependent variables, which might be considered possible safety effects of CEVMS. As was the case for the list of key factors (independent variables), the list of key measures represents a down selection from a more extensive list of the major dependent variables of interest (see table 2 in appendix A). The dependent variables are grouped into the following four major categories:

- Vehicle behavior.
- Driver and vehicle interactions.
- Driver attention and distraction.
- Crashes.

The structure of the list of key measures for dependent variables is similar to that for the list of key factors for independent variables. In the case of dependent variables, the major variable categories of driver and vehicle interactions and crashes found in table 2 are missing from the list of key measures below because all of the variables belonging to these two categories were eliminated in the selection process.

Key measures relating to vehicle behavior are as follows:

- Speed [1.1] (continuous, exceeding speed, speed variance).
- Lane position [1.2] (continuous, lane excursions, lane variance).
- Acceleration [1.3] (longitudinal, lateral, heave).
- Other vehicle interactions [1.4].
- Headway [1.4.1] (time to collision).

- Gap acceptance [1.4.2] (merge, passing).
- Conflicts [1.4.3] (near-crashes).
- Violations [1.4.4] (red light running, failure to yield, failure to stop).
- Errors [1.4.5] (missed exit, wrong lane).
- Timing [1.4.6] (late movements, premature movements).
- Infrastructure interactions [1.5].
- Response to roadway geometry [1.5.1] (swerves, sudden braking).
- Response to traffic control devices [1.5.2] (misses, delays).
- Pedestrian interactions [1.5.3] (yields).

Key measures relating to driver attention/distraction are as follows:

- Eye glance behavior [3.1.1] (number and duration of glances, glance object).
- Distractor performance [3.1.2] (secondary task).
- Visual occlusion [3.1.3].
- Feature detection [3.1.4].
- Feature recognition [3.1.5].
- Driver workload [3.1.6] (task performance).
- Head turning [3.1.7].
- Driver errors [3.1.8].
- Reaction time [3.1.9] (perception-reaction time).
- Surprise [3.2.1] (orienting response).
- Conspicuity [3.2.2] (attention grabbing).
- Search patterns [3.2.3].
- Capacity [3.2.4] (self-regulated attention, spare capacity).
- Subjective measures [3.3].

As mentioned above, the more detailed analysis underlying the combined list of key measures shown above may be found in table 2 in appendix A. Table 2 for the dependent variables has the same general structure as table 1 for the independent variables. The approximately 65 types of dependent variables listed in table 2 are further broken down into 105 specific subtypes or levels of variables which could play an important role in measuring the possible effects of CEVMS on driver distraction. As noted before, it is encouraged to carefully examine the many dependent variables and their advantages and disadvantages, as described in table 2 in appendix A, to gain a greater appreciation of the wide variety of ways that driver safety can be measured as they relate to possible influences from CEVMS. With so many potential measurement techniques available, care must be taken in selecting appropriate dependent variables for any proposed program of research.

Only the key dependent variables are listed in the combined list of 28 key measures given above. They were selected by the same process used to select the key independent variables in the list of key factors. As indicated before, the criterion for selection was importance in conducting research on CEVMS effects. Thus, the list of key measures indicates critical measures which need to be considered in future research. Eye glance behavior can serve as a particularly important potential indicator of specific visual distractions. The concept of self-regulated attention is very important for establishing excessive levels of distraction, despite difficulties in establishing a criterion threshold. This concept refers to attention that is under the driver's conscious control, as opposed to involuntary attention, which may compel the driver to glance away from the road for an excessive amount of time. Increases in driving conflicts and errors are likewise effective measures of safety. The next level of importance relates to other observations of vehicle behaviors, including determinations of acceleration, lane position, and speed. Similarly important infrastructure interactions, such as driver responses to roadway geometry and traffic control devices, need to be considered.

4.0 RESEARCH STRATEGIES

To successfully investigate the potential safety effects of CEVMS, the key factors (independent variables) and key measures (dependent variables) described in the previous section need to be selected, combined, and integrated into an effective research strategy. There are a number of possible research strategies that could address the basic research question. The list of recommended research strategies shown below lists eight key research approaches that might be considered. This list was generated from a more comprehensive and detailed analysis of the research strategies which might be of interest. This comprehensive analysis of research strategies was divided into six major groups (see table 3 in appendix A). The first group focuses on observing or counting actual motor vehicle crashes as they might occur or have occurred in the field. This field portion includes retrospective crash data base studies. The second group entails observing motor vehicle crashes as they might occur in a driving simulator. The third group involves observing safety surrogate measures as they might actually occur in the field. The fourth group focuses on observing safety surrogate measures as they might occur in a driving simulator. The fifth and sixth groups relate to social surveys and analytical studies. In this instance, the down-selection process eliminated all research strategies concerning crashes, social surveys, and analytical studies. Within the parentheses next to each strategy are some selected advantages and disadvantages associated with using that type of strategy in conducting research.

Only the key strategies are shown in the list of recommended research strategies. They were selected by the same process used to select the key independent and dependent variables, with one important exception. This exception involves the incorporation of several assumptions which were derived from the antecedent analysis of potential independent and dependent variables. First, the brightness, sharpness, photo realism, and visual context of the CEVMS are extremely important. Since these characteristics are difficult to reproduce in a laboratory, laboratory methods tended to be judged low. In addition, certain participant-related variables, in particular eye glance behavior, are highly effective measures of distraction and workload. Any research method that supported the measurement of such variables tended to be judged high. Last, crash data involve rare events with multiple causal factors, making them difficult to measure. The CEVMS technology is too new to have an adequate crash heritage. In general, crash estimation methods tended to be judged low.

After incorporation of the above assumptions, the following final list of recommended research strategies was developed. This final list included strategies from only two of the original six groups of strategies.

The recommended research strategies for the safety surrogate field group include the following:

- Unobtrusive observation [3.1] (natural driving context/no eye glance data, expensive).
- Naturalistic driving [3.2] (natural driving context/insensitive eye glance data, expensive).
- On-road instrumented vehicle [3.3] (experimental control, sensitive eye glance data, efficient, cost effective/artificial drive purpose).

- Closed-course test track [3.4] (stimulus control, efficient, cost effective/out of context driving).
- Commentary driving [3.5] (easy/artificial response, interfere with driving).
- Non-vehicle based field testing [3.6] (easy/artificial, out of context).

The recommended research strategies for the safety surrogate laboratory group include the following:

- Driving simulator [4.1] (experimental control, sensitive eye glance data, efficient/limited stimulus, artificial).
- Non-simulator laboratory [4.2] (relatively easy/artificial, out of context).

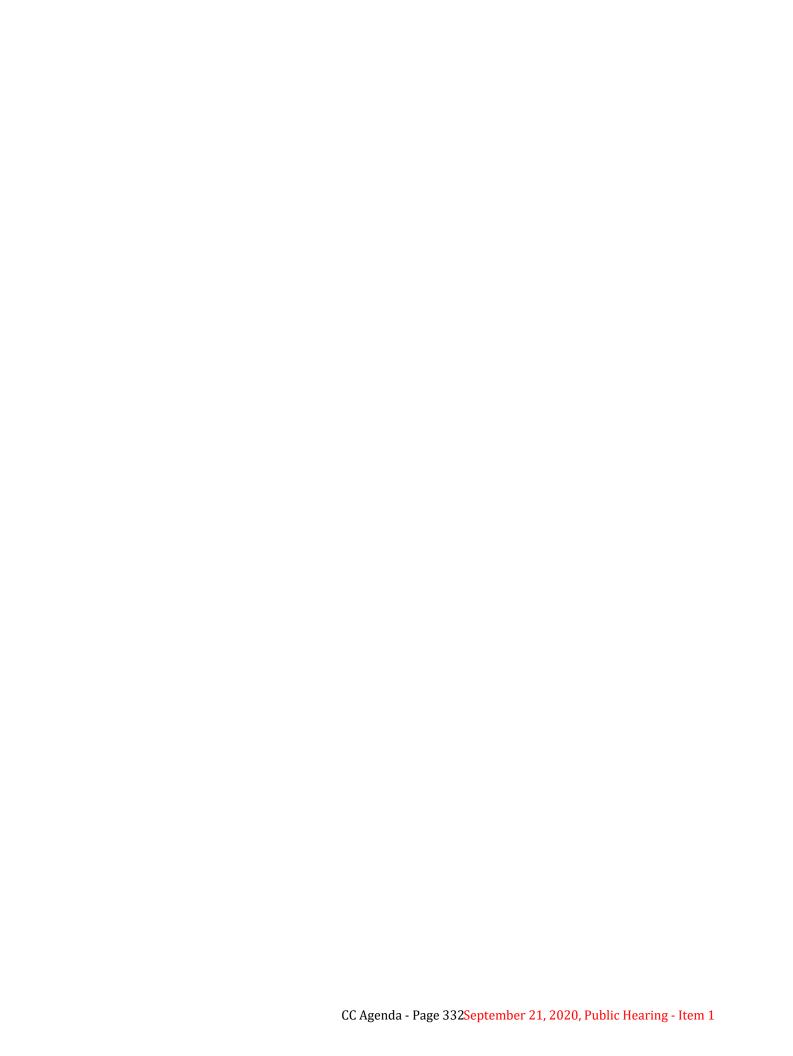
The more detailed analysis underlying the above combined list of recommended research strategies may be found in table 3 in appendix A. In the table, the more comprehensive analysis of research strategies is further broken down into approximately 55 specific categories and 165 subtypes or levels of these categories. The reader is encouraged to carefully examine the many strategies and their advantages and disadvantages, as described in the table, to gain a greater appreciation of the wide variety of potentially relevant research methods which might be employed to study possible CEVMS effects.

Table 3 can be used to discriminate among potential candidate research strategies. Certain research strategies can be eliminated from further consideration. Analytical studies cannot fill knowledge gaps and consequently often fall prey to reliance on unfounded assumptions. Social surveys are based on memory and opinion, and they are generally administered far from the event of interest both in terms of time and space. Crash rates, whether observed in the field or in the laboratory, represent extremely rare events, which are often the result of multiple complex causes and thereby difficult to evaluate. CEVMS technology has not been deployed long enough to accumulate a sufficient number of proximal motor vehicle crashes to make reliable estimates concerning population crash statistics in the field. Driving simulators used to measure safety surrogates have the advantage of careful control over stimulus parameters and testing conditions, but they suffer the disadvantage of being unnatural and artificial. More importantly, driving simulators have difficulty reproducing the luminance contrast and bright photorealism of the new CEVMS technology. In a similar manner, the closed-course test track and non-vehicle based field testing techniques represent a comparatively artificial and out-of-context experimental environment even though they are conducted in the field. Finally, commentary driving also affords natural billboard stimuli, but the driving task becomes somewhat artificial.

The three research strategies which were judged to be the most effective were the on-road instrumented vehicle, the naturalistic driving, and the unobtrusive observation method, which were all used to measure driver distraction and safety surrogates. Thus, the outcome of the present investigation of research strategies recommends three primary candidates for consideration in any program of future research to study the possible effects of CEVMS on driver distraction and roadway safety. Each of the three study methods represented has its own unique advantages and disadvantages. All three of these top candidate research strategies should

be considered in developing any future research program on CEVMS effects. They provide the basis for selecting a recommended first stage study in such a program.

This is not to say that other research strategies do not have a significant role to play in a comprehensive research program directed toward a common goal. For example, if significant negative CEVMS safety effects have already been found using one of the primary research strategies, subsequent driving simulator experiments might be employed to systematically vary certain billboard location, timing, or spacing parameters in a controlled and consistent manner to establish billboard placement guidance. In addition, combinations of research strategies can result in synergistic efficiency. For example, both the unobtrusive observation and the naturalistic driving methods naturally support the simultaneous collection of crash, near-crash, or safety surrogate data. The analysis of crash data will also be needed to relate measures of driver distraction to more direct determinants of roadway safety.



5.0 FUTURE RESEARCH PROGRAM

As stated previously, it is not possible to answer all of the critical questions concerning possible attention, distraction, and safety impacts from CEVMS in a single experiment. Instead, a carefully crafted program of research needs to be conceived and implemented to embrace a series of interrelated experiments and studies directed at answering different facets of this complex issue. This section describes the important elements of a recommended research program. This research program is broadly defined to provide a background and context for more concrete alternative first stage studies outlined in section 6.0. This section describes a long-range multistudy research program covering a number of years. Section 6.0 will outline three methods for implementing the first stage of that program.

5.1 STAGES

The proposed research program would have the following three stages:

- Stage 1—The attention and distraction effects of CEVMS would be investigated to
 determine whether any observed or measured distractions due to CEVMS is sufficient to
 interfere with attentional criteria for safe driving. This stage is directed at discovering
 whether or not distraction from CEVMS represents a potential driving hazard. Initial
 CEVMS parameters must be chosen carefully so as not to bias the result from the outset.
- Stage 2—If potential interfering distraction is observed, it would be necessary to investigate the relationship between the observed distraction and various CEVMS parameters (e.g., luminance, change rate, distance, CEVMS spacing, engagement level of sign content, and road geometry) to determine possible limitations on CEVMS deployment and operation which might reduce distraction to noninterfering levels. This stage is directed at developing empirical data to support the development of possible restrictions or regulation of CEVMS to reduce potential driving hazards.
- Stage 3—As related to CEVMS, researchers would have to investigate the relationship between distraction, defined in terms of eye glance behavior and safety surrogate measures (driving conflicts, errors, etc.), and safety, defined more directly in terms of crashes, fatalities, injuries, and property damage. This stage focuses on validating the eye glance and safety surrogate measures used to infer attention and distraction effects of CEVMS through the primary safety criterion of protecting life, health, and property.

The above stages of the proposed research program are to be pursued sequentially. The initial stage is directed at determining whether or not a potentially harmful CEVMS distraction effect exists. To demonstrate such a distraction effect, an independent and objective threshold criterion of excessive distraction must be employed. If no potentially harmful distraction is shown, at least as far as driving safety is concerned, there would be little need to pursue the second stage of developing a basis for regulating CEVMS or the third stage of relating CEVMS distraction to more direct measures of safety (crashes). If potentially harmful distraction is shown in the first stage, the second and third stages would be implemented in order. The order of the last two stages may appear to be reversed. Normally, it would seem desirable to establish a relationship

between CEVMS distraction and crashes before developing a basis for regulation. However, in this instance, the LED-based digital CEVMS technology is so new that it will not be possible to reliably measure crashes for some time. Meanwhile, if possible distraction is shown, the community of practitioners engaged in outdoor advertising control will need near-term technical information on the luminance, contrast, change rates, and spacing of CEVMS to minimize that distraction. For this reason, the stages have been proposed in the order given above.

5.2 APPROACH

The literature review update in section 2.0 points to some important principles that should be incorporated into the proposed program of research to enhance the probability that the program can successfully achieve its goals. These principles can be regarded as lessons learned from the experience of previous research. First, empirical studies should employ CEVMS stimuli, as well as a variety of comparison stimuli, including standard (non-digital) billboards, built objects of casual visual interest (e.g., houses, barns), and natural background control scenery (e.g., trees, fields). This principle establishes a relevant visual context against which to contrast CEVMS stimuli. Next, empirical studies should be constructed so as to compare the effects of CEVMS and the effects of the various comparison stimuli. This principle implies that some measurable (statistically significant) effect should be demonstrated for as many of the comparison stimuli as possible, at least for the standard billboards. It is necessary to show some distraction effect for both CEVMS and standard billboards relative to a baseline to be sure that the study is not just measuring random noise in the data. In addition, for the case of distraction and safety surrogate performance measures, the measured effects of CEVMS and standard billboards need to be compared with each other and with an independently determined criterion of potentially harmful consequences. The application of this criterion needs to incorporate the concept of self-regulated attention, as indicated in section 3.0. Last, to the degree possible, direct experimental control should be exerted over the CEVMS stimuli. In the first stage of determining a meaningful distraction effect, this control can be limited to turning the CEVMS on and off for predetermined periods according to a strict experimental protocol. In the second stage of establishing possible parameter limitations, this control may need to be expanded to changing the luminance, message change rate, or some other CEVMS characteristic according to an experimental protocol.

These four principles define the basic approach for implementing the proposed research program. They provide guidance and direction to the proposed program. It should be emphasized that only a systematic multiyear broad program of research can adequately answer the important questions posed by the community interested in outdoor advertising control concerning the possible distraction effects and safety implications of CEVMS. No single experiment can provide the solution. It should also be emphasized that all stages of the research program must be sensitive to the practical needs of the outdoor advertising community, which includes highway engineers, traffic engineers, the outdoor advertising industry, environmental advocates, and outdoor advertising regulators. Even though the second stage is where most of these practical needs are addressed, at all stages of the research, investigators need to try to provide practical information on the luminance, contrast, change rate, display size, display spacing, or other parameters over which the outdoor advertising community could possibly exert some control. Administrators concerned with issuing permits for billboards need practical engineering results to assist them in there daily jobs.

5.3 STRUCTURE

As outlined above, the proposed research program consists of three stages. The first stage focuses on determining the potential existence of harmful distraction effects due to CEVMS. The second stage involves determining limitations or restrictions to CEVMS parameters which could reduce or eliminate the implied potentially harmful distracting effects. The third stage focuses on relating the reduction in implied potentially harmful distraction to actual safety benefits of decreasing crashes, fatalities, injuries, and property damage on the roadway. The sections below describe these stages in more detail.

5.3.1 Stage 1—Determination of Distraction

The first stage, to determine the potential existence of harmful CEVMS distraction, may be implemented in many different ways. According to the analysis of research strategies in section 4.0, the three most effective approaches are the on-road instrumented vehicle, the naturalistic driving, and the unobtrusive observation methods.

The on-road instrumented vehicle method is sensitive to a wide range of variables, including accurate eye glance measurements. It affords the opportunity to ensure that the test participants drive by many CEVMS and comparison sites in a structured and reproducible manner.

The naturalistic driving method is similar to the on-road instrumented vehicle technique, but it has less control since the test participants drive their own vehicles according to their own personal daily schedules. As a result, the participants may pass few, if any, billboards. Furthermore, the naturalistic driving method has difficulty supporting accurate eye glance measurements, and it requires considerably more effort and expense. However, the naturalistic driving method is less artificial and has a high degree of face validity.

Although the unobtrusive observation method also involves considerable effort and expense, the data collected are based on the observation of vehicles rather than individual drivers. The unobtrusive observation method is the least artificial of the three because with this technique, research participants are generally unaware of being observed.

This first stage of the research program would employ one or more of these study approaches as a first step. A single method could be selected, or more than one approach could be combined. For example, the on-road instrumented vehicle and the unobtrusive observation method could make an effective combination, but the cost would be high. In either case, this first stage should also be designed to answer, at least in a preliminary manner to whatever degree possible, some of the practical questions of interest to the community concerned with outdoor advertising control.

5.3.2 Stage 2—Basis for Regulation

If the results of the first stage reveal a CEVMS driver distraction effect sufficient for public concern, then the second stage of the proposed research program would be implemented to provide an initial technical basis for possible regulation. This stage would consist of a series of eye glance and safety surrogate evaluations in the field and in the laboratory designed to investigate the various parameters of CEVMS which contribute to driver distraction. Although field methods can capture the realism of the CEVMS stimulus, they do not allow the researcher

to independently vary a variety of CEVMS parameters one at a time so as to isolate the effect of that variable, as some of the laboratory techniques would. For example, this second stage might begin with attempts to estimate the gross effects of certain salient CEVMS parameters in the field. Throughout this section, the brightness of the CEVMS will be used as an example, but the approach can be adapted to many other relevant CEVMS characteristics. For example, many current CEVMS displays adjust their brightness for day and night. If the outdoor advertising industry would agree to adjust the brightness of several installations both during the day and at night for the purposes of experimentation, partial estimates of the effects of brightness on eye glance behavior might be elaborated for selected luminance levels.

To obtain a more complete functional relationship between eye glance distraction and CEVMS luminance, a test track or driving simulator experiment might be devised. If it were possible to erect an experimental CEVMS installation at a test track location, the test track experiment would have realistic brightness and contrast levels, as well as controlled exposure conditions. However, it would suffer from a highly constrained and unnatural driving environment. The driving simulator experiment could easily portray a wide variety of driving environments with realistic contexts, but it would suffer from a severely restricted range of luminance and contrast ratios. Nonetheless, to overcome these disadvantages, correction factors or transformations might be applied to the test track data to account for discrepancies in level of attention and to the driving simulator data to account for photometric discrepancies. The incorporation of such correction factors or transformations to relate test track and laboratory data to driving data on real roads underscores the necessity of conducting a combination of field and laboratory testing environments in this stage of the proposed research program. Some degree of field validation needs to be a part of any laboratory component of the research during this stage.

This second stage of the research program must be designed to answer, to the degree possible, the practical questions of the community interested in outdoor advertising control. This is the stage of research which addresses functional relationships regarding the effects of CEVMS luminance (brightness), change rates, size, display spacing, and other variables on driver distraction and roadway safety. These functional relationships could subsequently be translated by outdoor advertising administrators and regulators into concrete rules which protect the safety of the driving public while at the same time allowing commercial growth and the rights of the outdoor advertising industry. To be fully successful, this stage of the research program must be pursued with active participation from all stakeholders, which include industry, environmentalists, researchers, and regulators alike.

5.3.3 Stage 3—Relationship to Crashes

The third stage of the proposed research program relates changes in potentially harmful distraction effects due to various CEVMS parameters to changes in actual roadway safety (crashes and their consequent fatalities, injuries, and property damage). This stage is directed at validating the earlier findings with regard to CEVMS distraction based on eye glance and safety surrogate measures in the context of retrospective crash data. This stage of the program would likely employ the Empirical Bayes, or Bayesian, method of analyzing crash statistics. The Bayesian approach formally incorporates prior knowledge into the process of current research, and it translates probabilistic calculations into statements of belief concerning statistical hypotheses in place of the classical confidence interval concept employed in parametric

statistics. The Empirical Bayes method also incorporates the crash history of other control sites with similar traits to account for extraneous factors which may be influencing the crash data at the site of interest. In short, the Empirical Bayes method possesses distinct statistical advantages over the naïve before/after technique and even the before/after technique with a simple control. The Empirical Bayes method is well suited for the task of estimating vehicle crash rates along different stretches of roadway, including those stretches with CEVMS. The prediction of baseline crash rates, and their potential increase or decrease with the introduction of CEVMS, is essential to this final stage of the proposed research program. This final stage should also be designed to answer, to whatever degree possible based on crash statistics, some of the practical questions of interest to the community concerned with outdoor advertising control. Because of the low numbers of crashes and their susceptibility to multiple determining causes, considerable effort, time, and expense will likely have to be expended on this final stage.



6.0 RECOMMENDED FIRST STAGE STUDY

The first stage of the research program, determination of distraction, provides the context for selecting the recommended next study. The first goal of this stage of the program is to determine whether any observed or measured distraction due to CEVMS is sufficient to interfere with attentional criteria for safe driving. The second goal is to provide some preliminary practical technical information that could be of help to the community interested in outdoor advertising control. This goal could consist of furnishing initial indications of the possible distraction effects produced by one or more of the concrete variables over which the community might exert some control, such as luminance (brightness), change rate, display size, and display spacing. According to the analysis summarized in section 4.0, to provide an initial answer to these types of questions, the three most effective research strategies are the on-road instrumented vehicle. the naturalistic driving, and the unobtrusive observation methods. In the present section, one possible preliminary study is briefly described using each of these three approaches. A more detailed description of each study approach is given in appendix B. This detailed description includes more specific information on the general method, factors and measures employed, advantages and disadvantages, and budgetary cost. After project initiation, a more comprehensive work plan and more in-depth budget will need to be developed. That comprehensive work plan should receive inputs from all of the important stakeholders in CEVMS research, which include industry, environmentalists, researchers, and regulators alike. After careful and thorough deliberation, the final details of that comprehensive work plan and budget may differ considerably from what is suggested in this section or in appendix B.

6.1 SUMMARY OF STUDY APPROACHES

6.1.1 On-Road Instrumented Vehicle

The on-road instrumented vehicle method employs an instrumented vehicle which is brought to the study site. The study site is a location where there are one or more CEVMS installations along a public access roadway. Each research participant drives the instrumented vehicle along a prescribed route, which includes CEVMS installations, standard (non-digital) billboards, objects of casual visual interest (e.g., houses and barns), and natural background control scenery (e.g., trees and fields). Each participant completes several such drives. The instrumented vehicle is capable of measuring vehicle speed, vehicle lane position, longitudinal acceleration, lateral acceleration, GPS time and position, and driver eye glance direction and duration. The instrumented vehicle is also equipped with accurate vehicle-mounted or head-mounted eyetracking equipment, video cameras (forward and cab views), and a voice recorder. The major independent variable in the study is the presence or absence of CEVMS and other comparison visual stimuli along the driving path. If possible, the CEVMS should be capable of being turned off and on or changing along some other dimension like luminance or change rate, according to a prearranged experimental design. Other important independent variables are the time of day (day/night), traffic conditions (peak, nonpeak) and driver variables (age, gender, and route familiarity). The primary dependent variables are the frequency, direction, and duration of driver eye glances. Secondary dependent measures are safety surrogate indicators associated with driver errors and other measures of driver performance, such as speed changes, headway, lane

deviation, and traffic conflicts. A rough budgetary estimate for conducting such an on-road instrumented vehicle study is between \$400,000 and \$800,000 (see appendix B for more details).

6.1.2 Naturalistic Driving

The naturalistic driving method employs a standardized instrument package which is installed in each participant's own private vehicle or in a vehicle loaned to the participant. The participant's vehicle appears and performs as it normally would. Participants drive their vehicles as part of their daily life routines, making control of CEVMS exposure difficult. The instrument package is capable of measuring speed, lane position, acceleration, GPS time and position, driver eye glance frequency, direction, and duration. However, because of the unobtrusive nature of the experimental technique, this method cannot support the use of accurate head-mounted or vehiclemounted eye-tracking equipment. Once the participant's vehicle has been instrumented, data are collected by means of automatic wireless downloads without participant awareness or involvement. The major independent variable is the presence or absence of CEVMS and other comparison visual stimuli (standard billboards, buildings, control settings, etc.) along the driven path. If possible, the CEVMS should be controlled according to a prearranged experimental protocol. Secondary independent variables could include the type of vehicle (sedan, pickup, or SUV) and driver characteristics (age, gender, and route familiarity). The primary measures or dependent variables are the frequency, direction, and duration of the driver's eye glances. However, as a result of the lower degree of accuracy in eye movement recording, this study method depends more heavily on secondary dependent variables. Safety surrogate measures associated with driver errors and other measures of driver performance (headway, lane deviation, conflicts, and erratic maneuvers) are of increased importance in this method. Additional dependent variables may include the time of day (day/night), traffic conditions (peak, nonpeak), in-vehicle distractions (eating, cell phone use), state of fatigue, etc. A rough budgetary estimate for conducting such a naturalistic driving study is between \$2 million and \$4 million (see appendix B for more details).

6.1.3 Unobtrusive Observation

The unobtrusive observation method employs an array of static cameras or other sensors mounted near the locations of the CEVMS and other comparison stimuli. The cameras are capable of recording the behavior of vehicles passing the various relevant visual stimuli as a part of the natural flow of traffic. The drivers are usually completely unaware that their vehicles are being observed. Post-hoc analysis of the video recordings from these cameras can yield data similar to some of that obtained by the on-road instrumented vehicle and naturalistic driving methods including vehicle speed, lane position, acceleration, and time. However, the data from distal video cameras are usually far less accurate and reliable than what can be collected by instruments on board the vehicle. Moreover, with present measurement technology, such video recordings cannot yield any data concerning driver eye glance movements. The major independent variable is the presence or absence of CEVMS and other comparison visual stimuli (standard billboards, buildings, etc.) along the driving path. If possible, the CEVMS should be controlled according to a prearranged experimental protocol.

Some secondary independent variables might include the time of day (day/night) and traffic conditions (peak, nonpeak). This study method depends completely on safety surrogate measures

associated with driver errors and other measures of driver performance (headway, lane deviation, and erratic maneuvers), and it requires a large camera array over a long distance recording for extended periods, as well as extensive data analysis. A rough budgetary estimate for conducting such an unobtrusive observation study is between \$1 million and \$3 million (see appendix B for more details).

6.2 COMPARISON OF STUDY ALTERNATIVES

This section has introduced and described three different candidate approaches for the recommended next study, which include the on-road instrumented vehicle method, the naturalistic driving method, and the unobtrusive observation method. Each study method would be capable of addressing the two-part basic research question to determine whether any observed or measured distraction due to CEVMS is sufficient to interfere with attentional criteria for safe driving, and to provide some preliminary practical technical information that could be of help to the community interested in outdoor advertising control. However, each method has certain advantages and disadvantages with regard to its ability to address these two questions.

The on-road instrumented vehicle method was judged the best, having the advantage of being sensitive to a wide range of participant variables, including accurate eye glance measurements with real CEVMS stimuli in natural settings. The degree of experimental control afforded by this method makes it the most productive of the three. Driving scenarios can be selected with a number of CEVMS and standard billboard stimuli along a single drive, which can be repeated both within and across research participants. To the degree that accurate measurements of visual distraction and eye glance behavior are pivotal dependent variables, the on-road instrumented vehicle method has the clear advantage. The high degree of experimental control ensures that exposure to CEVMS and to comparing visual stimuli is uniform and consistent. The on-road instrumented vehicle approach is the most productive research method for producing quality data in the shortest amount of time for the least cost.

The naturalistic driving method was judged the second best, offering some similar advantages to the on-road instrumented vehicle method. However, it suffered from less experimental control over CEVMS exposure, less ability to capture participant-related variables, and more logistical complication and expense. Both of these methods are somewhat related from the perspective of the research participant. In both cases, the research participant is driving in an instrumented vehicle on a real road. Both allow the determination of driver eye glance behavior to some degree, but the increased level of experimental control exercised in the on-road instrumented vehicle method gives this technique a distinct advantage, both in terms of more accurate eye glance measurements and more consistent driver exposure.

Finally, unobtrusive observation of safety surrogate measures involves no direct contact with the driver, thus preserving a completely natural driving environment. However, this method is not sensitive to participant variables. In particular, it is not possible to measure eye glance behavior with this method. This method depends solely on safety surrogate measures. Furthermore, since these safety surrogate measures are relatively subtle to detect at a distance, this method can be costly and time-consuming to implement.

The on-road instrumented vehicle method has a strong advantage in productivity and efficiency. The major advantage of the other two methods is the natural and unobtrusive nature of the study procedure from the perspective of the research participants. However, some degree of artificiality may be a small price to pay to gain the cost effectiveness of the on-road instrumented vehicle method. In the final analysis, the present report recommends the on-road instrumented vehicle method as the best choice for the first stage study. This recommendation is made on the basis of scientific merit, timeliness of producing a meaningful result, and cost.

7.0 CONCLUSIONS

The present report reviews the possible safety effects of CEVMS. The report consists of an update of earlier published work, an investigation of applicable research methods and techniques, recommendations for future research, and an extensive reference list and bibliography. The literature review update covers recent post-hoc crash studies, field investigations, laboratory investigations, previous literature reviews, and reviews of practice. The conclusion of the literature review is that the current body of knowledge represents an inconclusive scientific result with regard to demonstrating detrimental driver safety effects due to CEVMS exposure. This outcome points toward the importance of conducting carefully controlled and methodologically sound future research on the issue.

The present report also analyzes the key factors or independent variables affecting a driver's response to CEVMS and the key measures or dependent variables which serve as indicators of driver safety. These key factors and measures are selected, combined, and integrated into a set of optimal research strategies. Based on these strategies, as well as on lessons learned from the literature review update, a proposed long-term program of research has been developed to address the problem. This research program consists of three stages, which include determination of distraction, basis for possible regulation, and relationship of distraction to crashes.

The present report only addresses the first stage of the proposed research program in detail. For this first stage, three candidate studies, which are an on-road instrumented vehicle study, a naturalistic driving study, and an unobtrusive observation study, have been introduced and compared. An analysis of the relative advantages and disadvantages of each study indicate that the on-road instrumented vehicle study is the best choice as the recommended first stage in answering the basic research question.



APPENDIX A—EXPANDED TABLES

A.1 KEY FACTORS (INDEPENDENT VARIABLES)

Table 1. Expanded key factors (independent variables).

Variable	Ref. #	Advantages	Disadvantages
1.0 Billboard			
1.1 Location	8, 129, 38, 15, 44, 32		
1.1.1 Lat./long.; GPS; mile marker; survey location; reference location; mobile	13, 53, 160	Important to define stimulus; Easy to measure.	Likely to require travel expenses.
1.1.2 Distance from roadway; setback			Less important.
1.1.3 Sight distance; visual occlusions; distance first detected	13, 53	Determines exposure time.	
1.1.4 Orientation; angle to road; side of road; two-sided	144		Less important.
1.2 Display	144		
1.2.1 Type: Conventional; Digital; Tri-vision	125, 48	Digital type stands out.	Tri-vision likely to disappear.
1.2.2 Size; length; height; visual angle; mounting height	129, 32	Off-premise sizes somewhat standard.	On-premise sizes variable.
1.2.3 Resolution; dpi; LEDs/in	95, 48, 53	Crispness (sharpness) of image important.	
1.2.4 Luminance; contrast ratio; day/night settings	48, 53, 144	Brightness (luminance) extremely important.	Night setting may depend upon background illumination.
1.3 Dynamics	31		

Variable	Ref. #	Advantages	Disadvantages
1.3.1 Type: static; changing	158, 129, 26	Changing images extremely important. Static serves as control.	
1.3.2 Change rate; dwell time; change time; sequencing	48, 50, 158, 94	Change pattern important. Easy to measure.	
1.3.3 Special effects: wipe, dissolve, scintillate		Adds to uniqueness and conspicuity.	More difficult to measure.
1.3.4 Full motion video	125, 126	Full motion video extremely compelling.	Difficult to specify exact content seen.
1.3.5 Engagement value: ability to hold attention		Important overall distraction variable	Difficult to measure; requires subjective rating.
1.3.6 Sound			
1.4 Message	129, 44, 144, 53		
1.4.1 Type: text; graphics; mixed; targeted	32, 31	Particular message may be secondary.	
1.4.2 Text: word count; font size; color; content; legibility; affect	32, 48		Many variations. Less important.
1.4.3 Graphics: size; complexity; color; content; affect	31, 50		Difficult to specify. Many varieties.
1.4.4 Public safety alerts		Social benefit.	May be more distracting than advertising.
1.4.5 Interactive: encourages driver response		Interactive may require more attention.	
2.0 Roadway			
2.1 Type			

Variable	Ref. #	Advantages	Disadvantages
2.1.1 Category: two-lane rural; collector; arterial; freeway	13, 15 71, 54	Important determinate of driver workload.	Many variations even in single category.
2.1.2 Lanes: number; width; markings; medians; shoulders; rumble strips			Less important.
2.1.3 Speed: posted; advisory; 85 th percentile; median	50	Changes urgency of correct driving responses.	
2.1.4 Condition: dry, wet, ice, rain; oil slick		Important to driver control over vehicle.	
2.1.5 Traction: coefficient of friction			
2.2 Complexity	15		
2.2.1 Tangent: level; grade			Less important.
2.2.2 Curve: horizontal; vertical	13, 44, 118	May place sudden demand on driver attention.	
2.2.3 Intersection: signalized; stop controlled	129, 38, 48	Increased driver workload.	Wide variety of intersection complexities.
2.2.4 Interchange: exit, entrance, merge, gore	26, 44, 32, 48	Controlled access. More carefully engineered.	
2.2.5 Driveway; entrance			Less important.
2.2.6 Lane change: merge; diverge; lane drop		May place sudden demand on driver attention.	
2.2.7 Other: bicycle lane; fire house			Less important.
2.3 Traffic	158, 38, 15, 113,		

Variable	Ref. #	Advantages	Disadvantages
2.3.1 Average daily traffic; peak traffic; level of service	118	Likely to increase driver workload.	
2.3.2 Traffic mix: cars, trucks, buses, motorcycles			Less important.
2.3.3 Pedestrians			Mainly only in urban settings.
3.0 Vehicle	59		
3.1 Type: automobile; SUV; truck; motorcycle		Motorcycle has least obstructed view.	
3.2 Condition: response; vehicle dynamics			Hard to determine in field.
3.3 Windshield: size; tinting; field of view		Defines some stimulus exposure characteristics.	
4.0 Driver	10		
4.1 Characteristics: age; gender; demographics	53, 23, 12, 54		Less important.
4.2 Experience: years driving; route familiarity	15, 100	Route familiarity extremely important.	
4.3 State: alert; fatigue; alcohol; drugs			Difficult to measure.
4.4 Distractions: conversation; eating; cell phone	24, 90, 25		
5.0 Environment			
5.1 Visual—general	113		
5.1.1 Visual clutter; nearby billboards; ambient lighting	160, 15, 32, 44	Complexity of visual environment extremely important.	Difficult to specify.

Variable	Ref. #	Advantages	Disadvantages
5.1.2 Day/night viewing: dawn; dusk; sun-glare	53	Nighttime viewing of bright images important.	
5.1.3 Visual flow			Less important.
5.2 Official signs	160, 2, 26, 100		
5.2.1 Type: regulatory, advisory, navigational	94	Regulatory most important.	
5.2.2 Location: left, right, overhead	44, 15	Billboard can conflict with sign.	
5.2.3 Lighting: illuminated; luminous (VMS); retroreflective		Luminous (VMS) signs most important.	
5.2.4 Density: number in view, type mix	15		Many variations in urban settings.
5.2.5 Dynamics: change rate; motion; video		Extremely important point of possible conflict.	Motion and video not yet allowed.
5.2.6 Message: text; graphics			Less important
5.3 On-premise signs			
5.3.1 Type: conventional; Tri-vision; digital; full motion video	144	Digital and video most important.	Tri-vision likely to disappear.
5.3.2 Location: left, right, high, low	144		
5.3.3 Lighting: illuminated; luminous; LED	144	Bright, high resolution very compelling.	Difficult to measure.
5.3.4 Density: number in view, type mix		Can add to visual clutter.	Many variations possible.
5.3.4 Dynamics: change rate; motion; video; sound	144	Extremely important variable.	

Variable	Ref. #	Advantages	Disadvantages
5.3.5 Message: text; graphics; interactive		Interactive important.	Text and graphics less important.
5.4 Geographic	15		
5.4.1 Population: urban; suburban; rural	13, 71	Can affect visual clutter.	Many variations.
5.4.2 Terrain: mountain; valley; desert; hilly; near water		Can affect driver workload.	Many variations.
5.4.3 Area: city; state; region			Less important.
5.5 Meteorological			
5.5.1 Temperature; humidity; cloud cover	53		Less important.
5.5.2 Precipitation: rain; snow; fog; ice; visibility	53	Can affect driver workload.	

A.2 KEY MEASURES (DEPENDENT VARIABLES)

Table 2. Expanded key measures (dependent variables).

Variable	Ref. #	Advantages	Disadvantages
1.0 Vehicle Behavior	48		
1.1 Speed	125, 50		
1.1.1 Continuous		More accurate profile.	Large amounts of data. Expensive.
1.1.2 Discrete locations		Less data.	Cheaper.
1.1.3 Speed exceedances: high; low		Distraction indicator.	
1.1.4 Speed variance		Distraction indicator.	Best with continuous data.
1.2 Lane position	161, 48, 54		
1.2.1 Continuous		More accurate profile.	Large amounts of data. Expensive.
1.2.2 Discrete locations		Less data.	Cheaper.
1.2.3 Lane excursions: right; left	23	Distraction indicator.	More difficult to measure.
1.2.4 Lane variance		Distraction indicator.	Best with continuous data.
1.3 Acceleration	48, 54		
1.3.1 Longitudinal: hard braking; delayed acceleration; braking without cause		Excellent surrogate for distraction.	
1.3.2 Lateral: swerves	39	Good surrogate for distraction.	
1.3.3 Heave: bumps	125, 48		Not important.
1.4 Other vehicle interactions	39		

Variable	Ref. #	Advantages	Disadvantages
1.4.1 Headway (car following); time to collision	125, 48, 118	Good surrogate for distraction.	
1.4.2 Gap acceptance: merge; passing		Good surrogate for distraction.	Difficult to measure.
1.4.3 Conflicts; near- crashes	125	Extremely important measure.	
1.4.4 Violations: red light running; failure to yield; failure to stop			Low probability events.
1.4.5 Errors: missed exit; wrong lane		Good surrogate for distraction.	
1.4.6 Timing: late movements; premature movements			Difficult to measure.
1.5 Infrastructure interactions			
1.5.1 Response to roadway geometry: swerves; sudden braking	118, 15	Surrogate for distraction.	
1.5.2 Response to traffic control devices: misses, delays	15	Surrogate for distraction.	
1.5.3 Pedestrian interactions; yields			Only in urban settings.
1.6 Signals	39		
1.6.1 Brake light	125	Indication of sudden deceleration.	
1.6.2 Turn signals			Less important.
1.6.3 Other: backup lights			Not important.

Variable	Ref. #	Advantages	Disadvantages
2.0 Driver/Vehicle Interactions			
2.1 Steering			
2.1.1 Gross movements: curves; turns		Surrogate for distraction.	
2.1.2 Fine movements: lane keeping	60		Difficult to measure.
2.2 Throttle			
2.2.1 Pedal press; pedal position; duration			Less important.
2.2.2 Pedal release; duration			Less important.
2.3 Brake	125		
2.3.1 Pedal press; duration; excursion		Surrogate for distraction.	
2.3.2 Pedal release			Less important.
2.4 Shift (manual only)			
2.4.1 Gear selection (speed)			Not important.
2.4.2 Gear transitions (shifts)			Not important.
2.5 Displays	154		
2.5.1 Speedometer		Secondary visual distractor.	
2.5.2 Other: gauges; radio			Less important.
2.6 Other controls	154, 25		
2.6.1 Safety: windshield wipers; instrument lights; horn; turn signals	54		Less important, except turn signals.

Variable	Ref. #	Advantages	Disadvantages
2.6.2 Entertainment: radio; CD player	48, 24, 54	Secondary distractor.	
2.6.3 Auditory/vocal: voice actuated	154		Low probability of occurrence.
3.0 Driver Attention / Distraction	79, 113, 32, 146, 145		
3.1 Objective measures	129		
3.1.1 Eye glance behavior: eye movements; number of glances; duration of glances; glance object	129, 42, 125, 53, 160, 83, 161, 78	Excellent measure of unconscious attention / distraction.	Delicate, expensive equipment. Difficult to calibrate. Expensive to analyze data.
3.1.2 Distractor performance; secondary task	83, 53	Excellent measure of distraction.	Can increase risk in field experiments. Can be artificial.
3.1.3 Visual occlusion	15	Good measure of distraction.	Can increase risk in field experiments. Unnatural driving task.
3.1.4 Feature detection	48		
3.1.5 Feature recognition	48	Good measure.	
3.1.6 Driver workload; task performance	38, 15, 113	Excellent indicator of distraction.	Complicated to measure.
3.1.7 Head turning	78	Easy to measure.	Less important.
3.1.8 Driver errors	83	Excellent measure of distraction.	Many varieties. Low probability of occurrence.
3.1.9 Reaction time; perception-reaction time	15	Good indicator of distraction.	Difficult to measure.
3.2 Inferred measures			
3.2.1 Surprise; orienting response			Difficult to measure.

Variable	Ref. #	Advantages	Disadvantages
3.2.2 Conspicuity; attention grabbing			Difficult to measure.
3.2.3 Search patterns	15	Indicative of visual hypotheses.	
3.2.4 Capacity: self-regulated attention; spare capacity	15	Extremely important concept.	Hard to establish criterion threshold.
3.3 Subjective measures	161		
3.3.1 Conversational drive		Good possible method.	Lots of extraneous data.
3.3.2 Rating scale		Inexpensive.	Imprecise.
3.3.3 Questionnaire		Inexpensive.	Imprecise.
3.3.4 Survey	125	Relatively inexpensive.	Sampling frame difficult.
3.3.5 Focus group		Small sample. Lots of data.	Confounding social variables.
4.0 Crashes	158, 125, 26, 44, 128, 161, 95, 121		
4.1 Type: head-on; sideswipe; rear-end; backing; run-off-road; pedestrian	39	Very important discriminator variable. Related to ultimate goal.	Rare events. Many contributing factors. Difficult to estimate statistically.
4.2 Severity: fatal; injury; property damage; unreported		Important to determine impact.	Rare events. Many factors. Difficult to estimate statistically.
4.3 Method of measurement			Rare events. Hard to estimate.
4.3.1 Direct observation: simulator; field camera	42	Best studied in simulator. No chance of injury.	
4.3.2 Before/after study	39, 158	Most common study type.	No control site. Regression toward mean.

Variable	Ref. #	Advantages	Disadvantages
4.3.3 Before/after with control		Control adds rigor.	Regression toward mean.
4.3.4 Before/after/before		More convincing causal effect.	Regression toward mean.
4.3.5 Regression model		Directly account for multiple factors	Large amounts of data on many variables
4.3.6 Empirical Bayes		Control for regression toward mean.	More complicated statistical model.
4.3.7 Full Bayes		More complete treatment of conditional probabilities.	Not widely used.

A.3 KEY RESEARCH STRATEGIES

Table 3. Expanded key research strategies.

Method	Ref. #	Advantages	Disadvantages
1.0 Crashes: Field	97, 95, 21		
1.1 Unobtrusive observation			
1.1.1 Participant: random, uncontrolled; usually unknown	49	No sampling bias.	Do not know participant sample.
1.1.2 Experimenter: usually absent; remote observation; unknown to participant	49	No artificial participant behaviors due to experimenter.	
1.1.3 Stimuli: natural, ordinary, in context; variable, uncontrolled	49	Natural stimuli.	Stimuli not uniform; e.g., weather effects.
1.1.4 Responses: crashes; antecedent vehicle behaviors; rare; few participant variables	49	Directly related to the safety goal.	Extremely rare events; insensitive to participant variables.
1.1.5 Scenario: natural route and purpose; uses own vehicle	49	Completely natural experimental context; uses own vehicle.	Long-term monitoring required.
1.2 Naturalistic driving			
1.2.1 Participant: selected, sampled	79, 78, 42	Know participant sample.	Possible sampling bias.
1.2.2 Experimenter: absent; remote observation; known to participant	79, 78, 42		Possible artificial participant behaviors.
1.2.3 Stimuli: natural, ordinary, in context; variable, uncontrolled	79, 78, 64, 42	Natural stimuli.	Stimuli not uniform; e.g., weather effects.
1.2.4 Responses: crashes; antecedent vehicle and participant behaviors; rare	79, 78, 64, 42	Directly related to ultimate goal; sensitive to some participant variables.	Extremely rare events; difficult to collect adequate sample of crashes.

Method	Ref. #	Advantages	Disadvantages
1.2.5 Scenario: natural route and trip purpose; uses own vehicle	79, 78, 64, 42	Mostly natural experimental context; uses own or borrowed vehicle.	Participant aware of test status; may be injured or killed; vehicle may be damaged or destroyed; expensive.
1.3 Retrospective database: fatal, injury, property damage	87, 49, 128, 14, 58,	Directly related to ultimate goal.	Crashes are rare events; difficult to estimate.
1.3.1 Before-after study	158, 1, 130	Most common study type.	No control site; regression toward mean.
1.3.2 Before-after study with control	120	Control adds rigor.	Regression toward mean.
1.3.3 Before-after-before study		More convincing causal effect.	Regression toward mean.
1.3.4 Regression model		Directly account for multiple factors.	Large amounts of data on many variables.
1.3.5 Empirical Bayes		Control for regression toward mean.	More complicated statistical model.
1.3.6 Full Bayes		More complete treatment of conditional probabilities.	Not widely used.
2.0 Crashes: Laboratory			
2.1 Driving simulator			
2.1.1 Participant: selected, sampled	70	Know participant sample.	Possible sampling bias.
2.1.2 Experimenter: remotely present, unobtrusive observation	70	More experimenter control.	Possible artificial participant behaviors.
2.1.3 Stimuli: simulated, artificial; consistent, controlled	70	Extremely repeatable stimulus conditions.	Artificial stimuli; hard to simulate conspicuity and legibility.

Method	Ref. #	Advantages	Disadvantages
2.1.4 Responses: programmed crashes; antecedent participant and vehicle behaviors; can be more frequent crashes	70	Some control over crashes; can program more frequent crash opportunities.	Lack of negative consequences can unnaturally alter frequency of crashes.
2.1.5 Scenario: contrived route, artificial; unnatural vehicle and environment; safe from harm	70	Control over driving scenario; participant safe from harm.	Unnatural vehicle and environment; artificial scenario; simulator sickness.
2.2 Non-simulator laboratory	87		
2.2.1 Crash scenarios: movies, pictures, acting out		Relatively easy; less resources.	Artificial, out-of-context testing environment.
2.2.2 Crash reconstructions: questionnaires, focus groups		Relatively easy; focus groups more expensive.	Artificial, out-of-context testing environment; focus group social biases.
3.0 Safety Surrogate: Field	34, 85		
3.1 Unobtrusive observation			
3.1.1 Participant: random, uncontrolled; usually unknown	15	No sampling bias.	Do not know participant sample.
3.1.2 Experimenter: usually absent; remote observation; unknown to participant	15	No artificial participant behaviors due to experimenter.	
3.1.3 Stimuli: natural, ordinary, in context; variable, uncontrolled	15	Natural stimuli.	Stimuli not uniform; e.g., weather effects.
3.1.4 Responses: crash precursors; antecedent vehicle behaviors; more frequent; few participant variables	15	More frequent events than crashes; can collect more data with less risk.	Crash precursors only indirect indicators; insensitive to participant variables.
3.1.5 Scenario: natural route and trip purpose; uses own vehicle	15	Completely natural experimental context; uses own vehicle.	
3.2 Naturalistic driving			

Method	Ref. #	Advantages	Disadvantages
3.2.1 Participant: selected, sampled	79, 78, 42	Know participant sample.	Possible sampling bias.
3.2.2 Experimenter: absent; remote observation; known to participant	79, 78, 42		Possible artificial participant behaviors.
3.2.3 Stimuli: natural, ordinary, in context; variable, uncontrolled	79, 78, 42	Natural stimuli.	Stimuli not uniform; e.g., weather effects.
3.2.4 Responses: crash precursors; antecedent vehicle and participant behaviors; more frequent events	79, 78, 42	More frequent events than crashes; can collect more data with less risk.	Crash precursors only indirect indicators.
3.2.5 Scenario: natural route and trip purpose; uses own vehicle	79, 78, 118, 42	Mostly natural experimental context; uses own or long-term borrowed vehicle.	Participant aware of test status; may be injured or killed; vehicle may be damaged or destroyed; expensive.
3.3 On-road instrumented vehicle	14		
3.3.1 Participant: selected, sampled	54, 18	Know participant sample.	Possible sampling bias.
3.3.2 Experimenter: present; direct observation and interaction	83	More experimenter control; increased experiment safety.	Possible artificial participant behaviors.
3.3.3 Stimuli: selected; natural, in context	83, 18	Natural stimuli.	Stimuli not uniform; e.g., weather effects.
3.3.4 Responses: crash precursors; antecedent vehicle and participant behaviors; more frequent	54, 18	More frequent events than crashes; can collect more data with less risk.	Crash precursors only indirect indicators.
3.3.5 Scenario: natural route, artificial trip purpose; uses experimental vehicle	54, 83, 18	Semi-natural experimental context; more safe.	Artificial trip purpose; unfamiliar vehicle.
3.4 Closed-course test track			

Method	Ref. #	Advantages	Disadvantages
3.4.1 Participant: selected, sampled	136	Know participant sample.	Possible sampling bias.
3.4.2 Experimenter: present; direct observation and interaction	136	More experimenter control; increased experiment safety.	Possible artificial participant behaviors.
3.4.3 Stimuli: selected; out of context	136	Semi-natural stimuli.	Stimuli not uniform; some possible control.
3.4.4 Responses: crash precursors; antecedent vehicle and participant behaviors; more frequent	136	More frequent events than crashes; can collect more data with less risk.	Crash precursors only indirect indicators.
3.4.5 Scenario: unnatural route, artificial trip purpose; uses experimental vehicle	136	Low probability of harm to participant or vehicle.	Unnatural experimental context.
3.5 Commentary driving			
3.5.1 Participant: selected, sampled	36	Know participant sample.	Possible sampling bias.
3.5.2 Experimenter: present; direct observation; extensive interaction	36	More experimenter control; increased experiment safety.	Possible artificial participant behaviors.
3.5.3 Stimuli: selected; natural, in context	36	Natural stimuli.	Stimuli not uniform; e.g., weather effects.
3.5.4 Responses: extensive driver commentary; running verbal description; crash precursors observable		Collect large amounts of data; direct observation of gross attention.	Commentary could interfere with driving task; artificial task.
3.5.5 Scenario: natural route, artificial trip purpose		Semi-natural experimental context; more safe.	Artificial trip purpose.
3.6 Non-vehicle based field testing			
3.6.1 Roadside interviews	14, 125, 85	Relatively easy; less resources.	Artificial, distal testing environment.

Method	Ref. #	Advantages	Disadvantages
3.6.2 Fuel station, nearby mall interviews		Relatively easy; less resources.	Artificial, out-of-context testing environment.
4.0 Safety Surrogate: Laboratory	36		
4.1 Driving simulator			
4.1.1 Participant: selected, sampled	161, 4, 70, 82	Know participant sample.	Possible sampling bias.
4.1.2 Experimenter: remotely present, unobtrusive observation	161, 4, 70, 82	More experimenter control.	Possible artificial participant behaviors.
4.1.3 Stimuli: simulated, artificial; consistent, controlled	161, 4, 70, 82	Extremely repeatable stimulus conditions.	Artificial stimuli; hard to simulate conspicuity and legibility.
4.1.4 Responses: programmed crash precursors; antecedent participant and vehicle behaviors; can have more frequent events	10, 82,	Some control over near- crashes; can program more frequent near-crash opportunities.	Lack of negative consequences can unnaturally alter frequency of near-crashes.
4.1.5 Scenario: contrived route, artificial; unnatural vehicle and environment; safe from harm	161, 4, 70, 82	Control over driving scenario; participant safe from harm.	Unnatural vehicle and environment; artificial scenario; simulator sickness.
4.2 Non-simulator laboratory	75		
4.2.1 Pre-crash scenarios: movies, pictures, acting out	160, 36	Relatively easy; less resources.	Artificial, out-of-context testing environment; weak response measure.
4.2.2 Pre-crash reconstructions: questionnaires, focus groups	36	Relatively easy; focus groups more expensive.	Artificial, out-of-context testing environment; weak response measure; focus group social biases.
5.0 Social Survey	14, 125		
5.1 Telephone survey		Less resources; personal interviewer; more flexible.	Out of context; opinions only; more labor intensive; smaller scale.

Method	Ref. #	Advantages	Disadvantages
5.2 Mail survey		Less resources; standardized; larger scale.	Out of context; opinions only.
5.3 E-mail survey		Less resources; standardized; large scale.	Out of context; opinions only; internet user bias.
6.0 Analytical Study			
6.1 Literature review	53, 38, 26, 129, 52	Benefit from previous knowledge and mistakes.	Based on old information; abstract; hard to apply.
6.2 Review of practice	15, 44	Socially oriented, practical, legal.	Based on old information; not scientific; possibly misleading.
6.3 Deductive-inductive reasoning study	26	Less resources; no need for new data.	Must often make dangerous assumptions; cannot fill in knowledge gaps.



APPENDIX B—DETAILED DESCRIPTION OF STUDIES

B.1 ON-ROAD INSTRUMENTED VEHICLE APPROACH

The most effective research strategy to emerge from the analysis undertaken in section 6.0 is the on-road instrumented vehicle method. The following describes one possible study which might be conducted using this method.

B.1.1 Method

The on-road instrumented vehicle method employs an instrumented vehicle which is brought to the study site, along with a crew of about two or three researchers. The study site is a location where there is at least one CEVMS installation along a public access roadway. Preferably, there would be several CEVMS installations at the location so that a single test driving scenario might pass a few different CEVMS in the course of about half an hour of driving. The investigation should include at least two or three study sites which already have CEVMS in place. At each study site, approximately 20 to 30 research participants would be recruited from the local area.

Each research participant would drive the instrumented vehicle along a prescribed route, which includes CEVMS installations, standard (non-digital) billboards, human-constructed objects of casual visual interest (houses, barns, etc.), and natural background control scenery (trees, fields, etc.). Each drive takes less than 1 hour (preferably about 30 minutes), and each participant would return for several drives on different days. Other aspects would vary as well, such as the time of day, traffic density, and CEVMS conditions (e.g., CEVMS turned on versus CEVMS turned off). Each participant would complete between three and six such drives. The instrumented vehicle and crew would usually remain at a given study site for about 1 to 2 months. The crew would consist of an experimenter and a safety observer, who would both be present in the instrumented vehicle. The safety observer would also serve as a research assistant or technician. The instrumented vehicle is capable of measuring vehicle speed, vehicle lane position, longitudinal acceleration, lateral acceleration, GPS time and position, and driver eye glance direction and duration. The instrumented vehicle is also equipped with accurate vehicle-mounted or headmounted eye-tracking equipment, video cameras (forward and cab views) and a voice recorder.

B.1.2 Factors and Measures

The major factors or independent variables in the study are the presence or absence of CEVMS and other comparison visual stimuli (standard billboards, buildings, etc.) along the driving path. If possible, the CEVMS should be capable of being turned off and on or changed along some other dimension like luminance or change rate, according to a prearranged experimental design. The period of time that the CEVMS is off or changed could be kept relatively brief and carefully controlled since the study will follow a strict protocol. Other important independent variables are the time of day (day/night), traffic conditions (peak and nonpeak), and driver variables (age, gender, and route familiarity). One or more of the primary CEVMS variables of interest to the community concerned with outdoor advertising control should be represented by varying levels along the driving route (e.g., different degrees of luminance, change rate, or display spacing) as much as possible. Direct experimental control would be preferable to site selection in this regard.

The primary measure or dependent variable in this study is the frequency, direction, and duration of driver eye glances, which serves as an indication of visual attention and distraction. The fundamental hypothesis is that drivers have limited attention; they self-regulate their attention to perform demanding tasks. In the case of the driving task, a certain proportion of their attention needs to be concentrated on the roadway scene ahead. To the degree that eye glance behavior can serve as a measure of visual attention, eye glances need to be concentrated on the roadway ahead. If the frequency and duration of eye glances away from the roadway ahead exceed accepted norms or criteria for keeping a driver's eyes on the road, then driver safety may be compromised. Thus, eye glance behavior is the primary dependent variable in the study. Eye glance behavior has an intuitive connection to visual attention and is sensitive to subtle visual search strategies, including those which are below the level of conscious awareness (see section 2.7.2). Depending upon the type of eye glance measuring instrumentation selected, the act of measuring eye glance behavior may prove to be a more or less significant distraction to the driver in itself. This experimentally-induced artifact can be controlled by selecting a minimally intrusive measurement method or by ensuring adequate adaptation to the instrumentation on the part of the research participant.

This study includes another class of secondary dependent variables. These are safety surrogate measures associated with driver errors and other measures of driver performance, such as speed changes, headway, lane deviation, and traffic conflicts. These secondary variables can be measured by instrumentation in the vehicle in terms of speed, acceleration, and lane position. These secondary variables can also be directly observed and noted by the experimenter and/or safety observer in the instrumented vehicle for later analysis in terms of sudden braking, inadequate headway, swerving, and conflicts. Thus, events indicative of possible driver error or other maladaptive behavior can be flagged by human observers. Also, for these events, only objective vehicle performance data needs to be analyzed, saving considerable effort and expense by eliminating the need to analyze large amounts of continuous vehicle performance data.

B.1.3 Advantages/Disadvantages

One advantage of this method is its ability to implement accurate eye-tracking measurements which afford the opportunity to observe subtle and often unconscious eye movements. This ability to measure unconscious eye movements correlates with unconscious distraction facilitates incorporation of the notion of self-regulated attention into the experimental paradigm. When a driver is attempting to concentrate on the roadway ahead, a distractor, which unconsciously diverts attention away from the roadway against the driver's will, may have a more severe safety consequence than a distractor which can be maintained under conscious and voluntary control. Thus, in addition to being able to measure distraction which is both conscious and voluntary, accurate eye-tracking determinations have the potential to probe other phenomena, such as unconscious and involuntary distraction as they relate to CEVMS exposure.

Another advantage of this method is the ability to structure driving scenarios to have an appropriate number of CEVMS, standard billboard, and other visual stimuli all located on a controlled course, which all research participants drive in a consistent manner. The ability to choose and structure the test drive assures adequate and uniform exposure to CEVMS and other relevant visual stimuli. The ability to exert experimental control is a valuable asset to this method. It facilitates a clean and robust statistical analysis of the data because all of the

participants are exposed to all of the experimental conditions the same number of times in a relatively controlled manner. Experimental control ensures a high level of CEVMS exposure, thereby contributing to the productivity and cost effectiveness of this technique.

However, examined from a different perspective, such a degree of experimental control may also be regarded as a disadvantage. A certain amount of artificiality is introduced into the driving situation thereby. Research participants are definitely aware that they are participating in a controlled experiment, driving someone else's car on a contrived route which does not serve a personal purpose related to daily life. In addition, with the experimenter riding along with the participants in the vehicle, there may be a tendency for the participants to try to please the experimenter and to drive in some unnatural way. The introduction of eye-tracking equipment adds to the artificiality of the situation. Wearing head-mounted eye-tracking gear definitely represents unnatural driving attire. However, most research participants rapidly adapt to the gear with time, and they often report that they are unaware of its presence after a short drive. Vehiclemounted eye-tracking equipment can be far less intrusive, although the tedious calibration procedures and the presence of the cameras in the car remind participants that their head and eye movements are constantly being monitored. These are all valid experimental concerns; however, none of these interventions is likely to profoundly alter the driving behavior, much less the eye glance movements, of the research participants, as long as they are not informed of the purpose of the study. The enhanced experimental efficiency that this approach has to offer far outweighs its artificiality drawbacks.

B.1.4 Budgetary Cost

A rough budgetary estimate for conducting such an on-road instrumented vehicle study is between \$400,000 and \$800,000. The main cost drivers for this method are the eye glance measuring technology and the crew needed to implement the experiment at the study sites. The range in this estimate relates to the number of study sites, adequacy of the sites, length of the experimental drive, number of experimental drives, number of research participants, difficulty in obtaining research participants, ability to turn the CEVMS off and on, and numerous other factors which cannot be determined without further planning.

B.2 NATURALISTIC DRIVING APPROACH

The naturalistic driving method is similar to the on-road instrumented vehicle method. The major difference is that the participants drive their own vehicles (or loaned vehicles) for their own personal purposes. The method typically employs a large number of such vehicles. The following describes one possible study which might be conducted using this method.

B.2.1 Method

The naturalistic driving method employs a standardized instrument package which is installed in the participant's own private vehicle or in a vehicle loaned to the participant. The installation is made as unobtrusive as possible so that the participant's vehicle appears and performs as it normally would. The instrument package is capable of measuring many of the same variables as the on-road instrumented vehicle, such as speed, lane position, acceleration, GPS time and position, driver eye glance frequency, direction, and duration. The instrument package is also

connected to the vehicle data bus so that additional vehicle-related measures of engine, braking, and steering performance are also recorded. However, because of the unobtrusive nature of the experimental technique, this method cannot support the use of extremely accurate head-mounted or vehicle-mounted eye-tracking equipment. In the present state of technology, these accurate eye movement instruments involve careful calibration procedures with the driver. With this method, the eye-tracking system is mounted in the dashboard in a manner which involves little or no driver interaction. Once the participant's vehicle has been instrumented, data are collected by means of automatic wireless downloads without participant awareness or involvement. The instrumentation is left in the vehicle for a period of 3 to 6 months, during which time the participant drives the vehicle for normal personal or business use.

The fact that participants drive their own vehicles for their own use reduces control and adds uncertainty to the study. It is difficult to control where the participants are going to drive and when. The study site must be selected carefully so that participants are likely to drive by at least some of the target CEVMS installations. The participants must be selected carefully so that they are likely to take the selected roadway with some reasonable frequency. As a result of this increased uncertainty, the number of study sites must be increased to 4 and 5, the number of research participants selected at each site must be increased to 50 and 75, and the duration of measurement for each participant must be increased to 3 and 6. In this study, it is even more important that there are several CEVMS installations at each study site. As was the case for the on-road instrumented vehicle study, each study site needs to include CEVMS installations, standard (non-digital) billboards, objects of casual visual interest (houses, barns, etc.), and natural background control scenery (trees, fields, etc.).

B.2.2 Factors and Measures

As with the on-road instrumented vehicle study, the major factors or independent variables are the presence or absence of CEVMS and other comparison visual stimuli (standard billboards, buildings, control settings, etc.) along the driven path. If possible, the CEVMS should be turned off and on or changed in some other way, according to a prearranged experimental design. However, in this instance, the CEVMS would have to be turned off or changed for longer periods of time because it is not certain when the instrumented test vehicles might pass. These are the primary independent variables. Secondary independent variables could include the type of vehicle (sedan, pickup, or SUV) and driver characteristics (age, gender, and route familiarity). In addition, as much as possible, one or more of the primary CEVMS variables of interest to the community concerned with outdoor advertising control should be represented by varying levels in the selection of CEVMS stimuli.

As in the on-road instrumented vehicle study, the primary measure or dependent variable is the frequency, direction, and duration of driver eye glances. The fundamental hypothesis of self-regulated attention which needs to be concentrated on the roadway scene ahead remains the same. As before, if the frequency and duration of eye glances away from the roadway ahead exceed accepted norms or criteria, then driver safety is assumed be compromised. Thus, eye glance behavior is the primary dependent variable in this study, as well. However, the particular unobtrusive and disengaged dashboard-mounted eye-tracking device may not be capable of making as accurate measurements of eye-movements as can other more delicate vehicle-mounted or head-mounted devices which require periodic participant calibration. Consequently, this study

method depends more heavily on secondary dependent variables. Safety surrogate measures associated with driver errors and other measures of driver performance (headway, lane deviation, conflicts, and erratic maneuvers) become increasingly important in this method. Since the participants will be driving according to their own personal schedules, additional dependent variables may include the time of day (day/night), traffic conditions (peak and nonpeak), invehicle distractions (eating and/or cell phone use), and state of fatigue.

B.2.3 Advantages/Disadvantages

The naturalistic driving method possesses one major advantage over the on-road instrumented vehicle method: the driving scenario, driving task, and driving purpose are all completely natural. The research participants drive their own vehicles (or ones loaned to them) on their own personal schedules along personally selected routes to meaningful destinations. Although to a lesser degree, the naturalistic driving method shares another advantage with the on-road instrumented vehicle method: its ability to implement eye-tracking measurements. In fact, the dashboard-mounted eye-tracking device is far less intrusive to the driver than the head-mounted eye-tracking device sometimes employed in the on-road instrumented vehicle method.

Unfortunately, some dashboard-mounted eye-tracking devices may not be as sensitive and accurate as a head-mounted device. Also, they may not be able to track extensive head movements or measure subtle eye glances indicative of unconscious distraction. The useful field of view can also be an issue with certain unobtrusive vehicle-mounted eye-tracking equipment. Consequently, this experimental method may be less effective in its ability to probe the subtle phenomena of unconscious and involuntary distraction as they relate to CEVMS exposure.

Another disadvantage of this method is its inherent lack of structured driving scenarios. Since participants drive whenever and wherever they want, it is difficult to ensure adequate and uniform exposure to CEVMS and other relevant visual stimuli. This lack of experimental control and higher degree of uncertainty necessitate an increase in the number of study sites, research participants, and duration of the study, which negatively impacts the productivity and cost effectiveness of the technique. For example, this method typically requires the instrumentation of a relatively large number of vehicles at any given study site instead of the instrumentation of just one vehicle which is shared by many research participants. Another minor disadvantage is that research participants are aware that they are participating in an experiment, even if the study is minimally intrusive in terms of daily life routine.

B.2.4 Budgetary Cost

A rough budgetary estimate for conducting such a naturalistic driving study is between \$2 million and \$4 million. The main cost drivers for this method include increasing the number of study sites, installing instruments in a large number of vehicles at a single site, and collecting and analyzing data covering a long period of time. The range in this budgetary estimate relates to the number of study sites, adequacy of the sites, number of vehicles which need to be instrumented at one time, number of research participants, difficulty in obtaining research participants, driving patterns of the research participants, length of the study at any given site, ability to turn the CEVMS off and on, and numerous other factors which cannot be determined without further planning.

B.3 UNOBTRUSIVE OBSERVATION APPROACH

The unobtrusive observation method is different from the on-road instrumented vehicle method and the naturalistic driving method. The major distinction is that no study participants are selected, and all data are obtained from the natural flow of traffic past the CEVMS and other comparison stimuli. The following describes one possible study which might be conducted using this method.

B.3.1 Method

The unobtrusive observation method employs an array of static cameras or other sensors mounted near the locations of the CEVMS and other comparison stimuli. The other sensors may include loops, tubes, or radar to measure vehicle passes and driving parameters. The present report will focus on video recording of traffic. The cameras are capable of recording the behavior of vehicles passing the various relevant visual stimuli as a part of the natural flow of traffic. The drivers are usually completely unaware that their vehicles are being observed. Post-hoc analysis of the video recordings from these cameras can yield data similar to some of that obtained by the on-road instrumented vehicle and naturalistic driving methods, which include vehicle speed, lane position, acceleration, and time. However, the data from distal video cameras are usually far less accurate than what can be collected by instruments onboard the vehicle. Moreover, with present measurement technology, such video recordings cannot yield any data concerning driver eye glance frequency, direction, and duration. The camera arrays are usually left in place for a period of several months to 1 year at each study site. There would typically be three to four such sites in the study. At each study site, separate camera arrays would need to be installed at the locations of all selected CEVMS displays, standard (non-digital) billboards, objects of casual visual interest (houses, barns, etc.), and natural background control scenery (trees, fields, etc.).

B.3.2 Factors and Measures

As in the on-road instrumented vehicle and naturalist driving studies, the major independent variables are the presence or absence of CEVMS and other comparison visual stimuli (standard billboards, buildings, etc.) along the driving path. If possible, the CEVMS should be controlled according to a prearranged experimental protocol. However, in this instance, the CEVMS would have to be changed for longer durations because it is possible to predict when vehicles might pass. In addition, one or more of the primary CEVMS variables of interest to the community concerned with outdoor advertising control should be represented by varying levels in the selection of CEVMS stimuli. These constitute the primary independent variables. Since continuous video recording will be employed, the experimenter can decide to select different times of data collection for further analysis. This capability can provide insight into some secondary independent variables such as time of day (day/night) and traffic conditions (peak, nonpeak).

In contrast to the on-road instrumented vehicle and naturalistic driving studies, the primary dependent variable is not driver eye glance behavior. Instead, this study method depends completely on safety surrogate measures associated with driver errors and other measures of driver performance (headway, lane deviation, and erratic maneuvers). These are subtle driving behaviors to measure by means of distal cameras mounted along the roadway. Unless the

cameras are mounted very high, multiple vehicle images may occlude each other. For a long stretch of roadway, such as might required for CEVMS exposure, a relatively large array of cameras may be needed. Thus, a large amount of data needs to be collected and analyzed in such a study. Automatic machine vision video analysis algorithms can help in the data analysis process, but such algorithms are not yet sufficiently sensitive and robust to reliably identify all of the subtle indicators of driver errors, conflicts, or maladaptive performance which might accompany CEVMS exposure. The use of other sensors instead of or in addition to cameras may mitigate some of these data analysis problems to a certain extent.

B.3.3 Advantages/Disadvantages

The unobtrusive observation method possesses one major advantage over the other two methods: the data are derived from the natural flow of traffic. Other than erecting camouflaged camera arrays at various locations along the roadway, the experimenter does not disturb the natural flow of human driving. As opposed to the other two methods, the vast majority of drivers are completely unaware that they are part of a study depending on how well the camera camouflage works. Other sensors used for this application can also be hidden and made extremely hard to detect. This is the major advantage of the unobtrusive observation method. Another strong advantage is the large number of vehicles which pass by the CEVMS and other comparison stimuli every day. Sample sizes can be relatively large.

Like the other techniques, the unobtrusive observation method has disadvantages as well. First, with present technology, it is not possible to implement eye-tracking measurements in such a study. The inability to measure eye glance behavior makes it difficult to investigate important constructs, like self-regulated attention and unconscious distraction as they relate to CEVMS exposure. The method is left to rely on safety surrogate measures, such as driver errors and maladaptive maneuvers. These relatively subtle pre-crash and near-crash driving behaviors are difficult to measure by means of distal video cameras. Such driving behaviors also occur very seldom and need to be observed over great distances, leading to the necessity to collect large amounts of video data from extended camera arrays over long periods of time. The collection, reduction and analysis of such large amounts of data tend to make this method time-consuming and expensive.

B.3.4 Budgetary Cost

A rough budgetary estimate for conducting such an unobtrusive observation study is between \$1 million and \$3 million. The main cost drivers for this method include designing camera arrays which can measure subtle vehicle maneuvers, installing camera arrays to record a large extent of roadway for all CEVMS and comparison stimuli, and collecting and analyzing data covering a long period of time. The range in this budgetary estimate relates to the number of study sites, adequacy of the sites, number and location of cameras in an array, method of recognizing safety surrogate measures, length of the study at any given site, ability to turn the CEVMS off and on, and numerous other factors which cannot be determined without further planning.



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January 16, 2012

Ken Klein (/author/5713)

April 22, 2011—Earth Day—a tornado in the St. Louis area toppled a 14-foot-by-48-foot digital billboard, raising a question about this new large-format electronics product: What happens to digital billboards that are damaged beyond repair or that reach obsolescence?

As a result of the experience in St. Louis, the outdoor advertising industry has learned that almost the entire unit can be recycled. Some parts are reused, and a fraction—less than 2 percent—is disposed of at certified facilities.



"Recycling is more practical than the landfill," sums up Rod Wardle, vice president at digital Start your FREE one-year subscription to RECYCLING TODAY to secure our next issue. billboard manufacturer Young Electric Sign Co. (YESCO) in Logan, Utah. "The landfill is not a smart man's option."

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A Red Herring

Nationwide, there are up to 400,000 billboards. Paper and glue are giving way to polyethylene (PE) large-format printed materials. More than 4 million pounds of used billboard ads were recycled from 2009 through mid-2011.

In the last decade, some 2,400 billboards have been converted to digital displays containing LED lights. Color static images rotate every six, eight or 10 seconds, depending on state and local rules.

Advertisers like the flexibility, and government is using this new communications platform to deliver emergency messages and to find fugitives and abducted children.

Like most electronics products, digital billboards wear out eventually. All stakeholders—regulators, the billboard industry and anti-sign critics—wondered about the fate of digital billboards once they had fulfilled their useful lives.

In a report released in 2010, an anti-sign group based in Philadelphia raised the specter of "an abundance of difficult-to-recycle, discarded technology." To illustrate the group's point, this widely circulated report, "Illuminating the Issues" by Gregory Young, featured a photo of out-of-date cathode-ray-tube monitors with the caption: "Could digital signage one day face a similar fate?"

This scary question turned out to be a red herring.

Earth Day Lesson

The April 22 tornado in St. Louis created a real-life test scenario. Could a local billboard crew in the American heartland disassemble a digital billboard and could the parts be recycled?

Yes.

In the parlance of the outdoor advertising industry, the digital billboard that was damaged by the tornado is known as a "back-to-back" sign, or two displays on a monopole that face both directions of traffic. The billboard's owner (Lamar Advertising Co.) transported these two damaged digital displays to its company-owned shop in Hannibal, Mo.

Local Lamar crews successfully dismantled the components. Working with the sign manufacturer (Daktronics), they took these steps:

- The aluminum was sold to a local recycler for some \$2,000.
 (Sixty-four percent of a digital billboard is aluminum, according to manufacturers.)
- Another local recycler bought the stainless steel and copper wiring.



Aluminum comprises more than 64 percent of an LED billboard, which also yields stainless steel and copper wire and LED modules with metal content.

5

- The LED modules damaged beyond repair were separated from the plastic housing and Start your FREE one-year subscription to RECYCLING TODAY to secure our next issue, recycled for the metals. The plastic housing also was recycled into various items, including asphalt fill, says Bill Ripp, digital director at Lamar.
- Damaged fan assemblies were scrap be still be were scrap and others will be used as spare parts.

The cost to dismantle a digital billboard can be offset by the income from recycling, according to Daktronics' experience.

Local Options

Looking across the country, Ripp says damaged or obsolete digital billboards can be recycled in most areas.

"We now know we can disassemble the product, and recyclers will take the scrap," he says.

"Recycling locally can be a logical choice," says Jerry Young, Daktronics billboard account manager. "Most local recyclers will provide services to pick up materials after they have been dismantled. Recycling locally can save freight costs if recycling service providers can be found in the area."

He adds, "The result of recycling is a check after the recycler has weighed all the materials."

In some cases, a billboard manufacturer may opt to haul the damaged boards from the display location back to its facility for dismantling.

In the Phoenix area, four Clear Channel Outdoor digital billboards made by YESCO were damaged beyond repair by hail in 2010. YESCO delivered new digital billboards to Phoenix to replace the hail-damaged units, says Lou Musica, senior vice president for domestic digital at Clear Channel Outdoor. On the return trip, the trucks hauled the damaged billboards back to Utah to be dismantled and recycled.

Financially, this sort of transaction is a wash, or the manufacturer may lose a few dollars. But, consider the alternative: the undesirable prospect of digital billboards headed to landfills.

"These signs weigh up to 9,000 pounds," Wardle says. "It's more expensive to take a digital billboard to a landfill than it is to recycle it."

The author is executive vice president of the Outdoor Advertising Association of America, Washington, D.C. He can be contacted at kklein@oaaa.org (mailto:kklein@oaaa.org).

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A STUDY OF THE RELATIONSHIP BETWEEN DIGITAL BILLBOARDS AND TRAFFIC SAFETY IN ALBUQUERQUE, NM

SUBMITTED TO

THE FOUNDATION FOR OUTDOOR ADVERTISING RESEARCH AND EDUCATION (FOARE) 1850 M STREET, NW, SUITE 1040 WASHINGTON, DC 20036-5821

BY

MICHAEL WALTER TANTALA, P.E. ALBERT MARTIN TANTALA, SR., P.E.

ON

8 MARCH 2010



A STUDY OF THE RELATIONSHIP BETWEEN DIGITAL BILLBOARDS AND TRAFFIC SAFETY IN ALBUQUERQUE, NM

KEY POINTS

- Seven years of accident data comparison
- 17 digital billboards on local roads with eight second dwell times
- Data shows no statistically significant increase in accident rates
- Driver age (young/elderly) and time of day (daytime/nighttime) are neutral factors

13 9 11 Digital Location 12 15 16 Coors NW Bridge St SW 2 3 Lead 4 Lomas NE Cesar Chavez Montano NE Osuna NE Osuna NE Carlisle NE 10 Paseo Del Norte 11 San Mateo NE 12 San Mateo NE 13 Academy NE 14 Montgomery NE Wyoming NE 15 16 Lomas NE Eubank NE 17

Figure 1.

Digital Billboard locations in Albuquerque, NM
CC Agenda - Page 399September 21, 2020, Public Hearing - Item 1

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Seven years of data ...

... no statistically significant relationship with the occurrence of accidents ...

... age of drivers and time of day are neutral factors.

OVERVIEW

The purpose of this study is to examine the statistical relationship between digital billboards and traffic safety in Albuquerque, New Mexico. This study analyzed traffic and accident data along local roads near 17 existing, digital billboards (see Figure 1) with traffic volumes on roads collectively representing approximately 240 million vehicles per year. The study uses official data as collected, complied and recorded independently by the Police Department of the City of Albuquerque.

The study included seven years of accident data representing approximately 7,000 accidents near seventeen digital billboards. Ten of the seventeen billboards were converted to digital format circa August, 2006 and the remaining seven were converted circa November 2007.

Temporal (when and how frequently) and spatial (where and how far) statistics were summarized near billboards within multiple vicinity ranges from 0.2 to 1.0 miles upstream and downstream of the billboards. Additionally, subsets of daytime and nighttime accidents were analyzed for before and after comparisons.

The overall conclusion of the study is that the digital billboards in Albuquerque have no statistically significant relationship with the occurrence of accidents. This study also finds that the age of drivers (younger/elderly) and the time of day (daytime/nighttime) are neutral factors which show no increase in accident rates near the digital billboards in Albuquerque. This conclusion is based on the Police Department's own data and an objective statistical analysis; the data shows no increase in accident rates.

STUDY REGION

The City of Albuquerque 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 heavily traveled (approximately 665 thousand vehicles traveled per day on the sections of road near the digital billboards).

The City of Albuquerque is the largest City in the State of New Mexico, is situated in the central part of the State straddling the Rio Grande, and had a population of 522 thousand people and 183 thousand households. Albuquerque is ranked as the 34th largest City and the 6th fastest growing in America. In 2008, there were some 439 thousand licensed drivers in Albuquerque (approximately 84% of the population).

Albuquerque is geographically divided into four quadrants. They are NE (northeast), NW (northwest), SE (southeast), and SW (southwest). The north-south division line is Central Avenue (the path that Route 66 took through the city) and the east-west division line is the Burlington Northern and Santa Fe (BNSF) Railway track line. The City is generally bisected by the Pan American Freeway (also known as Interstate 25) in the north-south direction and the Coronado Freeway (also known as Interstate 40).

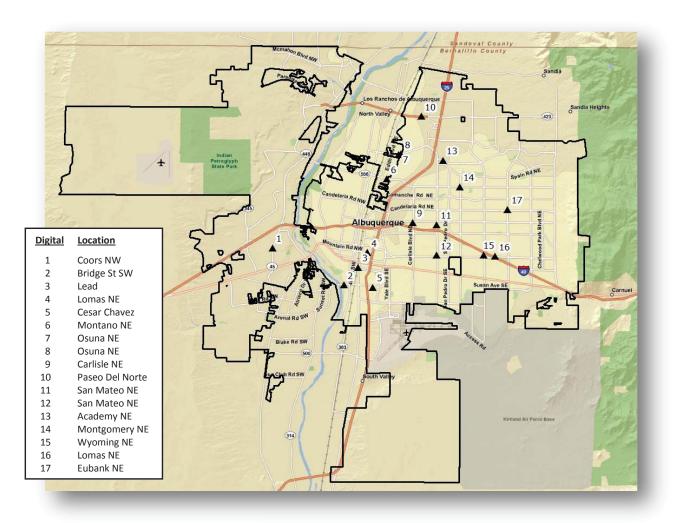


Figure 2. Digital Billboard locations and streets in Albuquerque, NM

The static display on each of these digital billboards has a "dwell time" of eight seconds.

BILLBOARD CHARACTERISTICS

Digital billboards display static messages which, when viewed, resemble conventional painted or printed billboards. With digital technology, a static copy "dwells" and includes no animation, flashing lights, scrolling, or full-motion video. The static display on each of these digital billboards has a "dwell time" of eight seconds.

The digital billboards were designed and manufactured by *Daktronics*, and 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 of the digital billboards to measure ambient light. The seventeen digital billboards that were studied are owned and operated by *Clear Channel Outdoor, Inc.*

The digital billboards are numbered 1 to 17 and are located along various local roads throughout the City. The locations of the seventeen billboards in Albuquerque are shown in Figures 2 and 3 which summarize direction, configuration and other sign characteristics. The digital boards and their surroundings were observed during day and night conditions. Each of the seventeen digital billboards is a freestanding, single-pole, structure with one digital face. Figure 4 summarizes the conversion dates. Ten of the seventeen billboards were converted to digital format circa August, 2006 and the remaining seven were converted circa November 2007. This allows for before/after comparisons of up to 4.3 years (or 52 months) and 7 years (or 84 months) respectively. Additional billboard-location photos, aerials, and map references for each billboard number are also included within this report as Figures 5 to 21.

Billboard No.	Location	Digital Facing		Configuration	Reader Side	Install / Live Date
1	Coors NW 510 ft south of Los Volcanes	N	11x22	Freestanding, Vee, Flag	Right Hand	11/19/2007
2	Bridge SW 115 ft west of 8th	E	11x22	Freestanding, Vee, Flag	Cross	11/27/2007
3	Lead SE 90 ft west of Broadway	E	11x22	Freestanding, Center-mount	Cross	8/14/2006
4	Lomas NE 444 ft east of Edith	E	11x22	Freestanding, Center-mount	Right Hand	8/14/2006
5	Avenida Cesar Chavez SE 0.2 mi west of University	W	11x22	Freestanding, Center-mount	Right Hand	10/4/2006
6	Montano NE 0.15 mi east of Edith	E	11x22	Freestanding, Superflag, Vee	Cross	8/31/2006
7	Osuna NE 0.38 mi east of Edith	W	11x22	Freestanding, Center-mount, Vee	Cross	11/19/2007
8	Osuna NE 0.47 mi east of Edith	Е	11x22	Freestanding, Center-mount	Right Hand	8/29/2006
9	Carlisle NE 115 ft south of Menaul	S	11x22	Freestanding, Vee, Flag with Eccentric Upright	Cross	11/13/2007
10	Paseo Del Norte NE 0.25 mi west of Jefferson	E	14x28	Freestanding, Center-mount, Vee	Right Hand	11/21/2007
11	San Mateo NE 100 ft north of Prospect	N	11x22	Freestanding, Flag	Cross	8/29/2006
12	San Mateo NE 174 ft north of Lomas	N	11x22	Freestanding, Vee, Center- mount with Eccentric Upright	Right Hand	11/13/2007
13	Academy NE 364 ft west of McKinney	W	11x22	Freestanding, Flag with Eccentric Upright	Cross, Center	8/31/2006
14	Montgomery NE 135 ft west of Louisiana	E	11x22	Freestanding, Center-mount with Eccentric Upright	Right Hand	8/17/2006
15	Wyoming NE 422 ft north of Lomas	N	11x22	Freestanding, Center-mount	Right Hand	8/30/2006
16	Lomas NE 725 ft west of Easterday	E	11x22	Freestanding, Vee, Flag	Right Hand	11/14/2007
17	Eubank NE 235 ft north of Candelaria	N	11x22	Freestanding, Flag	Cross	8/17/2006

Figure 3. Digital Billboard direction, sizes and other sign characteristics





Figure 4. Digital billboard conversion dates

Digital Billboard No. 1 advertises to southbound traffic on Coors Boulevard NW south of Los Volcanes Road NW. Digital Billboard No. 1 is a right-hand reader and a free-standing, vee, flag configuration. Figure 5a is a photo of the digital face. Figure 5b shows the location in an oblique aerial. The digital face was converted from a conventional face on 19Nov07 using the existing structure.

Figure 5. Digital No. 1 (a, left) View on Coors Boulevard NW, (b, right) Oblique Aerial of location

Digital Billboard No. 2 advertises to westbound traffic on Bridge Street SW west of 8th Street SW. Digital Billboard No. 2 is a cross reader and a free-standing, vee, flag configuration. Figure 6a is a photo of the digital face. Figure 6b shows the location in an oblique aerial. The digital face was a new location that was installed and activated on 27Nov07.

Figure 6. Digital No. 2 (a, left) View on Bridge Street SW, (b, right) Oblique Aerial of location

Digital Billboard No. 3 advertises to westbound traffic on Lead Avenue SE west of Broadway Boulevard SE. Digital Billboard No. 3 is a single-faced, cross reader and a free-standing, center-mount configuration. Figure 7a is a photo of the digital face. Figure 7b shows the location in an oblique aerial. The digital face was converted from a conventional face on 14Aug06 using the existing structure.

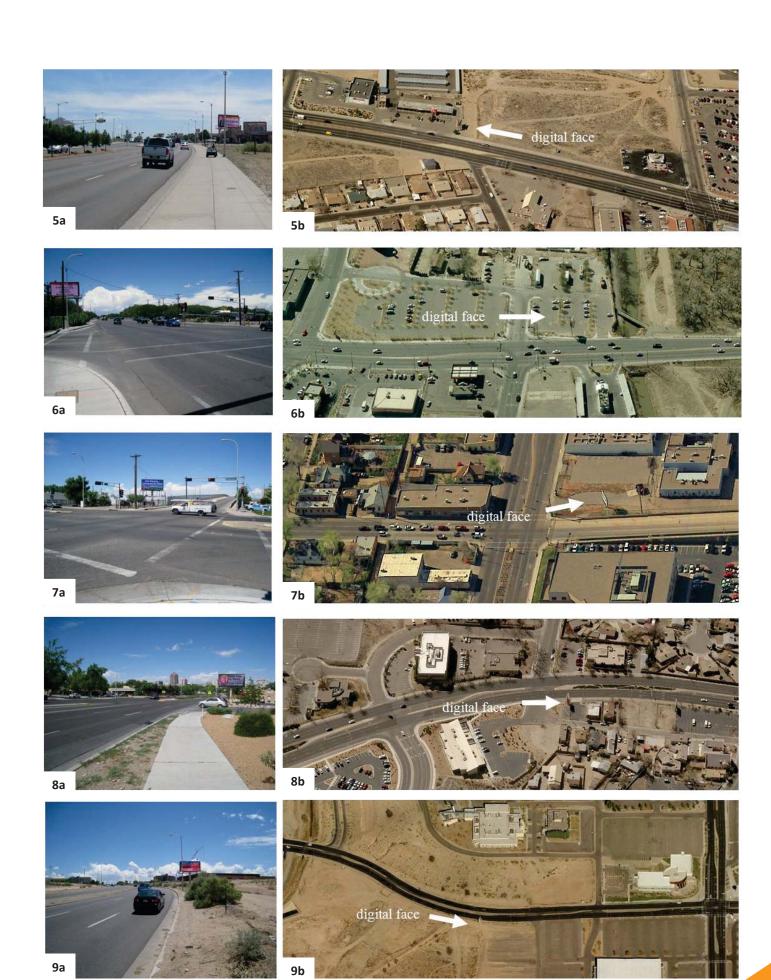
Figure 7. Digital No. 3 (a, left) View on Lead Avenue SE, (b, right) Oblique Aerial of location

Digital Billboard No. 4 advertises to westbound traffic on Lomas Boulevard NE east of Edith Boulevard NE. Digital Billboard No. 4 is a right-hand reader and a free-standing, center-mount configuration. Figure 8a is a photo of the digital face. Figure 8b shows the location in an oblique aerial. The digital face was converted from a conventional face on 14Aug06 using the existing structure.

Figure 8. Digital No. 4 (a, left) View on Lomas Boulevard NE, (b, right) Oblique Aerial of location

Digital Billboard No. 5 advertises to westbound traffic on Avenida Cesar Chavez SE west of University Boulevard SE. Digital Billboard No. 5 is a right-hand reader and a free-standing, center-mount configuration. Figure 9a is a photo of the digital face. Figure 9b shows the location in an oblique aerial. The digital face was converted from a conventional face on 4Oct06 using the existing structure.

Figure 9. Digital No. 5 (a, left) View on Avenida Cesar Chavez SE, (b, right) Oblique Aerial of location



Digital Billboard No. 6 advertises to westbound traffic on Montano Road NE east of Edith Boulevard NE. Billboard No. 6 is a cross reader and a free-standing, vee, superflag configuration. Figure 10a is a photo of the digital face. Figure 10b shows the location in an oblique aerial. The digital face was converted from a tri-vision face on 31Aug06 using the existing structure.

Figure 10. Digital No. 6 (a, left) View on Montano Road NE, (b, right) Oblique Aerial of location

Digital Billboard No. 7 advertises to eastbound traffic on Osuna Road NE east of Edith Boulevard NE. Digital Billboard No. 7 is a cross reader and a free-standing, vee, centermount configuration. Figure 11a is a photo of the digital face. Figure 11b shows the location in an oblique aerial. The digital face was converted from a conventional face on 19Nov07 using the existing structure.

Figure 11. Digital No. 7 (a, left) View on Osuna Road NE, (b, right) Oblique Aerial of location

Digital Billboard No. 8 advertises to westbound traffic on Osuna Road NE east of Edith Boulevard NE. Digital Billboard No. 8 is a right-hand reader and a free-standing, centermount configuration. Figure 12a is a photo of the digital face. Figure 12b shows the location in an oblique aerial. The digital face was converted from a conventional face on 29Aug06 using the existing structure.

Figure 12. Digital No. 8 (a, left) View on Osuna Road NE, (b, right) Oblique Aerial of location

Digital Billboard No. 9 advertises to northbound traffic on Carlisle Boulevard NE south of Menaul Boulevard NE. Digital Billboard No. 9 is a cross reader and a free-standing, flag configuration with an eccentric upright. Figure 13a is a photo of the digital face. Figure 13b shows the location in an oblique aerial. The digital face was converted from a conventional face on 13Nov07 using the existing structure.

Figure 13. Digital No. 9 (a, left) View on Carlisle Boulevard NE, (b, right) Oblique Aerial of location

Digital Billboard No. 10 advertises to westbound traffic on Paseo Del Norte Road NE west of Jefferson Street NE. Digital Billboard No. 10 is a right-hand reader and a free-standing, center-mount, vee configuration. Figure 14a is a photo of the digital face. Figure 14b shows the location in an oblique aerial. The digital face was converted from a larger, 14x48 conventional face on 21Nov07 using the existing structure.

Figure 14. Digital No. 10 (a, left) View on Paseo Del Norte Road NE, (b, right) Oblique Aerial of location



Digital Billboard No. 11 advertises to southbound traffic on San Mateo Boulevard NE north of Prospect Avenue NE. Digital Billboard No. 11 is a cross reader and a free-standing, flag configuration. Figure 15a is a photo of the digital face. Figure 15b shows the location in an oblique aerial. The digital face was converted from a conventional face on 29Aug06 using the existing structure.

Figure 15. Digital No. 11 (a, left) View on San Mateo Boulevard NE, (b, right) Oblique Aerial of location

Digital Billboard No. 12 advertises to southbound traffic on San Mateo Boulevard NE north of Lomas Boulevard NE. Digital Billboard No. 12 is a right-hand reader and a free-standing, center-mount. vee configuration with an eccentric upright. Figure 16a is a photo of the digital face. Figure 16b shows the location in an oblique aerial. The digital face was converted from a conventional face on 13Nov07 using the existing structure.

Figure 16. Digital No. 12 (a, left) View on San Mateo Boulevard NE, (b, right) Oblique Aerial of location

Digital Billboard No. 13 advertises to eastbound traffic on Academy Road NE west of McKinney Drive NE. Digital Billboard No. 13 is a cross and center reader and a free-standing, flag configuration with an eccentric upright. Figure 17a is a photo of the digital face. Figure 17b shows the location in an oblique aerial. The digital face was converted from a conventional face on 31Aug06 using the existing structure.

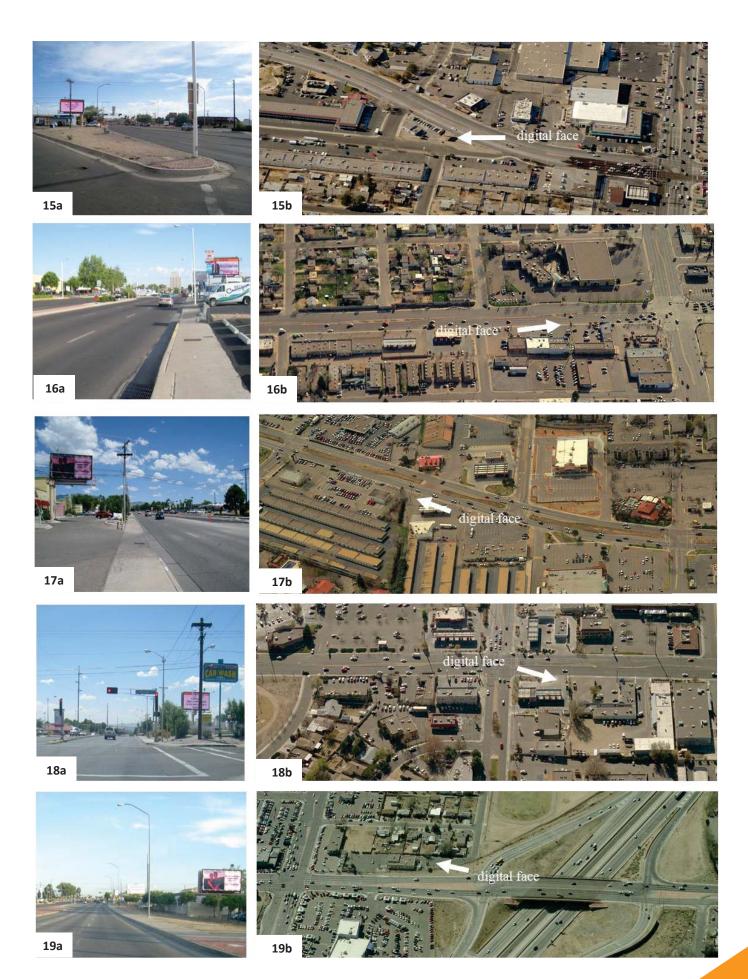
Figure 17. Digital No. 13 (a, left) View on Academy Road NE, (b, right) Oblique Aerial of location

Digital Billboard No. 14 advertises to westbound traffic on Montgomery Boulevard NE west of Louisiana Boulevard NE. Digital Billboard No. 14 is a right-hand reader and a free-standing, center-mount configuration with an eccentric upright. Figure 18a is a photo of the digital face. Figure 18b shows the location in an oblique aerial. The digital face was converted from a tri-vision face on 17Aug06 using the existing structure.

Figure 18. Digital No. 14 (a, left) View on Montgomery Boulevard NE, (b, right) Oblique Aerial of location

Digital Billboard No. 15 advertises to southbound traffic on Wyoming Boulevard NE north of Lomas Boulevard NE. Digital Billboard No. 15 is a right-hand reader and a free-standing, center-mount configuration. Figure 19a is a photo of the digital face. Figure 19b shows the location in an oblique aerial. The digital face was converted from a conventional face on 30Aug06 using the existing structure.

Figure 19. Digital No. 15 (a, left) View on Wyoming Boulevard NE, (b, right) Oblique Aerial of location



Digital Billboard No. 16 advertises to westbound traffic on Lomas Boulevard NE west of Easterday Drive NE. Digital Billboard No. 16 is a right-hand reader and a free-standing, vee, flag configuration. Figure 20a is a photo of the digital face. Figure 20b shows the location in an oblique aerial. The digital face was converted from a conventional face on 14Nov07 using the existing structure.

Digital Billboard No. 17 advertises to southbound traffic on Eubank Boulevard NE north of Candelaria Road NE. Digital Billboard No. 17 is a cross reader and a free-standing, flag configuration. Figure 21a is a photo of the digital face. Figure 21b shows the location in an oblique aerial. The digital face was converted from a conventional face on 17Aug06 using the existing structure.

Figure 20. Digital No. 16 (a, left) View on Lomas Boulevard NE, (b, right) Oblique Aerial of location

Figure 21. Digital No. 17 (a, left) View on Eubank Boulevard NE, (b, right) Oblique Aerial of location









AADT ranges individually near the seventeen billboards from 14 to 80 thousand vehicles per day, or equivalently 5 to 29 million vehicles per year.

TRAFFIC VOLUME DATA

Traffic volume data for the City of Albuquerque was obtained from the New Mexico Department of Transportation (NMDOT) and included the annual average daily traffic (AADT), which is the average of 24-hour counts collected throughout the year. The AADT volumes were recorded in Albuquerque between 2002 and 2008.

The AADT values are summarized in Figure 22. AADT ranges individually near the seventeen digital billboards from 14 to 80 thousand vehicles per day, or equivalently 5 to 29 million vehicles per year. For all seventeen billboards, this collectively represents approximately 665 thousand vehicles per day or 240 million vehicles per year.

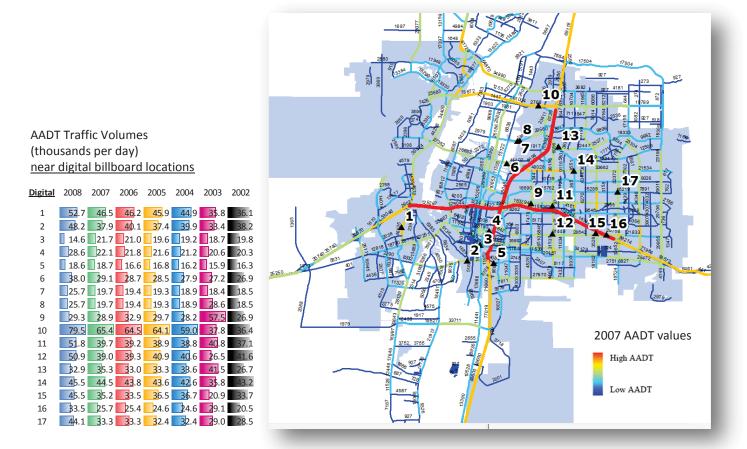


Figure 22. AADT Volume Data near digital billboard locations in Albuquerque, NM summarized in a table from 2002 to 2008 (left) and thematically mapped for 2007 (right)

ACCIDENT DATA

In Albuquerque, the majority of accident reports are investigated and recorded by the City of Albuquerque Police Department. Data is maintained by the Police Department. Law enforcement officials are required to submit reports on crashes they investigate that meet reporting thresholds provided by statue, which is five hundred dollars or more in property damage, or that anyone was injured, or killed in the crash. Data generally conforms to the American National Standards Institute (ANSI) Standard D16.1 – 1996, Manual on Classification of Motor Vehicle Traffic Accidents.

The accident data set provided by the Police Department of the City of Albuquerque includes 7,000 accidents over seven years between 2003 and 2009 and near digital billboard locations. Most of the data is specified by addresses and intersections. Figure 23 shows the geocoded accident locations generally near digital billboards in the City of Albuquerque.

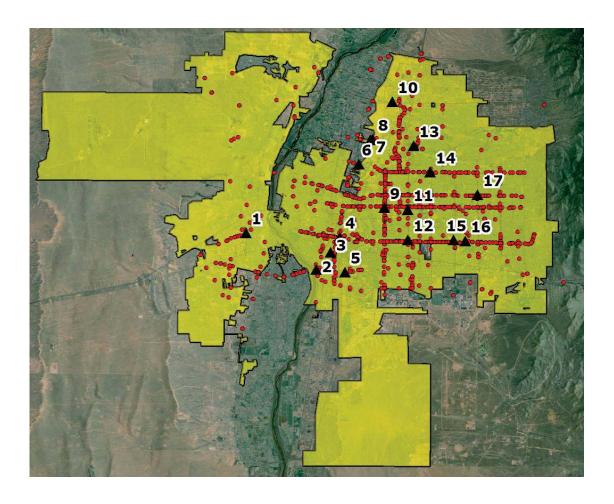


Figure 23. Traffic Accidents (red dots) near digital billboard locations in Albuquerque, NM, from 2003 to 2009

Figure 24 summarizes the traffic accident data for the past seven years generally within one mile of the digital billboard locations in the City of Albuquerque and shows the distribution of accidents by year, month, day of week and time of day. This represents a consistent pattern of data and illustrates that more accidents occur on weekdays and at rush hour (before and after work).

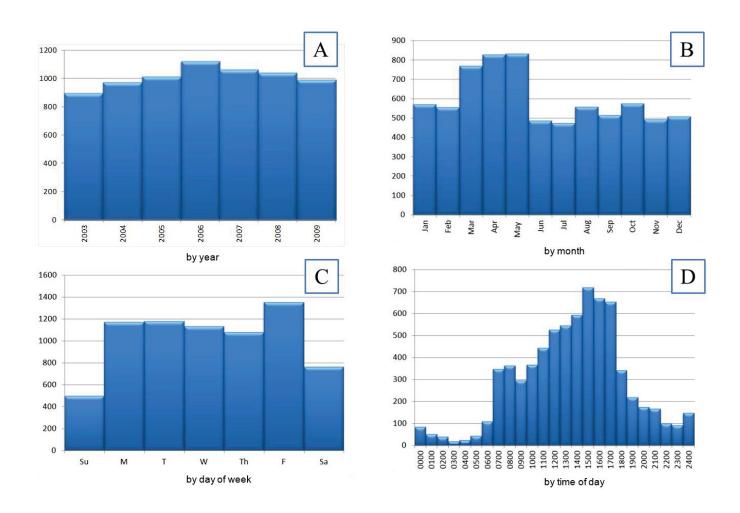


Figure 24. Histogram of traffic accident data of the past seven years near digital billboards in the City of Albuquerque and by (A) year, (B) month, (C) day of week digital and (D) time of day

The analysis of this robust data involves an engineering-statistics based approach and uses a widely accepted method to show what happened when these seventeen digital billboards were installed in Albuquerque.

ANALYSIS

The analysis of this robust data involves an engineering-statistics based approach and uses a widely accepted method to show what happened when these seventeen digital billboards were installed in Albuquerque. The analysis has two parts.

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 0.2, 0.4, 0.6, 0.8, and 1.0 miles both upstream and downstream of the billboard. These vicinity ranges also sampled data to include: (1) accidents along the principal roads to which the digitals directly advertise, (2) accidents recorded as occurring within the intersection of the primary road and any cross roads, and (3) for crossroad accidents within a reasonable distance from the primary road to include drivers turning onto or leaving the primary road. Accident data for roads to which the digitals do not advertise or are not connected were excluded, even if they were within the specified vicinity range.

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 were analyzed for before and after comparisons. For a more lengthy discussion of analysis methods, please refer to previous studies (see References 6 and 7).

The number of accidents and rates of accidents near the seventeen digital billboards remained consistent within all vicinity ranges.

RESULTS

Figure 25 shows a comparison of the accident metrics before and after the conversion near all seventeen digital billboards studied in Albuquerque. The statistics are summarized for vicinity ranges of 0.2, 0.4, 0.6, 0.8 and 1.0 miles of the billboard. The metrics 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, including rates and vehicle-miles traveled, were also analyzed.

The number of accidents and rates of accidents near the seventeen digital billboards decreased in all vicinity ranges, except in 1.0 miles. The benchmark 0.6 mile vicinity experienced a 3.3% decrease in accidents over the average seven year span for all signs; this includes 1.6 fewer accidents per month after conversion. Figure 26 shows the locations of accidents for each of the seventeen signs and within vicinity ranges within 0.2, 0.4, 0.6, 0.8 and 1.0 miles of the billboards. Figure 27 shows the distributions of the number of accidents per month near digital billboards between 2003 and 2009 within vicinity ranges with radii of 0.2, 0.4, 0.6, 0.8 and 1.0 miles and in Albuquerque, NM. Each blue line shows the approximate conversion date of the first ten and second seven digitals; the dashed rectangles show equal time periods for months before and after the conversion dates. Within the 0.6 mile vicinity, the average number of accidents in any given month decreased from 48.5 to 46.9 collectively for these seventeen signs; similarly the peak number of accidents in any given month decreased from 88 to 79. Similar decreases and trends in both averages and peaks were observed for both smaller and larger vicinity ranges.

A statistical t-test was used to compare 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, there is no statistically significant difference in the accident statistics evaluated between conventional and digital billboards near these digital locations.

Consistent results were obtained for before and after comparisons of the older set of ten digital conversions, and for the later set of seven digital conversions, respectively. Additionally, consistent results were obtained for driver-age comparisons. Low correlation coefficients were calculated for the spatial analysis. Correlation coefficients were calculated and indicated a very strong correlation of accident patterns near digital billboards when compared with the accident patterns prior to conversion.

		DISTANCE RANGE FROM BILLBOARD (MILES)						
		0.2	0.4	0.6	0.8	1.0		
	Total Accidents as Conventional Billboard	805	1228	1650	1931	2569		
lation	Average Number of Accidents in a Month	23.7	36.1	48.5	56.8	75.6		
Prior to Installation	Standard Deviation	11.2	152	15.8	15.0	18.7		
Prior t	Peak Number of Accidents in Any Given Month	54	74	88	93	129		
	Minimum Number of Accidents in Any Given Month	4	12	25	32	42		
	Total Accidents as Digital Billboard	752	1181	1595	1858	2578		
pard	Average Number of Accidents in a Month	21.5	347	46.9	54.6	75.8		
Digital Biilboard	Standard Deviation	9.2	10.6	147	12.1	16.9		
Digit	Peak Number of Accidents in Any Given Month	43	53	79	83	112		
	Minimum Number of Accidents in Any Given Month	7	10	12	29	37		
nge	Total Accidents, % Change	-6.6%	-3.8%	-33%	-3.8%	0.4%		
% Change	Change in Average Number of Accidents in a Month	-2.2	-1.4	-1.6	-2.1	0.3		

Figure 25. Summary accident statistics during seven years within vicinity ranges of 0.2, 0.4, 0.6, 0.8 and 1.0 miles near seventeen digital billboards locations in Albuquerque, NM

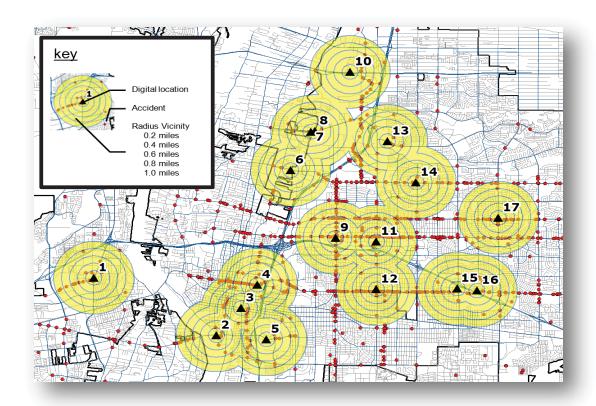


Figure 26. Accident location near digital billboards between 2003 and 2009 within vicinity ranges with radii of 0.2, 0.4, 0.6, 0.8 and 1.0 miles and in Albuquerque, NM.

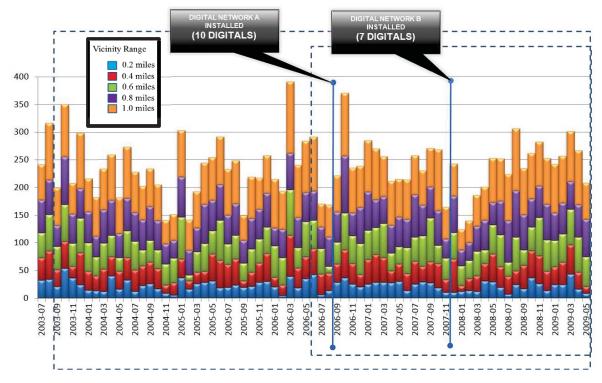


Figure 27. Stacked distributions of the number of accidents per month near digital billboards between 2003 and 2009 within vicinity ranges with radii of 0.2, 0.4, 0.6, 0.8 and 1.0 miles and in Albuquerque, NM. Each blue line shows the approximate conversion date of the first ten and second seven digitals; the dashed rectangles show equal time periods for months before and after the conversion dates.

Figure 28 summarizes the accident rates that account for variations in traffic volumes for all digital locations within vicinity ranges. The 0.6 mile benchmark vicinity experienced a decrease in accident rates over the seven-year span; the change in accident rates decreased 0.04 accidents per 100,000 vehicles per year. Similar decreases and trends were observed for both smaller and larger vicinity ranges.



Figure 28. Summary accident rates during seven years within vicinity ranges of 0.2, 0.4, 0.6, 0.8 and 1.0 miles near seventeen digital billboards locations in Albuquerque, NM

COMPARISON OF ACCIDENTS BY AGE OF DRIVER

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 was specially studied to determine if there are increases in the accident rates of young drivers (under 21) or elderly drivers (65 and older). Figure 29 shows the distribution of accidents by age of driver for all accidents, by age of female drivers, and by age of male drivers.

Figure 30 shows the distributions of ages of driver for all accidents within a one mile vicinity before digital conversions (top, left), after digital conversion (top, right) and the correlation between before and after conversions for the number of accidents for each age (bottom). Individual accidents may have multiple cars and drivers involved, which is reflected in the analysis. In comparing the histograms in Figure 30, note the typical distribution type (shape) and typical average values. The average driver age for accidents prior to digital conversion is 38.2 years; the average drive age after conversions is 38.4 years.

Correlation coefficients were calculated and indicated a very strong correlation of accident patterns for age-of-driver factors. Figure 33 shows a 0.980 (98.0%) correlation coefficient when comparing accidents before conversion with those after conversion.

Additionally, the accident statistics were also analyzed to determine if the time of day of accidents near digital billboards was a factor. The data was specially studied to determine if there are increases in the accident rates during dawn, daylight, dusk and dark/nighttime conditions near these digital billboards. Correlation coefficients were calculated and indicated a very strong correlation of accident patterns for time-of-day factors. There is a 0.976 (97.6%) correlation coefficient when comparing accidents before conversion with those after conversion.

COMPARISON OF ACCIDENTS BY AGE OF DRIVER

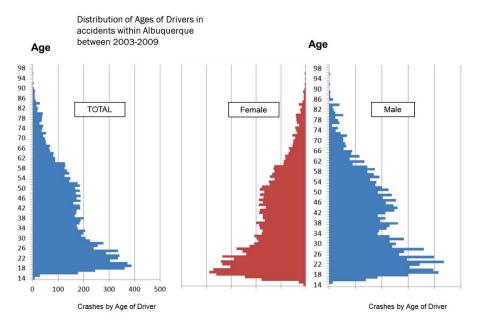


Figure 29. Distributions of age of driver for all accidents, by age of female drivers and by age of male drivers and for accidents within one mile of digital billboards in Albuquerque

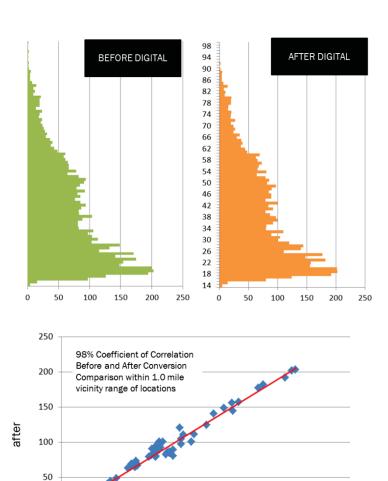


Figure 30. Distributions of age of driver for all accidents before digital conversion (top, left green histogram), after digital conversion (top, right orange histogram) and the correlation between before and after of number of accidents for each age (bottom).

before

100

150

200

250

50

FINDINGS

Albuquerque, New Mexico, was 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 much as seven years. The overall conclusion is that the digital billboards in Albuquerque have no statistically significant relationship with the occurrence of accidents. This conclusion is based on the City of Albuquerque's own data and an objective statistical analysis; the data shows no increase in accident rates. This study also finds that the age of drivers (younger, older) and the time of day (nighttime, daytime) are neutral factors which show no increase in accident rates near digital billboards along the local roads in Albuquerque.

The specific conclusions of this study of Albuquerque indicate the following.

- The number and rates of accidents near the seventeen digital billboards show a 3.3% decrease within 0.6 miles of all digital billboards over an average seven years. Similar decreases and trends in both averages and peaks were observed for both smaller and larger vicinity ranges.
- 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 over the 52- to 84-month periods, 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.
- Consistent results were obtained for comparisons of daytime and nighttime accidents and for young and elderly drivers in accidents. Correlation coefficients were calculated and indicated a very strong correlation of accident patterns near digital billboards when compared with the accident patterns near the former, conventional-face billboards.

Simply stated, the data shows no increase of accident rates near these billboards.

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A STUDY OF THE RELATIONSHIP BETWEEN DIGITAL BILLBOARDS AND TRAFFIC SAFETY IN HENRICO COUNTY AND RICHMOND, VIRGINIA

SUBMITTED TO

THE FOUNDATION FOR OUTDOOR ADVERTISING RESEARCH AND EDUCATION (FOARE) 1850 M STREET, NW, SUITE 1040 WASHINGTON, DC 20036-5821

BY

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ON

29 NOVEMBER 2010



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A STUDY OF THE RELATIONSHIP BETWEEN DIGITAL BILLBOARDS AND TRAFFIC SAFETY IN HENRICO COUNTY AND RICHMOND, VIRGINIA

KEY POINTS

- More than 7 years of accident data comparisons
- Ten locations with 14 digital billboard faces with 10 second duration times
- Data show no statistically significant increase in accident rates, using before and after comparisons and using an Empirical Bayes Method Analysis for the actual and predicted comparisons
- Comparisons of driver age (young/elderly) and time of day (daytime/nighttime) are neutral factors

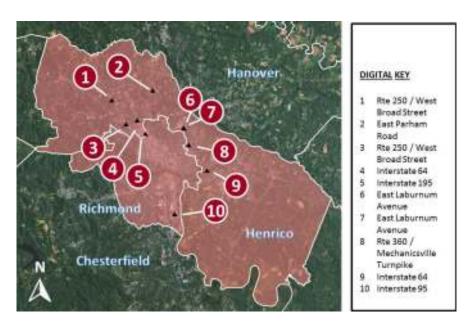


Figure 1. Digital Billboard Locations analyzed in Henrico County and Richmond, Virginia

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More than 7 years of data ...

... no statistically significant relationship with the occurrence of accidents ...

... 10-second duration times ...

OVERVIEW

The purpose of this study is to examine the statistical relationship between digital billboards and traffic safety in Henrico County and Richmond, Virginia. This study analyzes traffic and accident data along routes near 10 locations with 14 digital billboard faces (see Figure 1) with traffic volumes on roads collectively representing approximately 154 million vehicles per year. The study uses official data as collected, complied and recorded independently by municipal police departments, Henrico County and the Virginia Department of Transportation.

The study includes more than **seven years of accident data** representing approximately 40 thousand accidents near ten locations in Richmond and Henrico County. The billboards were converted to digital format between 2006 and 2009 and allow periods of comparison as long as 7.3 years (88 months).

Temporal (when and how frequently) and spatial (where and how far) statistics are summarized near billboards within multiple vicinity ranges as large as one-half mile for areas that are upstream and downstream of the billboards. Subsets of daytime and nighttime accidents and driver age are analyzed for before and after comparisons.

Additionally, an Empirical Bayes Method (EBM) analysis is performed to estimate the number of accidents that could statistically be expected without the introduction of digital signs. This 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 (AASHTO, Reference 14). This report establishes benchmarks for the basis of accident records at pre-digital locations and also uses other comparison sites in Henrico County and Richmond.

The overall conclusion of the study is that the digital billboards in Richmond, Virginia have no statistically significant relationship with the occurrence of accidents. 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. These conclusions are based on Police Department data and an objective statistical analysis; the data show no significant increase in accident rates.

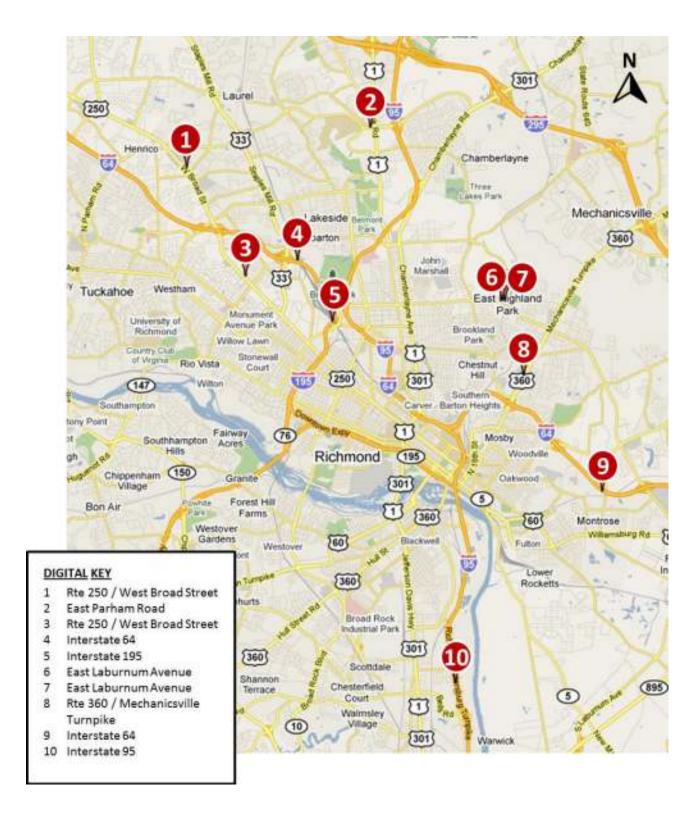


Figure 2. Digital Billboard Locations analyzed in Henrico County and Richmond, Virginia. Each location studied has a 10 second duration time.

The static display on each of these digital billboards have "duration times" of 10 seconds.

STUDY REGION

This portion of the Greater Richmond 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 heavily traveled (approximately 423 thousand vehicles traveled per day collectively on the sections of road near the digital billboards in Figure 2).

The study area of Henrico County and the City of Richmond, a portion of the Greater Richmond Area in Virginia, is situated in the central part of the State, and collectively has an area of approximately 308 square miles, has a population of 352 thousand people and has 174 thousand households (2000 census).

Several federal and state highways allow entry to the Greater Richmond Area as it is situated at the junction of east-west Interstate 64 and north-south Interstate 95, two of the most heavily traveled highways in the state. Henrico County is one of only two counties in Virginia that maintain their own roads. Interstate highways include Interstate 64, Interstate 95, and Interstate 295. Interstate 64 runs east-west and overlaps Interstate 95 for several miles in Richmond. Interstate 195 is a short spur from north of downtown Richmond, south into the downtown. Interstate 295 is a bypass to the east of Richmond and extends from Interstate 95 south of Petersburg. Other major highways include U.S. Route 1, U.S. Route 250 and U.S. Route 360.

BILLBOARD CHARACTERISTICS

Digital billboards display static messages which, when viewed, resemble conventional painted or printed billboards. With digital technology, a static copy displays for a duration and includes no animation, flashing lights, scrolling, or full-motion video. The static display of each of these digital billboards has a "duration time" of 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. Each of the digital billboards that were studied is owned and operated by *Lamar*.

Billboard Location	Location	Configuration	of Road	Digital Facing Direction	Reader Side	Face Size (ft)	Duration Time (seconds
1	Rte 250 / West Broad Street at 7912 West Broad Street (37*37*25.194*, -77*31*40.515*)	free standing, Flag, Vee	N	E	right cross	11x23 10.5x36	10 10
2	East Parham Road 0.25 miles west of Interstate 95 (37" 38' 6.7668", -77" 27' 40.381")	Flag Vac		w	cross	11x22	10
3	Rte 250 / West Broad Street at 5912 West Broad Street (37" 35' 32.607", -77" 30' 22.834")	et Free standing, Center-mount N E		E	right	11x23	10
4	Interstate 64 0.2 miles east of Staples Mill Road { 37" 35" 49.729", -77" 29" 14.935" }	Free standing, Center-mount, Vee	N	E	right	12.5x40	10
5	Interstate 195 south of the Insterstates 64 and 95 intersection (37" 34' 45.757", -77" 28' 29.744")	Free standing, Flag, Vee	w	5 N	cross	14x36 14x36	10
6	East Laburnum Avenue 0.07 miles east of Carolina Avenue (37° 35' 7.3211", -77" 24' 48.898")	Free standing, Center-mount, Vee	N	E	right	10x21	10
7	East Laburnum Avenue 0.12 miles east of Carolina Avenue (37" 35' 7.3427", -77" 24' 45.050")	Free standing, Center-mount, Back-to-Back	N	E	right	10.5x36	10
8	Rte 360 / Mechanicsville Turnpike 0.3 miles north of Interstate 64 (37" 33" 50.011", -77" 24" 19.292")	Free standing, Center-mount, Back-to-Back	w	5 N	cross right	14x28 14x28	10 10
9	Interstate 64 0.6 miles west of South Laburnum Avenue (37° 31' 50.091", -77° 22' 36.814")	Free standing, Center-mount, Vee	5	SE:	cross	12.5x42	10
10	Interstate 95 0.6 miles north of Bells Road / Rte 161 (37" 28' 32.231", -77" 25' 49.227")	Free standing, Center-mount, Vee	w	N 5	right cross	14×48	10

Figure 3. Digital Billboard Direction, Sizes and Other Sign Characteristics

Of the ten, digital-billboard locations studied, nine are located in Henrico County and one is located in the City of Richmond. Several additional digital locations were installed in the study region in 2010. These newer locations are not included as in this study because data collection would be limited to 2009; 2010 accident data was not available at the time of this study.

The digital, billboard locations are numbered 1 to 10 with 14 billboard faces. The ten locations in Henrico County and Richmond are shown in Figures 1, 2 and 3 which summarize 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; four locations have two digital boards on the same upright.

Figure 4 summarizes the conversion dates. Nine of the 14 billboard faces were converted to digital format prior to 2008 and the others were converted on various dates in 2008 and 2009. These dates allow for before/after comparisons as long as 7.3 years (or 88 months). Additional billboard-location photos, aerials, and map references for each digital location are included in this report as Figures 5 to 14.

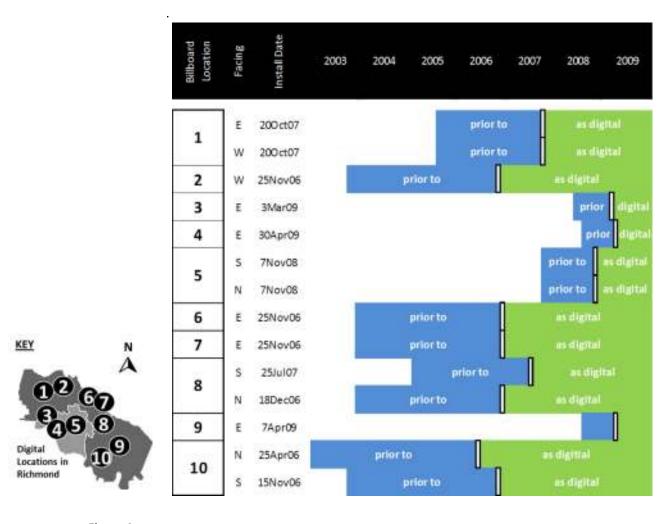


Figure 4.

Digital billboard Conversion Dates and Comparison Timelines for Digital Locations in Henrico County and Richmond, Virginia

Location No. 1 is on the north side of Route 250, at 7912 West Broad Street. The structure is a double-face, free standing, flag, vee configuration. The west face is a digital bulletin and is a right-hand reader. The west face (which faces east) has a 10.5x36 size and was a new build on 27Oct07 at this location. The east face (which faces west) is a digital poster and a cross reader. The east face has an 11x23 size and was a new build on 27Oct07. Each face is operated by Lamar, and has a duration time of 10 seconds. Figure 5a is a photo of the south digital face. Figure 5b shows the location in an oblique aerial.

Figure 5. Location No. 1 (5a, left) View on Route 250; inset shows opposite-face digital, (5b, right) Oblique Aerial of location

Location No. 2 is on the north side of East Parham Road, approximately 0.25 miles west of Interstate 95. The structure is a face, free standing, flag configuration. The east face is a digital poster and a cross reader. The face was converted from a conventional format on 25Nov06 using the existing location. The face is operated by Lamar, and has an 11x22 size with a duration time of 10 seconds. Figure 6a is a photo of the digital face. Figure 6b shows the location in an oblique aerial.

Figure 6. Location No. 2 (6a, left) View on East Parham Road North, (6b, right) Oblique Aerial of location

Location No. 3 is on the north side of Route 250, at 5912 West Broad Street. The structure is a double-face, free standing, center-mount with an offset, vee configuration. The west face is a digital poster and a right-hand reader. The north face was a new build on 3Mar09. The face is operated by Lamar, and has an 11x23 size with a duration time of 10 seconds. Figure 7a is a photo of the digital face. Figure 7b shows the location in an oblique aerial.

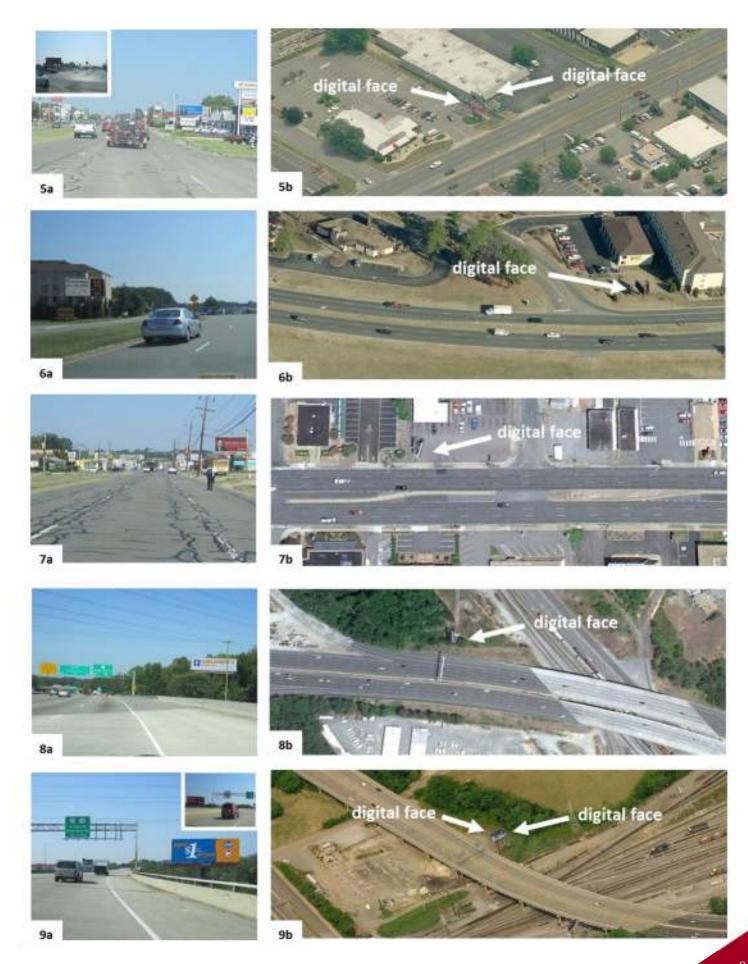
Figure 7. Location No. 3 (7a, left) View on Route 250, (7b, right) Oblique Aerial of location

Location No. 4 is on the north side of Interstate 64, approximately 0.2 miles east of Staples Mill Road. The structure is a double-face, free standing, center-mount, vee configuration. The west face is a digital bulletin and a right-hand reader. The face was a new build on 30Apr09 at this location. The face is operated by Lamar, and has a 12.5x40 size with a duration time of 10 seconds. Figure 8a is a photo of the digital face. Figure 8b shows the location in an oblique aerial.

Figure 8. Location No. 4 (8a, left) View on Interstate 64, (8b, right) Oblique Aerial of location

Location No. 5 is on the west side of Interstate 195 just south of the intersection of the Interstate 64 and Interstate 95. The structure is a double-face, free standing, flag, vee configuration. The north face is a digital bulletin and a cross reader. The north and south faces were converted from conventional format on 7Nov08. Each face is operated by Lamar and has a 14x36 size with a duration time of 10 seconds. Figure 9a is a photo of the digital face. Figure 9b shows the location in an oblique aerial.

Figure 9. Location No. 5 (9a, left) View on Interstate 195, inset shows opposite-face digital (9b, right) Oblique Aerial of location



Location No. 6 is on the north side of East Laburnum Avenue, approximately 0.07 miles east of Carolina Avenue. The structure is a double-face, free standing, center-mount, vee configuration. The west face is a digital poster and a right-hand reader. The face was converted from a conventional format on 25Nov06 using the existing location. The face is operated by Lamar and has a 10x21 size with a duration time of 10 seconds. Figure 10a is a photo of the digital face. Figure 10b shows the location in an oblique aerial.

Figure 10. Location No. 6 (10a, left) View on East Laburnum Avenue, (10b, right) Oblique Aerial of location

Location No. 7 is also on the north side of East Laburnum Avenue, approximately 0.12 miles east of Carolina Avenue. The structure is a double-face, free standing, centermount, back-to-back configuration. The west face is a digital poster and a right-hand reader. The west face was a new build on 25Nov06 at this location. The face is operated by Lamar and has a 10.5x36 size with a duration time of 10 seconds. Figure 11a is a photo of the digital face. Figure 11b shows the location in an oblique aerial.

Figure 11. Location No. 7 (11a, left) View on East Laburnum Avenue, (11b, right) Oblique Aerial of location

Location No. 8 is on the west side of the Route 360 (Mechanicsville Turnpike), approximately 0.3 miles north of Interstate 64. The structure is a double-face, free standing, back-to-back, center-mount configuration. The north face is a digital poster and a cross reader and was converted from a conventional format on 25Jul07. The south face is a digital poster and a right-hand reader. The south face was converted from a conventional format on 18Dec06. Each face is operated by Lamar and has a 14x28 size with a duration time of 10 seconds. Figure 12a is a photo of the digital face. Figure 12b shows the location in an oblique aerial.

Figure 12. Location No. 8 (12a, left) View at Route 360 (Mechanicsville Turnpike), inset shows opposite-face digital, (12b, right) Oblique Aerial of location

Location No. 9 is on the south side of Interstate 64, approximately 0.6 miles west of South Laburnum Avenue. The structure is a double-face, free standing, center-mount, vee configuration. The west face is a digital poster and a cross reader. The face is operated by Lamar, has a 12.5x42 size with a duration time of 10 seconds, and was converted on 7Apr09. Figure 13a is a photo of the east digital face. Figure 13b shows the location in an oblique aerial.

Figure 13. Location No. 9 (13a, left) View on Interstate 64, (13b, right) Oblique Aerial of location

Location No. 10 is on the west side of Interstate 95, approximately 0.6 miles north of Bells Road (Route 161). The structure is a double-face, free standing, center-mount, vee configuration. The south face is a digital poster and a right-hand reader. The south face was converted from a conventional format on 25Apr06. The north face is a digital poster and a cross reader. The north face was converted from a conventional format on 15Nov06 using the existing location. Each face is operated by Lamar and has a 14x48 size with a duration time of 10 seconds. Figure 14a is a photo of the digital face. Figure 14b shows the location in an oblique aerial.

Figure 14. Location No. 10 (14a, left) View on Interstate 95, inset shows opposite-face digital (14b, right) Oblique Aerial of location

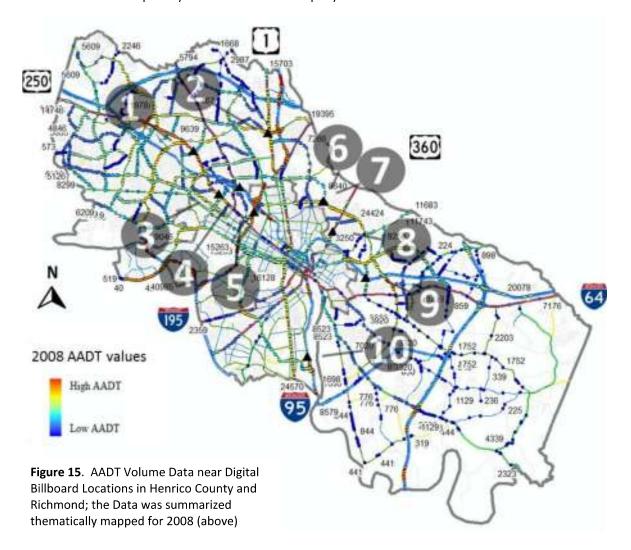


AADT ranges individually near the 10 digital locations from 27 to 100 thousand vehicles per day, or equivalently 9 to 36 million vehicles per year.

TRAFFIC VOLUME DATA

Traffic volume data for Henrico County and Richmond were obtained from the Virginia Department of Transportation (VDOT) and include the annual average daily traffic (AADT), which is the average of 24-hour counts collected throughout the year. The AADT volumes were recorded for the Henrico County and Richmond between 2004 and 2009.

The AADT values are summarized in Figure 15. AADT ranges individually near the 10 digital locations from 27 to 100 thousand vehicles per day, or equivalently 9 to 36 million vehicles per year. For all locations, this collectively represents approximately 423 thousand vehicles per day or 154 million vehicles per year.



ACCIDENT DATA

In this portion of the Greater Richmond Area, the majority of accident reports were investigated and recorded by each local and county Police Departments. Data were maintained by those Police Departments and compiled by the Virginia Department of Transportation. 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. Data generally conform to the American National Standards Institute (ANSI) Standard D16.1 – 1996, Manual on Classification of Motor Vehicle Traffic Accidents.

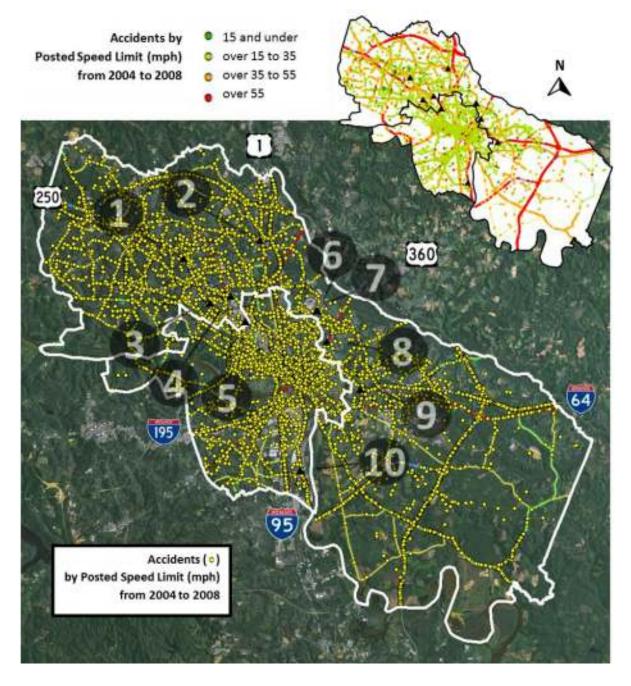


Figure 16. Traffic Accidents (yellow dots) near Digital Billboard Locations in Henrico
County and Richmond, Virginia from 2004 to 2008; Inset shows Accident by Posted
Speed Limit (mph)

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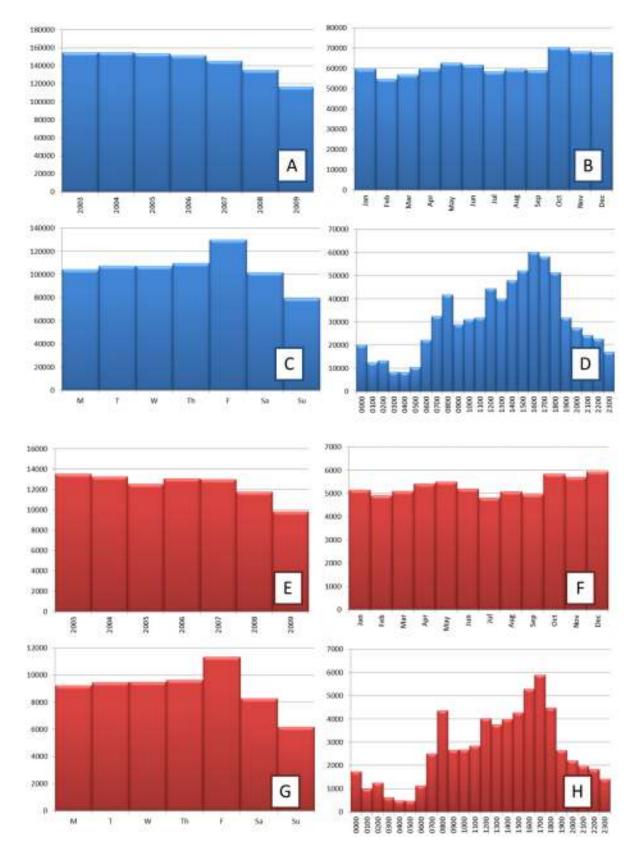


Figure 17. Histogram of Traffic Accident Data of the Past Seven Years in the State of Virginia (in blue) by Year (A), Month (B), Day of Week (C), and Time of Day (D) and in Henrico County and Richmond (in Red) by Year (E), Month (F), Day of Week (G), and Time of Day (H).

The analysis of this robust data involves an engineering-statistics based approach and uses widely accepted methods to show what happened when these 14 digital billboards faces were installed in Richmond.

The accident data-sets provided by VDOT include approximately 40,000 accidents during the seven years between 2004 and 2009 and near the digital billboard locations. Most of the data are specified by latitude and longitude or route nodes with offset distances. Figure 16 shows the geocoded accident locations generally within Henrico County and the City of Richmond.

Figure 17 summarizes the traffic accident data for the past seven years generally within the State of Virginia and within Henrico County and Richmond and show the distribution of accidents by year, month, day of week and time of day. This distribution represents a consistent pattern of data and illustrates that more accidents occur on weekdays and at rush hour (before and after work).

ANALYSIS

The analysis of this robust data involves an engineering-statistics based approach and uses widely accepted methods to show what happened when these 14 digital billboard faces were installed in Henrico County and Richmond.

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 Method (EBM). 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 in the 2010 *Highway Safety Manual* of the American Association of State Highway Official (AASHTO, Reference 14). We quantify what the actual 'after' accident statistics are and compare them with what

the predicted values are from the EB analysis. This method analyzes data from the ten billboard location and incorporates data using non-digital comparison sites.

Analysis: Part 1 – Temporal Comparisons

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 0.2, 0.4, 0.6, 0.8, and 1.0 miles both upstream and downstream of each billboard. For locations on local roads, these vicinity ranges also sampled data to include: (1) accidents along the principal roads to which the digitals directly advertise, (2) accidents recorded as occurring within the intersection of the primary road and any cross roads, and (3) for crossroad accidents within a reasonable distance from the primary road to include drivers turning onto or leaving the primary road. Accident data for roads to which the digitals do not advertise or are not connected were excluded, even if they were within the specified vicinity range.

Analysis: Part 2 - Spatial Comparisons

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 (see References 3 and 4).

Analysis: Part 3 – The Empirical Bayes Method (EBM)

The third part of the analysis uses the Empirical Bays Method (EBM).

An Empirical Bayes Method (EBM) analysis is performed to estimate the number of accidents that could statistically be expected without the introduction of a digital sign.

Research literature suggests that the EBM method is appropriate for this type of analysis and is a widely accepted method in the field of traffic safety (see References 14 to 31). 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 (AASHTO, Reference 14).

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 (see References 14 through 31). The correction for regression to the mean and the use of a negative binomial distribution are strengths of the EBM.

The EBM 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 Δ 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 no digital technology been 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

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

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

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

$$PC_b = rac{\sum_{before} EB}{\sum_{before} C_y}$$
, and

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

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

$$B = C_v * PC_b$$
, and

$$Var(B) = C_v^2 * Var(PC_b).$$

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 Δ crashes will be a negative value significantly lower than zero.

This analysis is applied to the data at 66 locations representing the 10 digital locations and 56 comparison sites.

The number of accidents and rates of accidents near the ten digital billboards locations remained consistent within all vicinity ranges.

RESULTS

Figure 18 shows a comparison of the accident metrics for before and after conversions near all ten digital billboards in Henrico County and Richmond, Virginia. The statistics are summarized for vicinity ranges of 0.2, 0.4, 0.6, 0.8, and 1.0 miles of the digital locations with 10 -second duration times collectively. The metrics in Figure 18 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, including rates and vehicle-miles traveled were also analyzed.

For all locations (Figure 18), the number of accidents and rates of accidents near the ten, digital billboards decreased in all vicinity ranges. The benchmark, 0.6-mile vicinity experienced a 4.5% decrease in the number of accidents over the seven year span for all location; this includes a 9.5% decrease in accident rates per hundred thousand AADT vehicles.

Figure 19 shows the distributions of the number of accidents per month near digital billboards within the benchmark 1.0 mile vicinity between 2003 and 2009.

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 that no statistically significant difference in the accident statistics evaluated between conventional and digital billboards at these digital locations.

Additionally, consistent results were obtained for driver-age comparisons. Low correlation coefficients were calculated for this spatial analysis. Correlation coefficients were calculated and indicated a very strong correlation of accident patterns near the digital billboards when compared with the accident patterns prior to conversion.

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 66 locations within Henrico County and Richmond.

Between 2003 and 2009 for equal periods before and after At 10 locations in Henrico County and Richmond, Virginia with 10 second duration times

		Vicinity Range from Digital Location (miles)					
		0.2	0.4	0.6	0.8	1.0	
	Total Number of Accidents for Equal Periods Before Conversion	241	649.75	832.25	1049:5	1243	
	Average Number of Accidents per Month at Each Location	1.02	2.75	1.53	4.45	5.22	
Prior to Installation	Rate of Accidents per Vehicles (by hundred thousand AADT)	0.15	0.41	0.53	0.fr7	0.79	
	Standard Deviation of Number of Accidents in any given month	1.82	4.01	4197	5.89	6.84	
	Peak Number of Accidents in any given Month per Location	11	19		28	45	
	Minimun Number of Accidents per Month per Location	0.	0.		9.		
	Average Number of Accident-Free Months at Locations	52%			35%	33%	
As Digital Location	Total Number of Accidents for Equal Periods After Conversion	205	617.25	795	977.25	1121	
	Average Number of Accidents per Month at Each Location	0.89	2.67	1/3,44	4.23	4.85	
	Rate of Accidents per Vehicles (by hundred thousand AADT)	0.12	0.37	0.48	0.59	0.68	
	Standard Deviation of Number of Accidents in any given month	1.35	3.05	3,72	4.35	5.03	
	Peak Number of Accidents in any given Month per Location	7.5	16	20	22	26.25	
	Minimun Number of Accidents per Month per Location	0	O	D	0	Ü	
	Average Number of Accident-Free Months at Locations	62%	52%	50%	42%	40%	
	Change in Number of Accidents	-36	-32.5	-37.25	72.25	-122	
	Change in Average per Month	-0.19		-0.08	-0.22	-0.41	
Comparison	Change in Rate per vehicles (by hundred thousand AADT)	-6:0A	-0.04	0.05		-0.12	
ð	Percent Change in Number of Accidents	-14.95				9.8%	
	Percent Change in Rate of Accidents	+1974%	-10,0%		-1118%	-14:6%	

Figure 18. Summary of Accident Statistics within Vicinity Ranges near all Ten Digital-Billboards Locations with 10-second Duration Times in Henrico County and Richmond, Virginia

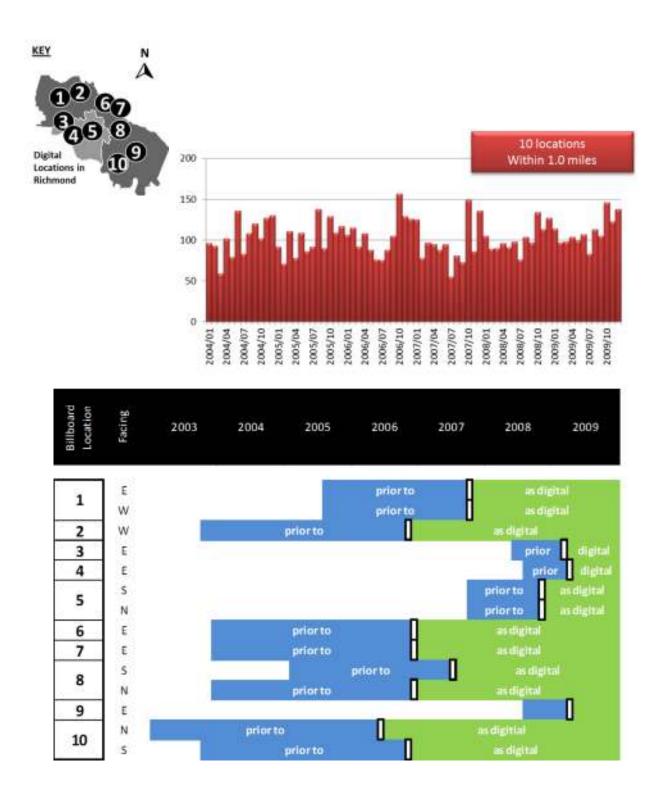


Figure 19. Distributions of the Number of Accidents per Month near Digital Billboards between 2004 and 2009, within a 1.0-mile Vicinity Range near all Digital Locations (top, red) compared with Conversion Dates and Before/After Comparison Periods

Figure 20 summarizes the accident rates that account for variations in traffic volumes for all digital locations within vicinity ranges of 0.2, 0.4, 0.6, 0.8, and 1.0 miles of the digital location. The 0.6 mile benchmark vicinity experienced a decrease in accident rates over the eight-year span. The change in accident rates decreased by 0.05 accidents per hundred thousand vehicles per year; a 9.5% decrease. Similar decreases and trends were observed for both smaller vicinity ranges.

Between 2003 and 2009 for equal periods before and after At 10 locations in Henrico County and Richmond, Virginia with 10 second duration times

		Vi	cinity Range	from Digital I	Location (Mil	es)
		0.2	0.4	0.6	0.8	1.0
Prior to Installation	Number of Accidents per million vehicles (by hundred thousand AADT)	0.15	0.41	0.53	0.67	0.79
As Digital Location	Number of Accidents per million vehicles (by bundred thousand AADT)	0.12	0.37	0.48	0.59	0.68
Companison	Change in Rate per million vehicles (by hundred thousand AADT)	+0.03	-0,64	0:05	-0,08	-0.12
Come	Percent Change in Rate of Accidents	19.4%	-10.0%	9.5%		-14.6%

Figure 20. Summary of Accident Rates within Vicinity Ranges near Ten Digital Billboards Locations 10- second-duration Times in Henrico County and Richmond, Virginia

COMPARISON OF ACCIDENTS BY AGE OF DRIVER

The accident statistics were also analyzed to determine if the age of the drivers involved in the accidents near the 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). Figure 21 summarizes the accidents and accident-rates by age of driver for all accidents.

Figure 22 shows the distributions of ages of driver for all accidents within Henrico County and Richmond (A, blue) and for all accidents within 1.0 miles of all digital locations (B, purple).

Figure 23 shows the distributions of driver ages within 1.0 miles of all digital locations for before (orange) and after (purple) periods of comparison. Figure 23 (left) also shows the correlation between before and after conversions for the number of accidents for each age. Individual accidents may have multiple cars and drivers involved, which is reflected in the analysis. In comparing the histograms in Figure 22 and 23, note the typical distribution type (shape) and typical average values. The mode driver age for accidents prior to digital conversion is 19 years; the mode drive age after conversions is 19 years.

Correlation coefficients were calculated and indicated a very strong correlation of accident patterns for age-of-driver factors. Figure 23 shows a 0.920 (92.0%) correlation coefficient when comparing accidents before conversion with those after conversion.

Between 2003 and 2009 for equal periods before and after At 10 locations in Henrico County and Richmond, Virginia with 10 second duration times

			Crashes By Dri	ver Age Group	
		under 17	under 21	21-65	over 65
Prior to installation	Number of Accidents for equal periods prior to conversion	6	134	1007	97
As Digital Location	Number of Accidents for equal periods after conversion	6	98	922	95
Companison	Change in Number of Accidents	None			
dunos	Percent Change in Number of Accidents	None	-26.9%		-2.196

Figure 21. Summary of Accidents by Age Group within Vicinity Ranges near Ten Digital Billboard Locations in Henrico County and Richmond, Virginia

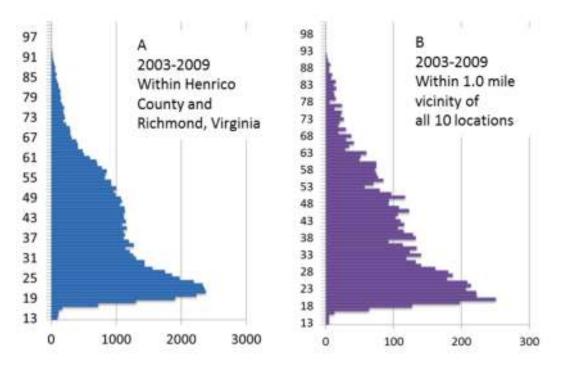


Figure 22. Distributions of Age of Drivers for all Accidents in the Henrico County and Richmond (left, blue), and within 1.0 miles of all Digital Locations (right, purple)

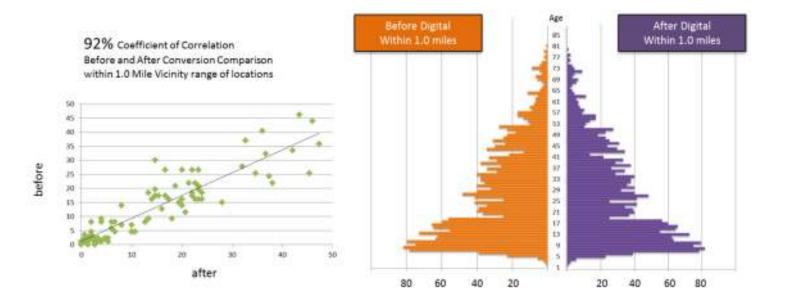


Figure 23. Distributions of Age of Drivers for all Accidents before Digital Conversion (left, orange histogram), after Digital Conversion (right, purple histogram) and the Correlation between Before and After Accident Counts for each Age (left).

COMPARISON OF ACCIDENTS BY TIME OF DAY

The accident statistics are also analyzed to determine if the time of day of the accidents near digital billboards is a factor.

The data are studied to determine if any increases in the accident rates during dawn, daylight, dusk and dark/nighttime conditions occurred. Figure 24 summarizes the accidents and accident-rates by time of day for all accidents within 1.0 miles of the digital locations. The daylight accident rate experienced a 15.5 percent decrease after conversion; the nighttime accident rate experienced a 4.7% decrease.

Figure 25 shows the distributions of times of accidents within 1.0 miles for before conversion (top, blue) and for after conversion (middle, red) data periods of comparison. Figure 25 (bottom) also shows the correlation between before and after conversions for the number of accidents. In comparing the histograms in Figure 25, note the typical distribution type (shape) and typical average values. Correlation coefficients were calculated and indicated a very strong correlation of accident patterns for time-of-day factors. Figure 25 shows a 0.90 (90.0%) correlation coefficient when comparing accidents before conversion with those after conversion.

Between 2003 and 2009 for equal periods before and after At 10 locations in Henrico County and Richmond, Virginia with 10 second duration times.

		During Time of Day and Lighting					
		Dawn	Daylight	Dusk	Dark		
Prior to Installation	Number of Accidents for equal periods prior to conversion	98	828	124	190		
Prior to In	Number of Accidents per million vehicles (by hundred thousand AADT)	0.06	0.53	0.08	0.12		
Location	Number of Accidents for equal periods after conversion	66	700	88	181		
As Digital Location	Number of Accidents per million vehicles (by hundred thousand AADT)	0.04	0.42	0.05	0.11		
Ī	Change in Number of Accidents	-82	-128	-36	-4		
mpanison	Change in Rate per million vehicles (by hundred thousand AADT)	-0.02	-0.11				
Compa	Percent Change in Number of Accidents	-32.7%			4.7%		
	Percent Change in Rate of Accidents	-36.2%	19.9%	-32.8%	-9.8%		

Figure 24. Summary of Accident Rates during Dawn, Daylight, Dusk and Dark/Nighttime Conditions within a 0.5 mile vicinity range near ten Digital Billboards Locations with 10-second-duration times in Henrico County and Richmond, Virginia

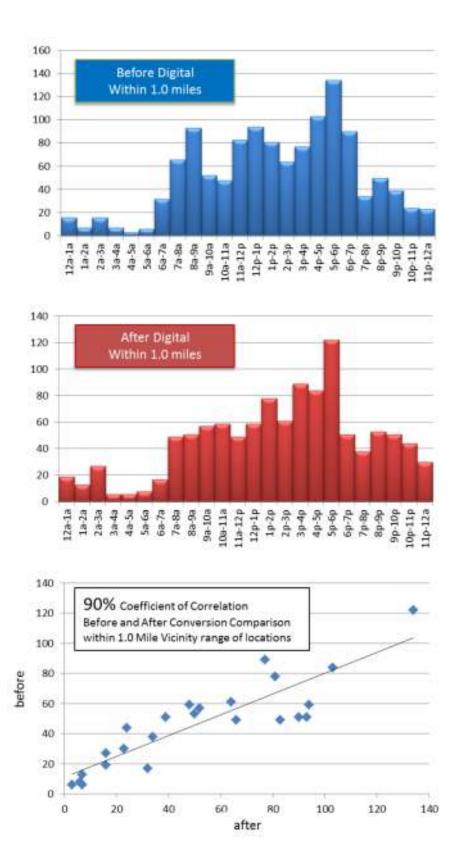


Figure 25. Distributions of Number of Accidents Accident by Time of Day within a 1.0 mile Vicinity Range prior to Digital Conversion (top, blue) and after digital conversion (middle, red) near ten digital billboards locations with 10- second-duration times in Henrico County and Richmond, Virginia

STATISTICAL MODEL AND RESULTS FOR THE EMPIRICAL BAYES METHOD

The Empirical Bayes Method (EBM) is used to analyze available crash data in Henrico County and Richmond, Virginia. The EBM method is a rigorous method capable of estimating the safety impact of changes at a location. The EBM method is well documented and used in numerous traffic-safety studies (see References 14 through 31). Simply stated, the method estimates the number of crashes at a location that would have occurred without the introduction of digital billboards. The estimates may then be compared with the actual crashes that have occurred.

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 26 and models Average Annual Daily Traffic (AADT), Number of Lanes (Lane), and the posted Speed Limit (Speed) as independent variables; β_0 , 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 90 sites representing 10 digital billboard locations and 80 comparison sites. Figure 27 shows these locations. Figure 26 summarizes the CEM parameters using a maximum likelihood estimates for a multivariate regression model with negative binomial distribution. The CEM parameters are significant at $\alpha=0.05$. The resulting CEM equation is also presented in Figure 26.

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.

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

Explicit CEM:
$$P = (AADT)^{.0285} (LANE)^{0.1381} (Speed)^{-0.0070} e^{2.7599}$$

CEM Model Parameters:

Variable		Coefficient	Standard Error	Chi-square statistic	Pr > Chi-square	Wald 90% confidence limits	
						Lower	Upper
Intercept		2.7599	0.1943	201.81	<.0001	2.3792	3.1407
AADT	β_1	0.0285	0.0020	205.35	<.0001	0.0246	0.0324
lanes	β_2	0.1381	0.0293	22.25	<.0001	0.0807	0.1955
speed	β_3	-0.0070	0.0022	10.45	0.0012	-0.0112	-0.0027
Dispersion	ф	0.4445	0.0325			0.3808	0.5081

SAS Goodness of fit measures: deviance (value/d.f.) = $438.3687 \{1.1014\}$; Pearson chi-square (value/d.f.) = 373.611 (0.9387); Number of observations = 680

Figure 26. General and Explicit Crash Estimation Model (CEM) and CEM Model Parameters from SAS Output

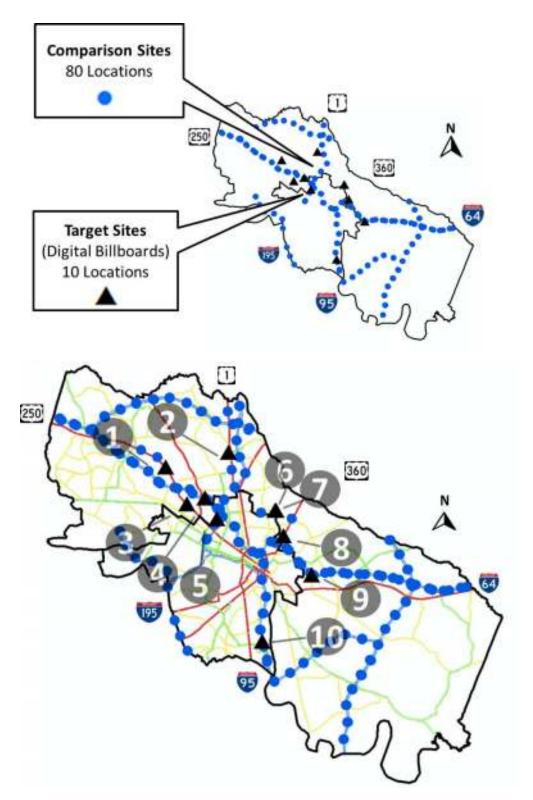


Figure 27. Crash and AADT Data for 10 Target (Digital) Locations and 80 Comparison (non-Digital) Locations

The Empirical Bayes Method results 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. 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 consistent. A large sample size was used with 10 digital locations, 80 treatment or comparison sites with seven years of accident data. The statistical evaluation of the Empirical Bayes Method analysis shows that the total number of accidents is slightly less than 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 90 locations within Henrico County and Richmond, Virginia. 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.

Parameter	Value
Total Crashes for the "After" Period with Digital Conversion (Actual Values)	1121
Total Crashes for the "After" Period assuming no Digital Conversion ever occurred (Estimate by Empirical Bayes Method)	1137
Overall Index of Effectiveness	0.986
Percent Change in Crashes between actual and estimate	1.42%

Figure 28. Results of the Empirical Bayes Method Estimation in Henrico County and Richmond, Virginia with 10 digital locations, 80 Treatment or Comparison Sites and with Seven Years of Accident Data

Simply stated, the data show no statistically significant increase of accident rates near these billboards.

FINDINGS

Henrico County and Richmond, Virginia are 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 more than seven years. The overall conclusion is that these digital billboards in Richmond have no statistically significant relationship with the occurrence of accidents. This conclusion is based on local Police and VDOT data and an objective statistical analysis; the data show no statistically significant increase in accident rates. This study also finds that the age of the driver (younger, older) and the time of day (nighttime, daytime) are neutral factors which show no increase in accident rates near these digital billboards along the routes in in Henrico County and Richmond, Virginia.

The specific conclusions of this study indicate the following.

- The before and after rates of accidents near the 10 digital billboard locations show decreases within 1.0 miles of all digital billboards for more than seven years. Similar decreases and trends in both averages and peaks are observed for smaller vicinity ranges.
- 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 consistent with 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 90 locations within and near Richmond Virginia.
- The overall conclusion of the study is that these digital billboards in Richmond have no statistically significant relationship with the occurrence of accidents.

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. These conclusions are based on the collected Police Department data and on an objective statistical analysis.

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Driving Performance and Digital Billboards

FINAL REPORT

Prepared for:

Foundation for Outdoor Advertising Research and Education

By:

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and

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Center for Automotive Safety Research March 22, 2007

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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 openended 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 ≥ 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 rearend 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.

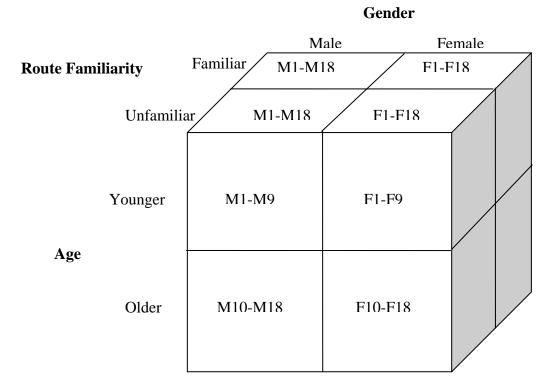


Figure 1. Assignment of Participants to Experimental Conditions.

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 ().

Conventional Billboards. 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.

Comparison Sites. 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.

	Specific Site Location Information.						
	Event						Road
	Type	Description	Side			Site	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		4866 West 150th	S
11	4	Baseline	Both	41.4307785	-81.80125427	4545 West 150th	S
12	2	Static Billboard	Left	41.43348694		13986 Puritas Ave	S
13	4	Baseline	Both	41.43657303		13456 Bellaire Rd	S
14	3	On Prem/Logo	Left	41.43969727		12686 Bellaire Rd	S
15	3	Tri-Vision Billboard	Right			12071Bellaire Rd	S
16	4	Baseline	Both	41.45092773		3757 West 117th	S
17	2	Static Billboard	Left	41.46089554		3370 West 117th	S
18	4	Baseline	Both	41.46966553		90 E, @ W. 97th St.	I
19	1	LED Billboard	Right			90 E, @ W. 55th St.	I
20	2	Static Billboard	Left	41.47385406		90 E, W/O Fulton Rd.	I
21	3	On Prem/Logo	Left	41.48424911		90 E, S/O Abbey Ave.	I
22	1	LED Billboard	Right			90 E, @ W. 3rd St.	I
23	3	On Prem LED Billboard		41.49866867		2071 Carnegie Ave.	S
24	3	On Prem/Logo	Left	41.49928284		2351 Carnegie Ave.	S
25	3	On Prem LED Billboard		41.52510452		90 E, E/O E. 49th St.	I
26	3	Building	Right			90 E, W/O E. 72nd St.	I
27	2	Static Billboard	Right			90 E, W/O E. 99th St.	I
28	2	Static Billboard	Right			90 E, W/O E. 105th St.	I
29	4	Baseline	Both	41.5479126		90 E, @ E. 109th St.	I
30	3	On Prem/Logo	Right			90 E, @ Coit Rd.	I
31	4	Baseline	Both	41.56173325		90 E, W/O E. 140th St.	I
32	4	Baseline	Both	41.56638718		90 E, W/O E. 140th St.	I
33	2	Static Billboard	Right			90 E, @ E. 167th St.	I
34	3	On Prem/Logo	Right			90 W, @ E. 161st St.	I
35	4	Baseline	Both	41.56744385		90 W, W/O E. 152nd St.	I
36		Baseline	Both			90 W, W/O E. 132nd St. 90 W, W/O E. 140th St.	I
37	1	LED Billboard	Left	41.54701233		90 W, W/O E. 140th St.	I
38	2	Static Billboard	Left	41.54128647		90 W, W/O E. 103th St.	I
39	3		_				_
40	2	Static Billboard	Right Left	41.52567673 41.49006653		90 W, W/O E. 55th St.	I
41	2					77S, S/O Woodland Ave.	I
-		Static Billboard LED Billboard	Right			77 S, @ I-490 Exit	I
42	1		Right			77 S, S/O Pershing Ave.	I
43	4	Baseline Static Billhound	Both	41.45179367		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

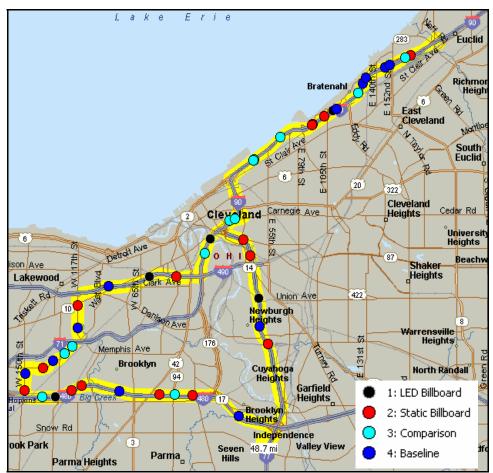


Figure 2. Map Illustrating Digital Billboards (black), Conventional Billboards (red), Comparison Sites (aqua blue), and Baseline Sites (blue).

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 5th percentile value was 0.68 s and the 95th 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 5th percentile value was 0.32 s and the 95th 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.

Table 3. Directions for 50-mile daytime route in Cleveland, OH.			
	<u>Directions</u>	Trip Distance	<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.

<u>Directions</u>	Trip Distance	<u>Notes</u>
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.

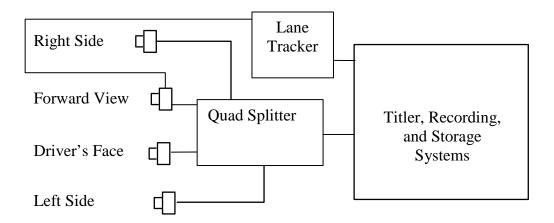


Figure 13. Components of the Data Collection System.

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	0	М
2	0	М
3	Υ	М
4	0	М
5	Υ	F
6	Υ	F
7	0	F
8	Υ	F
9	0	F
10	Υ	М
11	0	F
12	Υ	M
13	0	М
14	0	М
11 12 13 14 15 16 17 18 19 20	Υ	M M F F M M F M M M M F F M M M M M M M
16	0	F
17	0	F
18	0	F
19	0	М
20	Υ	F
21	Υ	M
22	Υ	F F
23	Υ	F
24	0	М
25	Υ	F
26	0	F
27	0	М
28	Y	М
29	0	F
30	O O O Y O O O O O O O O O O O O O O O O	F M M F F
31	Y	F
32	0	F M M
33	Υ	М
34	Υ	М
35	Y	M
36	Υ	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 predetermined 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 2hour 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.

	<u>Directions</u>	Trip Distance	<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 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	

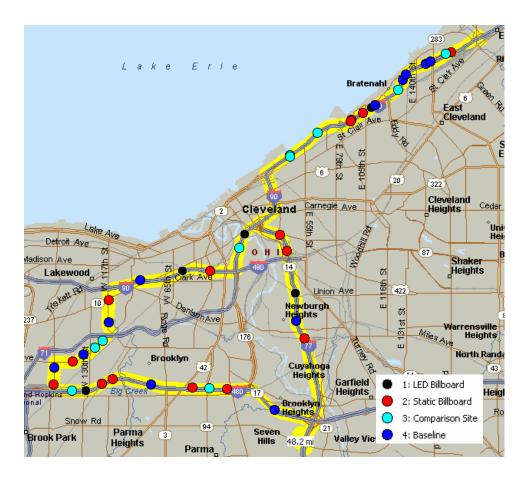


Figure 14. Map Illustrating Nighttime Route with Digital Billboards (black), Conventional Billboards (red), Comparison Sites (aqua blue), and Baseline Sites (blue).

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.

<u>Age.</u> 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).

<u>Education Level.</u> 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.

<u>Marital Status.</u> 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.

<u>Ethnicity.</u> 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	Older	All Drivers	
	Drivers	Drivers		
	27.9 years	58.7 years	43.3 years	
Education	High Sch.	2-Yr Deg.	B.A./B.S.	
Level	52.8%	25.0%	22.2%	
Marital Status	Single	Married	Divorced	Separated
	27.8%	50.0%	16.7%	5.6%
Ethnicity	African	European		
	American			
	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.

<u>Living and Working Location.</u> 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).

<u>Familiarity</u>. 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	W.130th -	I-90	Carnegie	I-77
	between I-	Bellaire -	between	Ave.	between I-
	77 and	W.117th	9th and		90 and
%	W150th		185th		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.

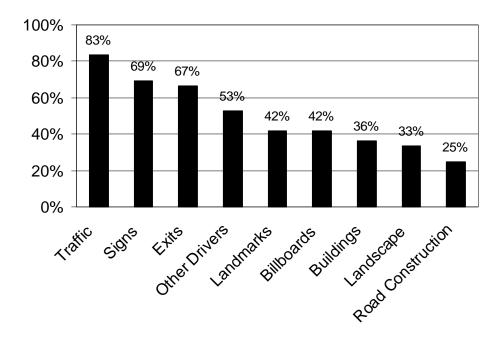


Figure 15. Top Daytime Attention Getters (top nine of eighteen possible).

<u>Most Memorable.</u> 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%

<u>What Bothers You?</u> 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."

	Number of	Percent of
Comment Category	Comments	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%

<u>Other Activities</u>. 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	Older	All Drivers	
	Drivers	Drivers		
	31.5 years	57.5 years	44.5 years	
Education	High Sch.	2-Yr Deg.	B.A./B.S.	
Level	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	W.130th -	I-90	Carnegie	I-77
	between I-	Bellaire -	between	Ave.	between I-
	77 and	W.117th	9th and		90 and
	W150th		185th		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.

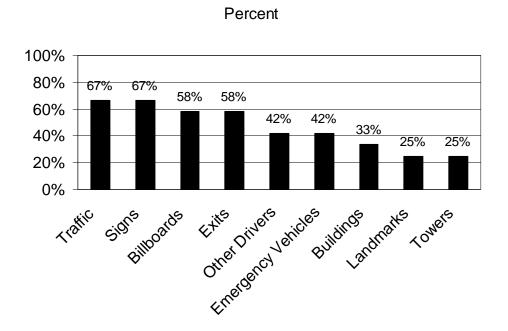


Figure 16. Top Nighttime Attention Getters (top nine of eighteen possible).

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

<u>Eyeglance Results.</u> 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.

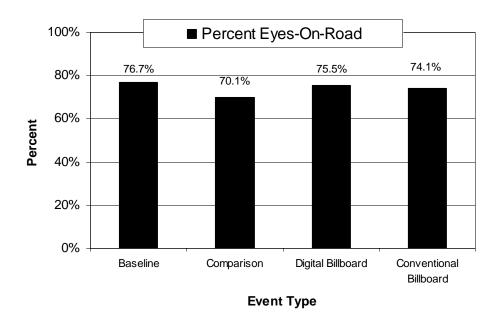


Figure 17. Percent Eyes-on-Road Time for the Four Event Types. (Comparison events were significantly lower than the other three event types, which did not differ from one another).

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.

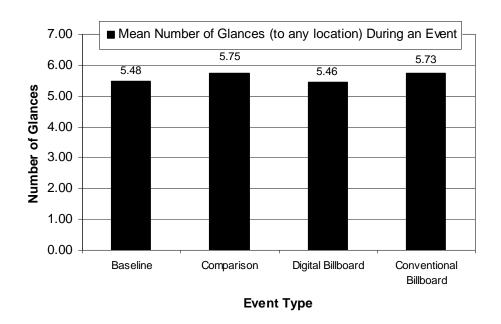


Figure 18. Mean Number of Glances to Any Location During an Event. (There were no significant differences between event types.)

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).

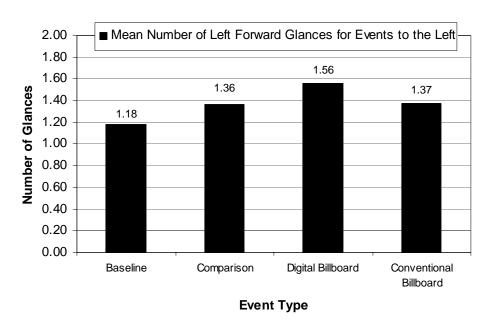


Figure 19. Mean Number of Left Forward Glances for Events on the Left Side of the Road. (There were no significant differences between event types.)

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 $(F_{3.77} = 0.29, p = 0.8353)$.

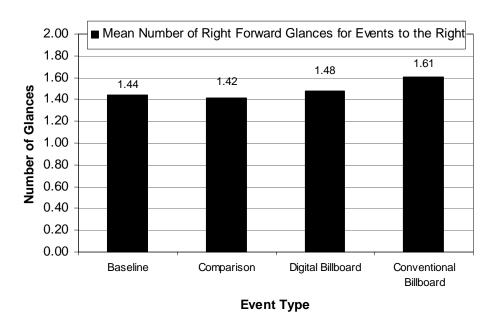


Figure 20. Mean Number of Right Forward Glances for Events on the Right Side of the Road. (None of the observed differences were significant.)

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.

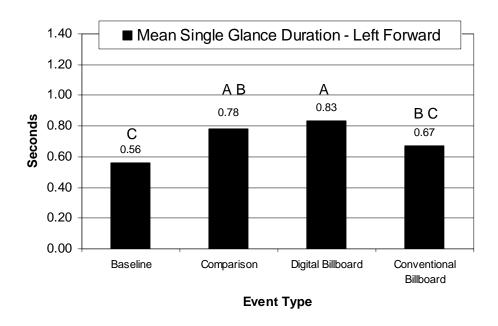


Figure 21. Mean Single Glance Time for Left Forward Glances for Events on the Left Side of the Road. (Data points with a shared letter do not differ significantly from one another.)

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.

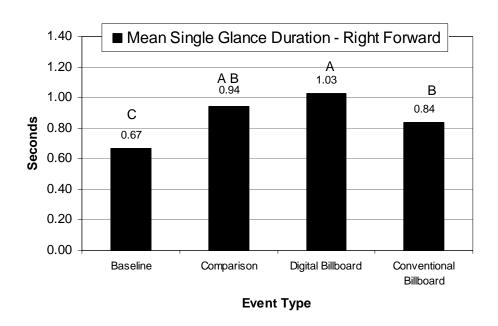


Figure 22. Mean Single Glance Time for Right Forward Glances for Events on the Right Side of the Road. (Data points with a shared letter do not differ significantly from one another.)

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.

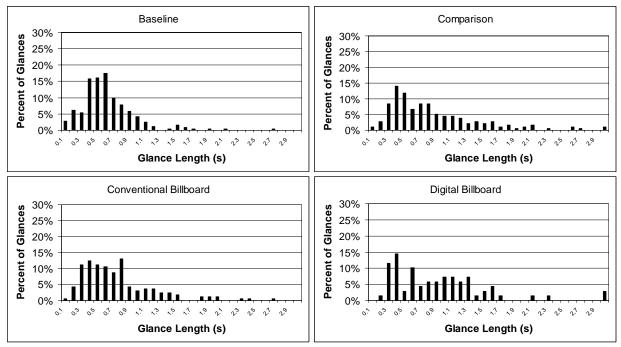


Figure 23. Tails analysis for the distribution of glance duration, (method described in Horrey and Wickens, 2007).

<u>Discussion of Daytime Eyeglance Results</u>. 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.

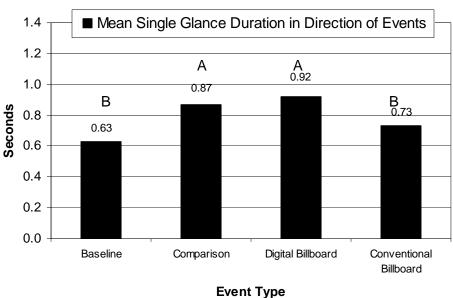


Figure 24. Mean Single Glance Time for Glances in the Direction of Events. (Data points with a shared letter do not differ significantly from one another.)

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.

<u>Speed maintenance.</u> 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.

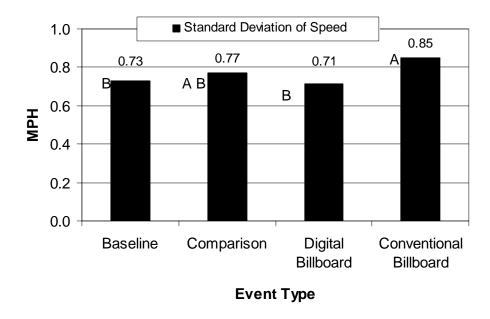


Figure 25. Standard Deviation of Speed by Event, in miles per hour. (Data points with a shared letter do not differ significantly from one another.)

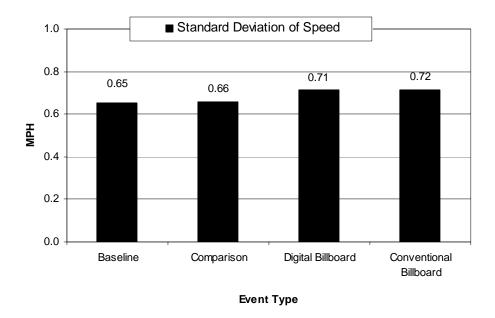


Figure 26. Standard Deviation of Speed by Event for Events Occurring on Interstates, in miles per hour. (None of the observed differences was significant.)

<u>Lane keeping.</u> 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.

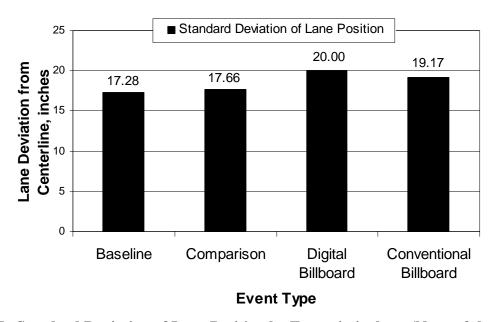


Figure 27. Standard Deviation of Lane Position by Event, in inches. (None of the observed differences was significant.)

Other findings

<u>Road Type.</u> 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.

<u>Familiarity.</u> 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.

<u>Age.</u> 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.

<u>Gender.</u> There were no significant findings for gender for eyeglance, speed maintenance, or lane keeping measures.

Driving Performance Results – Nighttime

Event Type

<u>Eyeglance results.</u> 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.

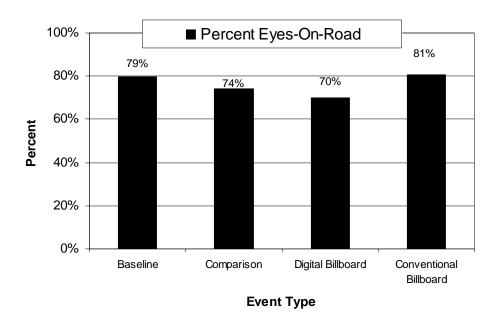


Figure 28. Eyes-on-Road Percent by Event Type for the Nighttime Exploratory Study.

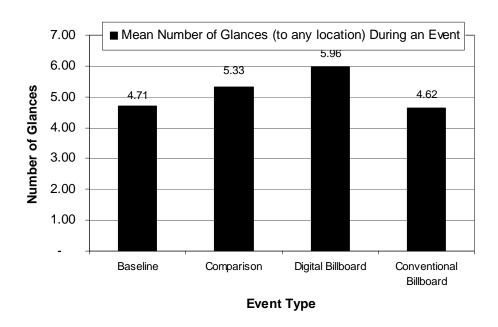


Figure 29. Overall Glance Frequency by Event Type for the Nighttime Exploratory Study.

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.

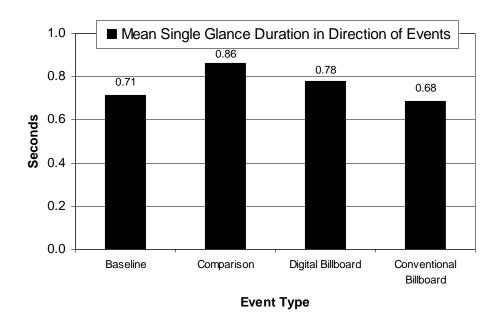


Figure 30. Mean Glance Time for Glances in the Direction of an Event for the Nighttime Exploratory Study.

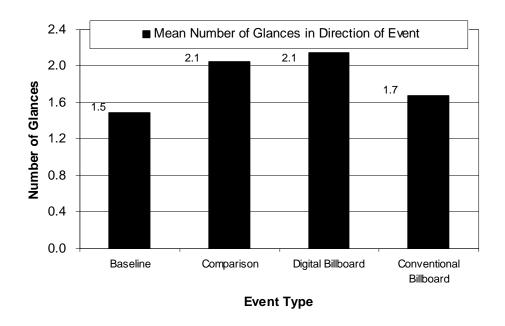


Figure 31. Mean Number of Glances in the Direction of an Event for the Nighttime Exploratory Study.

<u>Speed maintenance</u>. 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.

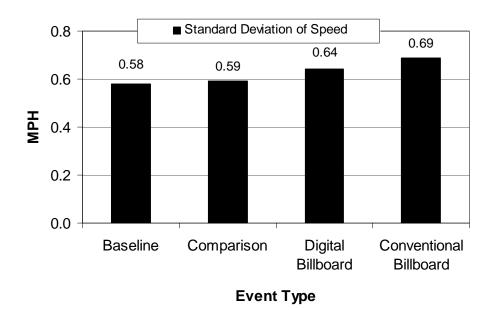


Figure 32. Speed Maintenance as Measured by the Standard Deviation of Speed by Event for the Nighttime Exploratory Study.

<u>Lane keeping</u>. 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.

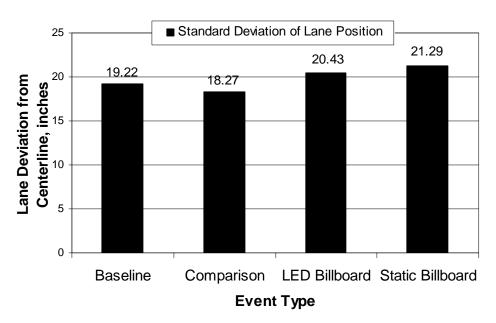


Figure 33. Lane Keeping as Measured by the Standard Deviation of Lane Position by Event for the Nighttime Exploratory Study.

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.**

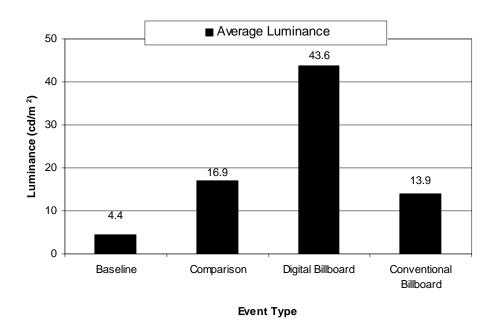


Figure 36. Average Luminance of the Four Event Types, in Candelas per Meter Squared.

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:
 - o 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
 - O 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.
 - o 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 <u>Residence Inn by Marriott</u> 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.

Q	uestion	S			
4	ъ		11 1 1 1	1 11	0

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 equipment? Yes No	n without	assistive	devices	or specia	ıl
8.	Do you have a history of any of the following? If ye	s, please ex	xplain.			
	Stroke	No	_ Ye	es		
	Brain tumor	No	_ Y	es		
	Head injury	No		es		
	Epileptic seizures	No		es		
	Respiratory disorders	No		es		
	Motion sickness	No		es		
	Inner ear problems	No	_ Y	es		
	Dizziness, vertigo, or other balance problems	No	_ Y	es		
	Diabetes	No		es		
	Migraine, tension headaches	No	_ Y	es		
pa fer pe alt	Yes No (If "yes" then rticipant: "It is not recommended that pregnant won male participants who are pregnant and wish to presonal physician for advice and guidance regarding shough minimal, include the possibility of collision and a decomposition. Are you currently taking any medications on a regulary Yes	n read the nen partic articipate g participa l airbag de ar basis? I	ipate in the must first ation in a reployment.	nis study. t consult t study w ")	However with thei here risks	r, ir
11	No 1. Do you have normal or corrected to normal hearing Yes No			lease exp	lain.	_
12	. Have you ever had radial keratotomy, LASIK, or oth Yes No		_	yes, plea	se specify	•

I would like to	take your name,	phone numb	er or phone	numbers,	and/or	email '	where :	you o	can t	эe
reached and ho	ours/days when it	t's best to reac	h you.							

Name	Male/Female
Phone Numbers	Age:
Best Time to Call	
Fmail	

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.

Participant #

Appendix B: Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

<u>Title of Project</u>: Influence of driver characteristics on driving performance

<u>Investigators</u>: 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

Participant #

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.

Participant #

- 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

Participant #	
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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 limit Keratotomy, and cataract surgery.)	ed to, LASIK, Radial
☐ I have had an eye injury/eye surgery and I've have been informed participants who have had eye surgery. I choose to accept this point this study.	•

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 Melinda J. McElheny, Senior Research Specialist (540) 231-1511 (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

good general health?	Yes	No		
ny health-related conditions you ar	e experie	encing or have experienced in the		
n the last 24 hours, experienced ar	ny of the	following conditions?		
Inadequate sleen	Ves	No		
		No		
		No		
		No		
· -	Yes	No		
	Yes	No		
		No		
se describe.)				
Seizures or other lapses of consciousness	Yes	No		
ase describe.)				
Any disorders similar to the above or that would impair your driving ability	Yes	No		
se describe.)				
	n the last 24 hours, experienced ar Inadequate sleep Hangover Headache Cold symptoms Depression Allergies Emotional upset e a history of any of the following Visual Impairment use describe.) Seizures or other lapses of consciousness use describe.) Any disorders similar to the above or that would impair	n the last 24 hours, experienced any of the Inadequate sleep Yes Hangover Yes Headache Yes Cold symptoms Yes Depression Yes Allergies Yes Emotional upset Yes e a history of any of the following? Visual Impairment Yes Seizures or other lapses of consciousness Yes ase describe.) Any disorders similar to the above or that would impair		

List any prescription or non-prescription of last 24 hours.	rugs you are currently taking or have tak	en in
List the approximate amount of alcohol (beconsumed in the last 24 hours.	eer, wine, fortified wine, or liquor) you l	—— have
Are you taking any drugs of any kind other	r than those listed in 4 or 5 above? Yes No	

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

W.130th –Bellaire–W.117th

I-90 between 9th and 185th

Carnegie St.

I-77 between I-90 and Rockside

Familiar

Familiar

Familiar

Not Familiar

Not Familiar

Not Familiar

Not Familiar

2. For the following systems, please check what you liked or disliked:

dislike Seating like neutral Air conditioning like neutral dislike Engine power dislike like neutral Visibility like neutral dislike Steering like dislike neutral

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?YesNo 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?
1	0. In what city do you work?
1	1. What level of education have you completed?
	Elementary/SecondaryJunior High SchoolHigh School degree2-yr Associate degreeBachelor's degreeMaster's degreeDoctoral/Professional degree
1:	2. Please indicate your marital status:
	singlemarriedwidoweddivorcedseparated
1	3. Which of the following groups best represent your ethnicity? African American Hispanic (Latino) Asian

	_Native American (Americ _European (Caucasian, Wl _Multi-racial	,		
14. Whi	th of the following best rep	presents your annual hous	sehold income?	
	_\$0-\$24,999			
	_\$25,000-\$49,999			
	_\$50,000-\$74,999			

Participant #_____

15. What was the purpose of this study?



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August 18, 2020

Eugene Planning Commission 99 West 10th Avenue

Eugene, OR 97401

Re: Digital Billboards

Dear commissioners:

As an advocate for transportation safety for all members of our community, it is the aim of Better Eugene-Springfield Transportation (BEST) to stay informed on all changes to our roadways that may affect the level of safety for those traveling on our streets.

DELIVERED VIA EMAIL

Recently, BEST became aware of the City of Eugene's Planning and Development Department (PDD) receiving direction from City Council and the Planning Commission to develop regulations and facilitate installation of digital billboards in Eugene. In doing our due diligence to examine the effects of possible changes made in close proximity to our roadways, BEST staff has done some research on digital billboards to help educate ourselves and the PDD in any action moving forward. BEST staff has condensed points of interest in the bullet points below, in addition to providing sources following each point.

- According to the National Highway Traffic Safety Administration (NHTSA), the amount of time that is considered to be a distraction from driving (inattention to the roadway and surroundings) is only 2 seconds. Furthermore, the organization stated that the odds of a crash double if the driver's eyes are distracted for more than 2 seconds. Quoted from the sourced article, "In 2016, more than 9 percent of United States traffic deaths—or 3,450—were linked to distracted driving."1
- A 2006 study conducted by Virginia Tech for the National Highway Traffic Safety Administration found that 80 percent of all crashes involve drivers taking their eyes away from the roadway for just about 3 seconds prior to the crash. Brighter, more visible signage, such as that found with digital billboards, could have the propensity to distract drivers from the roadway, especially during evening hours where they may appear brighter.²

Building a successful community by bringing people together to promote transportation options, safe streets, and walkable neighborhoods.

Better Eugene-Springfield Transportation • PO Box 773, Eugene, OR 97440 • 541-343-5201

- A 2012 study conducted by researchers at the Swedish National Road and Transport Research Institute found that drivers looked at digital billboards significantly longer than at non-digital signs while driving down a roadway. The time taken to look at digital billboards was approximately the same amount of distracted seconds 80 percent of crashes occur at. As a result of this study's findings, the Swedish government removed all digital billboards.³
- Emerging technologies within the digital billboard conversation speak to what could be referred to targeted driver distraction. Though not in every case with digital billboards, some have the propensity to display ads during specific times of traffic flow; i.e., a digital billboard displaying food images close to dinner time when traffic is heavy and flashing quicker images when there is lighter traffic. Even if they do not start out as advanced as in other locations, the possibility (and promise) of evolving technologies should be considered in moving forward with the conversation on implementation of digital billboards.⁴
- The impact of digital advertising on different age groups of drivers should also be taken into consideration. A study conducted in 2019 found that younger drivers pay more attention to roadside advertising. This becomes more significant when coupled with the following 2017 statistic from the CDC, "The risk of motor vehicle crashes is higher among teens aged 16–19 than among any other age group. In fact, per mile driven, teen drivers in this age group are nearly three times more likely than drivers aged 20 and older to be in a fatal crash." 5,6

Thank you for your time, and please don't hesitate to reach out if any questions or comments should arise.

For BEST,

Claire Roth

Claire Roth

Safe Streets Coordinator
(650) 416-4802

claire@best-oregon.org

¹ "2-Second Rule for Distracted Driving Can Mean Life or Death," *New York Times*, 9/27/2018, https://www.nytimes.com/2018/09/27/business/distracted-driving-auto-industry.html.

² "Swedish Study Shows Digital Billboards Distract Drivers," Scenic America, https://www.scenic.org/sign-control/digital-billboards/swedish-digital-billboard-study/.

³ Ibid.

⁴ Oscar Oviedo-Trespalacios, Verity Truelove, Barry Watson, Jane A. Hinton, "The impact of road advertising signs on driver behaviour and implications for road safety: A critical systematic review," *Transportation Research Part A: Policy and Practice*, 122 (2019): 85–98, https://doi.org/10.1016/j.tra.2019.01.012.

⁵ Ibid.

⁶ "Teen Drivers: Get the Facts," Centers for Disease Control and Prevention, https://www.cdc.gov/motorvehiclesafety/teen-drivers-factsheet.html.

DRAGOVICH Jenessa L

From: FORREST Beth L

Sent: Monday, September 7, 2020 5:29 PM

To: DRAGOVICH Jenessa L

Subject: FW: Caution on electronic billboards

Hi Jenessa, Just wanted to be sure you received this email. Thanks, Beth

From: Christopher L <ctm_logan@yahoo.com> Sent: Saturday, September 05, 2020 11:56 AM

To: *Eugene Mayor, City Council, and City Manager <MayorCouncilandCityManager@eugene-or.gov>

Subject: Caution on electronic billboards

[EXTERNAL ⚠]

Greetings, Deciders!

Seemingly without citizen input, the City has apparently decided to allow electronic billboards in town. This in itself is a grievous mistake, both aesthetically and in terms of the added energy use that is thus mandated. However, if you're determined to uglify our city with electronic signs, further exacerbating the angst produced by a society awash in electronics, then **some guidelines are important**.

First, the signs should not change and the pictures move, if visible by motorists. Sudden movement - and especially mind-candy swirls of color - are highly distracting to motorists already navigating between rows of moving metal. Existing electronic distractions - you can legislate against em, but they keep popping up - include drivers texting and checking their email and recorded music booming out of pickup trucks and hot sedans, which provide sudden distraction as they drive past. If you want people to pay attention to street lights and stutter-flashes, don't distract them with giant kids running around with Coca Cola. If an electronic sign is static - that is, one image, not moving - it will be less of a road distraction, though still horrific in a natural landscape like Eugene.

Second, you should consider the existing aesthetics, and at least not allow them anywhere near natural or park-like areas. We have to have *some* place to rest our senses, and putting one up by the River or Skinner's Butte would be a crime. West 11th is already aesthetically dead, and mandated for commercial activity, so these innovations should be restricted to such zones as W. 11th and Hwy 99. Certainly they should not be allowed in residential neighborhoods, which is where we go after a hard day of intense inputs, to relax and think our own thoughts.

Finally, if you're committed to allowing the damthings, please consider a trial period, in which a few are introduced on a temporary basis. If residents find them noxious, we should have the power to restrict or eliminate them. Please don't just open the floodgates to this obnoxious technology. A sunset on this experiment would be prudent.

In an age just realizing that human activity - notably electricity use - is literally killing the planet, I'm amazed that such an unnecessary technology would even be considered. It's not like home heat, which we need. It's not like using electricity to have lights on in the schools. This is a totally unnecessary use of electricity, and it benefits only the company investing in the sign, and nobody else. Why would a government *of the people* allow that kind of selfish activity at all? If you're already stuck with allowing these ugly and wasteful items, do **please restrict them carefully**.

Sincerely, Christopher Logan River Road From: <u>Aaron Noteboom</u>
To: <u>DRAGOVICH Jenessa L</u>

Cc: MCKERROW Mike J; SOMMERS Lauren A; Mike Reeder

Subject: Eugene Sign Code Amendments

Date: Monday, September 14, 2020 11:34:55 AM
Attachments: Ltr City Council with Exhibits 09.14.2020.pdf

[EXTERNAL]

Jenessa,

Please forward the attached correspondence to the City Council for their review. Thank you for all of your help.

Yours truly,

Aaron Noteboom | Attorney at Law

Noteboom Law LLC

375 W 4th Ave, Ste 204 | Eugene, Oregon 97401 Ph: (541) 513-2298 | aaron@noteboomlaw.com

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NOTEBOOM LAW LLC

September 14, 2020

Via Email

Eugene City Council c/o Jenessa Dragovich 125 E. 8th Avenue, 2nd Floor Eugene, OR 97401

Re: Support for Eugene Sign Code Amendment to allow Digital Billboards / Response to Planning Commission Concerns.

Dear City Council:

I represent Meadow Outdoor Advertising, an Oregon based, family owned company that has owned and operated multiple billboards within Eugene for the past 38 years. I am writing on behalf of my client to express their strong support for the proposed sign code amendments. We are grateful for the professional and diligent manner in which City Planning Division staff has implemented Council's directive to draft sign code amendment language that accommodates digital billboards while ensuring that important state regulatory and national standards for digital billboard safety were adhered to and incorporated into the code (e.g. provisions for auto dimming, ambient light, dwell time). These amendments will greatly improve the City's sign code to incorporate modern technology, include greater free speech protections and create new opportunities for local businesses, non-profits and government agencies while maintaining the City's commitment to Vision Zero. In short, this sign code amendment proposal is in the public interest and should be adopted, with two minor clarifications discussed below.

While my client is disappointed that the Planning Commission was not able to recommend adoption at this time, believing there were some yet unanswered questions, we are nevertheless confident that the those questions have been answered through extensive discussion, research and trials in jurisdictions at the state and city level in Oregon and throughout the United States. We believe Planning Division staff's recommended amendments are ready for adoption, with two minor clarifications.

When identifying which existing manual copy billboards would be allowed to convert to digital sign faces, staff inadvertently left off two small segments of major arterials (Garfield between 11th & 7th and Broadway/Mill between 8th & Hilyard). There was no planning or safety reason identified by staff or the Planning Commission for not including these areas. They were simply overlooked by staff



when initially putting together the amendments. Those areas contain a total of 5 billboards (of the 120 existing billboards within Eugene). My client has identified the east facing sign face of the billboard at the northwest corner of Broadway and Hilyard (Goodwill) as suitable for conversion to a digital face. We would ask that the omitted portions of Garfield, Broadway and Mill Street where billboards are currently allowed be included with the proposed amendments.

Additionally, staff initially recommended a 10 second dwell time between flips but subsequently revised their recommendation to include adoption of the industry and national standard 8 second dwell time after receiving additional information from the industry. Planning Commission did not reach a consensus on the appropriate dwell time. Industry and national standard for dwell time is 8 seconds. Studies provided by the industry demonstrate that an 8 second dwell time is safe. Having consistency between jurisdictions is important to being able to market and sell regional and national advertising blocks. Further, the lower dwell time creates additional add space allowing for greater opportunities for small business, non-profits and PSA's to display their message which is one of the driving reasons behind the proposed amendment.

With respect to the Planning Commission's concerns, we believe that they were adequately addressed and the relevant information necessary to evaluate the proposed amendments was provided by the industry and staff as reiterated and discussed in this letter below. Unfortunately, a technological snarl (a commissioner's device battery died) during deliberations and voting resulted in a "no" vote on a motion that would have otherwise passed and moved the proposed amendments forward if the meeting would have been held in person rather than via Zoom.

1. Community Benefit.

The allowance of digital billboards is a great opportunity for Eugene's local and small businesses, non-profits and government agencies that does not currently exist within the marketplace. Currently, users are limited to purchasing static adds which often run for weeks or months, if not longer, on a single location. There is obviously limited capacity and access. Digital allows for multiple users on a daily if not hourly basis to advertise for short periods of time and on short notice. This greater access creates greater opportunity and will be especially important in helping Eugene's businesses and economy reestablish itself over the coming months and years. It is becoming increasingly clear that the health of the economy and in particular local and small businesses is tied to the overall health and welfare of the community. The stronger the economy and job market, the better the overall health and wellbeing of the community including increased revenue and taxes for the operation of important government services.

Local non-profits stand to be beneficiaries of the increased add space brought by digital billboards. It is industry practice to donate unused add space when available to local non-profits and government agencies. FOOD For Lane County has been a recipient of this in the past (both digital and static)(see attached Exhibit A). Unlike static signs, it is significantly easier and more cost effective to provide add space to non-profits on digital billboards. Each sign company has their own practice and policies for allocating space to non-profits. A description of Meadow Outdoor Advertising's practice is attached (Exhibit B).

In addition to non-profit messaging, digital billboards are used to rapidly convey across the community important government messaging including Amber Alerts and Silver Alerts. Allowing digital billboards in Eugene will help create a digital billboard network not only within the Eugene/Springfield area but in Oregon and along the I-5 corridor. Digital billboards have been used with great success in Salem to apprehend wanted criminals and to warn to the public of flooded routes to avoid. With the recent fire activity, they could be employed to advise residents of evacuations, closed areas, donation drop offs and emergency shelter locations which are constantly changing.

Conversion of Eugene's conventional billboards to digital will have a positive environmental effect. Traditional static billboards use vinyl copy, a petroleum product, and require crews to travel to install the copy on each sign face. Depending on the sign this might occur on a weekly, monthly or annual basis. Converting those boards eliminates the need to use vinyl altogether and to spend vehicle miles driven to change copy. The digital faces are themselves recyclable. The sign industry estimates that as many as 10 signs in Eugene could be converted to digital in the next 5 years thereby permanently eliminating the vinyl product and vehicle miles driven for those signs on a go forward basis. Power used to operate the signs is from EWEB which procures over 80% of its power from renewable resources.

2. No Proliferation of Billboards.

There was some early confusion amongst some of the Planning Commission as to whether the proposed amendments might result in a proliferation of new billboards or digital billboards. To be clear and to set the record straight, they will not.

It should be understood that the Eugene billboard market is already built out and effectively closed to construction of new billboards. That is a result of existing local, state and federal regulations governing billboards. The combination of the zoning (commercial or industrial), spacing, height, size, non-conforming use limitations and permit requirements in these regulations together act to limit the available sites where a billboard may be lawfully located. Virtually all of the legal sites within the City of Eugene have been identified and improved with signs. The cumulative effect of existing regulations is that the inventory in Eugene is for all intents and purposes capped and the sign locations are fixed. The proposed amendments would allow the existing billboards to convert their sign faces from static to digital. The amendments do not open the door for new billboards to be constructed where they are currently prohibited.

The amendments will also not result in a proliferation of new digital billboards. The amendments include a 1,200 foot spacing limitation between digital boards, which staff has determined will reduce the possible number of digital billboards by approximately 1/2 of the existing inventory. Market forces will act to further reduce the number of billboards that would potentially convert. Not every location that will support a conventional static faced billboard will support a digital billboard. Digital billboards are expensive to purchase and install (e.g. in excess of \$100K) and typically require replacing or upgrading the sign structure to support the new LED face. Consequently, digital billboards must be constructed along arterials with sufficient views to garner willing advertisers thereby warranting the increased cost. These facts act to limit the number of existing locations where digital billboards would be economically feasible. Moreover, too many digital billboards in one market (or in

one place) will result in saturation and underutilization. The result is a natural balance point where a portion of the billboards in any market convert to digital. Depending on the market, this may be anywhere from 8-12% historically. There are a total of 5 active billboard owners/companies in Eugene of which 4 have expressed a strong interest in conversion. Those companies have identified, and shared with City staff, 10 locations in Eugene that would possibly convert over the next five years. It is estimate that not more than 3 to 4 billboards would convert in any given year given the aforementioned cost constraints, market forces (including current economic recession) and qualified contractors capable of doing this work. The effect is a "slow roll out" or implementation of digital within Eugene.

3. Perceived Safety Concerns.

Various Planning Commission members believed that there was insufficient safety information to recommend moving forward with the amendments and that more information was needed. At the outset, it is important to remember that digital billboards are not a new technology and have been employed across the United States and in Oregon for over a decade with a proven safety track record. Oregon communities with digital billboards include: Springfield, Salem, Medford, Klamath Falls, Hillsboro, Oregon City, Gladstone, Bend, Pendleton, Ontario, Hermiston.

It is unclear why those Planning Commission members believed there was inadequate information given the widescale employment of digital billboards across Oregon and communities through the US, the State's adopted regulatory scheme (including safety measures) and the numerous studies that have been done to date including those studies provided to the commission by the industry and described below. The following studies were before the Planning Commission and are available as part of the record for the Council's review. Those studies have shown that digital billboards are safe.

- MassDOT Digital Advertising Board Pilot Program, November 22, 2011.
 - 2009-2011 "pilot study" in cooperation between MassDOT, Mass state police and billboard industry of 8 digital billboard sites analyzing crash data one year "before and after" installation.
 - Study concluded: "The Traffic engineers preparing the reports found no detrimental safety impacts of the DABs (digital advertising billboards) in any of the 8 study area locations."
- USDOT Federal Highway Administration Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS), September 2012.
 - o 2010 Eye tracking study in Richmond, VA and Reading, PA of four digital billboard sites (2 freeway & 2 arterial) with 56 participants.

 Study concluded: "the results did not provide evidence indicating that CEVMS (digital billboards) were associated with long glances away from the road that may reflect an increase in risk."

Tantala Associates Crash Studies:

- 2007-2010 crash studies in 5 US cities looking at official crash records for 5-8 years of data evaluating more than 120,000 crash incidents at 55 digital billboard sites before and after sign installation.
- Study Concluded: "no statistically significant increase in accident rates" (and actually found a decrease in accident rates at some sites.)
- Virginia Tech Transportation Institute Driving Performance and Digital Billboards, March 2007.
 - Driver performance study in Cleveland, OH of 36 drivers between ages of 18 and 71 both in the daytime and nighttime passing 5 digital billboards, 15 conventional billboards, 12 "comparison sites" with conditions similar to "everyday driving" and 12 "baseline sites" with no signage.
 - Study Concluded: "changes in driver performance in the presence of digital billboards...are on par with those associated with everyday driving..." (p. 73)

Not only have digital signs been proven safe with respect to traffic, but they also offer additional safety to communities through their ability to quickly change and broadcast messages across the community including amber alerts, silver alerts, PSA's, government alerts, and non-profit messaging campaigns (e.g. FOOD For Lane County.)

4. Eugene's *de facto* "Pilot Study" – Matt Knight Arena 2011-2020.

Public Works staff and certain of the Planning Commission members suggested that a pilot program to study digital billboards might be prudent in light of the perceived lack of safety data. With all due respect, we do not believe that such a study is necessary in this instance. The City has been operating a *de facto* study for the past nearly 10 years with the University of Oregon's digital billboard located at the corner of Franklin Ave and Villard Street. As discussed below and shown on the attached satellite imagery (Exhibit C), this intersection is one of the most complex intersections in all of Eugene if not the most complex intersection in the City. Yet despite its complexity, during the nearly 10 years of its operation there has not been a single serious or fatal injury as a result of the digital billboard despite over 100,000,000 vehicles trips during that time.

i. Installation.

The Matthew Knight Arena digital sign was installed on or about January 13, 2011 (Official opening of Arena). This digital sign was approved November 24, 2010 through an adjustment review for an Electronic Message Center (City File V 10-02).

ii. Description of Digital Sign and Surrounding Areas.

Located at the south east corner of Franklin Ave. and Villard Street, Eugene, OR. Double-sided sign with sign faces oriented to eastbound and westbound traffic on Franklin Ave. Commercial advertising for sporting events, concerts and shows. Eastbound traffic has limited view of sign during summer months due to street trees.

Located at intersection of a bifurcated major arterial (Franklin) with neighborhood collector (Villard). Complex intersection with the following features:

- 20 traffic lanes,
- 9 permitted turning directions (including 2 U-turns),
- 12 traffic lights/signals,
- 1 dedicated bus rapid transit (BRT) lane (bi-directional),
- 1 designated bike lane (eastbound),
- 5 signalized pedestrian cross walks,
- 2 pedestrian islands/refuges,
- 5 commercial driveway aprons within ~100 feet of the intersection.

Zoned C-2 to SW of intersection. Zoned Special Areas to NW, NE and SE of intersection. Adjacent uses include 12,000+ seat arena, 23,000+ enrolled university, commercial grocery store (Market of Choice, drive through Starbucks, automotive repair, hotel (Days Inn), restaurants (House of Chen, Café Seoul, Subway). This intersection receives especially heavy pedestrian foot traffic during events at the Matt Knight Arena. For example, in 2019-2020, the Oregon Women's Basketball team averaged 10,852 per game over its 15 home games while the Oregon Men's Basketball team 8,038 per game over its 17 home games.

iii. Traffic Count.

Traffic information obtained from LCOG – City of Eugene 2013 Traffic Flow Map. Presumably, traffic counts have increased since then and the total number of trips below is <u>underinclusive</u> of the actual vehicle trips.

<u>Eastbound Franklin</u>: 13,900 per day, 48,900,200 vehicles trips between January 13, 2011 and August 31, 2020.

Westbound Franklin: 14,800 per day, 52,066,400 vehicles trips between January 13, 2011 and August 31, 2020.

Total Vehicle Trips: 100,966,600 vehicles trips between January 13, 2011 and August 31, 2020.

iv. Crash Data.

In over 100,000,000 vehicles trips there were NO fatal or serious injuries resulting from the digital billboard at Matthew Knight Arena. Information was obtained online from Eugene Vision Zero Crash Data for crashes occurring after installation of the digital billboard on or about January 11, 2011.

Fatal and Serious Crashes: None

<u>Crashes Involving People Walking</u>: Not available.

<u>Crashes Involving People on Bikes</u>: 1 crash was noted at the intersection of Franklin and

Walnut in 2013 involving a bike. It is not stated whether this crash involved a vehicle. The crash was almost certainly not connected with the digital billboard given its distance from the billboard (approximately 970 ft). At that location the billboard is barely visible and largely obscured by existing obstructions (e.g. telephone poles, traffic light poles, transformer boxes, parked cars, cars/trucks, Market of Choice sign and Hiron's sign). See attachment. (Exhibit

D)

5. Regulation of Speech/First Amendment Issues.

As is often the case, technology moves faster that the law. Much has changed in the way we communicate since Eugene's sign code was last updated over 20 years ago. The interim "fix" has been to allow some digital signs to be approved through an adjustment review process (i.e. an exception). From a regulatory standpoint, it is problematic for the City to allow for speech on a case by case basis. That type of ad hoc regulation of speech presents many challenges for the City and especially for those tasked with approving such signs. The better policy is for all speech to go through a legislatively adopted process, with uniform rules, evenly applied to permit applicants. Modernizing Eugene's sign code will allow the City to continue its strong protection of speech ensuring fairness and neutrality in the process while at the same time protecting the safety and wellbeing of the community.

6. Conclusion.

Digital billboards have been in operation in communities across the country and the state of Oregon for over a decade during which time they have proved themselves as safe both in practice and through numerous studies. Their real-world application and track record coupled with the proposed code language is adequate to ensure the continued safety of all users of Eugene's streets and is consistent with the City's Vision Zero goals. We are excited about the tremendous new opportunities these signs will provide to our local businesses, non-profits and government services as they begin the

long and difficult process of rebuilding our local economy to create a better and brighter Eugene for all.

Lastly, we would like to thank the City's planning staff Jenessa Dragovich and Mike McKerrow for their detailed, thoughtful and thorough work throughout this process.

Sincerely,

NOTEBOOM LAW, LLC

/s/ Aaron J. Noteboom

Aaron J. Noteboom



770 Bailey Hill Road Eugene, OR 97402 PH (541) 343-2822 FX (541) 343-5019 info@foodforlanecounty.org foodforlanecounty.org September 3, 2020

To Whom It May Concern:

FOOD for Lane County has received donated advertising on the digital billboard along I-105/Highway 126 in Springfield, as well as occasional donated advertising on conventional billboards in other parts of Lane County. We appreciate the support of the billboard companies involved, as it helps us communicate our mission and message to the public.

Please feel free to call me if you have any questions or need any additional information about donated billboard advertising benefiting FOOD for Lane County.

Sincerely,

Tom Mulhern Executive Director



FFLC is an equal opportunity provider and a member of





and the Oregon Food Bank Network

Mike,

Thanks for the email. I'm sorry to have missed your call. I was on a conference call (seems like we spend most of our time on those calls these days!). I appreciate your engagement and the chance to provide input.

See my responses in blue below.

Some additional information regarding the PSAs. Each company is going to have a different process. Our system at Meadow is pretty informal. We receive a request from a non-profit to post an Ad, then we design an Ad, have them approve it and then post the Ad when we have space available. This is our process for both static and digital signs. With our digital signs we also use PSAs from the Outdoor Advertising Association of America, where organizations or entities will have national or regional messages they want to be communicated. These are things like COVID awareness campaigns etc. There are occasions where community awareness message pre-empt paying advertising, such as Amber alerts.

I hope this helps! Feel free to call me again or email if you need additional information.

Brian Casady

Real Estate Manager
Meadow Outdoor Advertising

Office: 541.296.9684 Cell: 541.993.4839 Fax: 541.296.1855

bcasady@meadowoutdoor.com www.meadowoutdoor.com



From: MCKERROW Mike J < MMcKerrow@eugene-or.gov>

Sent: Monday, August 10, 2020 3:32 PM

To: Brian Casady < BCasady @meadowoutdoor.com >; Aaron Noteboom < aaron @noteboomlaw.com >

Cc: DRAGOVICHJenessa L<JDragovich@eugene-or.gov>

Subject: Billboard Info for Planning Commission Deliberations Tomorrow

Importance: High

Hi Brian and Aaron,

We are compiling answers to commissioners questions prior to the deliberations meeting tomorrow. Two specifics that I think you can help with are:

1. The ORS citation that Brian mentioned at the public hearing last week regarding energy use. A commissioner and staff haven't been able to find it.

OAR. 734-060-0007

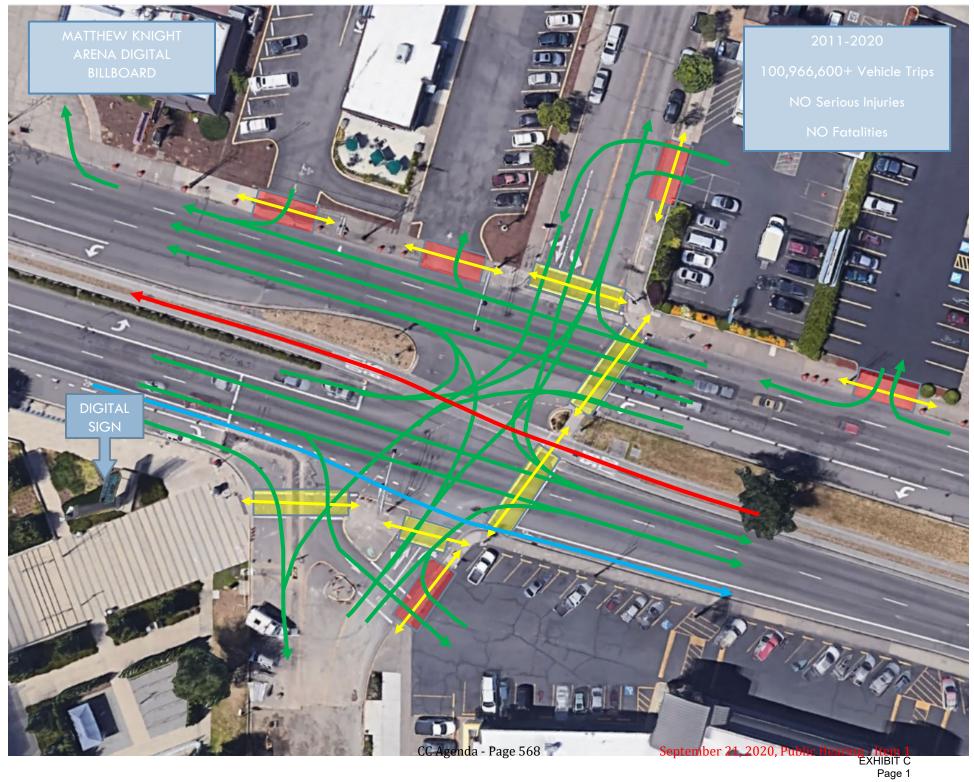
Digital Billboard Procedures (9) Use of renewable energy resource. The applicant must provide a statement with the application that clarifies what, if any, renewable energy resources are available at the site and are being utilized. If none, then a notarized statement to that effect must be included with the application.

- 2. A summary with more detail of how extra slots are used for PSA, municipal messages, amber alerts etc. We talked about it being an industry standard but commissioners want more nuts and bolts on the process even though we can't legislate a requirement do to the content regulation standard.
 - How often do they occur, about once every 5-6 minutes when the sign is fully sold out. More frequently when it is not fully sold.
 - what percentage of total messages, A minimum of 2% if a sign is 100% sold out (we reserve 150 slots per day) Can be from 5-10% when not all "slots" are sold.
 - does it depend on if commercial messages are all booked or if there is "extra capacity" at the time, See previous answer. We post PSAs on a "space available" basis (ie. when we don't have paying advertisement for a time slot or in the 150 slots we have reserved.)
 - Who determines the PSA Two processes. When we have slots available we decide which announcements to run. If we have specific requests we include those as space is available
 - Would a city email a pdf? A couple different ways to get an Ad "into the hopper". The graphic has to be sized and formatted for the software and the specific sign face. An advertiser can either provide a graphic to us which can then be resized and formatted by our graphics team or the advertiser can provide the info they want in a message and the design elements and then our graphic artists design an Ad. Once the ad is designed and/or formatted it is sent to the advertiser for approval then it will be put in the rotation.

Thanks for providing information in these areas so we can inform the PC as soon as possible.

Mike McKerrow Land Use Analyst

Building and Permit Services 99 West 10th Avenue Eugene OR 97401 Phone 541.682.5288



	BILLBOARD	AVG. TRAFFIC VOLUME	SIGN FACES	TRAFFIC LANES	TRAFFIC LIGHTS	PERMITTED TURNS	SIGNALIZED CROSSWALKS	DESIGNATED BIKE LANES	PEDESTRIAN ISLANDS	BUS RAPID TRANS	DRIVEWAY APRONS 100 FT
MATT KNIGHT	SW Corner Franklin/Villard (Matt Knight)	13,900 East 14,800 West	2	20	12	9 (2 U- Turns)	5	1	2	1	5
Proposed for Inclusion	NW Corner Broadway/Hilyard (Goodwill)	18,100 West 15,600 East	2	19	13	8 (U-Turns Prohibited)	4	0	1	0	6
Proposed for Inclusion	~100 Ft E. Intersection Mill/Broadway	18,100 West 15,600 East	2	6	0	5	0	0	0	0	6
Proposed for Inclusion	~75 Ft SW Intersection 8 th /Mill (Bates Steak House)	18,100 West 15,600 East	1	14	11	3	2	1	1	0	0
Proposed for Inclusion	~200 Ft S Intersection 7 th /Garfield	17,400 North 18,200 South	2	4	0	0	0	0	0	0	2
Proposed for Inclusion	2 Blocks N. Intersection 11 th / Garfield	17,400 North 18,200 South	2	6	0	4	0	0	0	1	4



Reported crash site at intersection of Franklin Blvd and Walnut looking west towards Mathew Night Area. Digital billboard is generally not visible from crash site.

EUGENE CITY COUNCIL AGENDA ITEM SUMMARY



Public Hearing: An Ordinance Amending the Eugene-Springfield Metropolitan Area General Plan Diagram and the Willakenzie Area Plan Diagram to Redesignate the Property Identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 And 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800 from Campus Industrial to Light Medium Industrial and Rezone the Property from E-1 Campus Employment to E-2 Mixed Use Employment.

Meeting Date: September 21, 2020

Department: Planning & Development

Agenda Item Number: 2

Staff Contact: Jeff Gepper

www.eugene-or.gov Contact Telephone Number: 541-682-5282

ISSUE STATEMENT

City Council will hold a public hearing on a privately initiated Metro Plan Amendment and Refinement Plan Amendment to change the plan designation from Campus Industrial to Light-Medium Industrial, with a concurrent Zone Change from E-1 Campus Employment to E-2 Mixed Use Employment, on five lots referred to as the Sheppard Motors property (City files: MA 20-1, RA 20-1, & Z 20-1). The five undeveloped tax lots total approximately 17 acres and are located between I-5 and Old Coburg Road, on the south side of North Game Farm Road. A vicinity map showing the location of the subject property and existing zoning of the surrounding area is provided in Attachment A.

BACKGROUND

The applicant, Sheppard Motors, applied for a privately initiated, site-specific Metro Plan Amendment, Refinement Plan Amendment, and concurrent Zone Change for the subject property with the goal of developing an automobile dealership. The requested amendments are necessary to allow the applicant's intended development of an Audi automobile sales and service center. The applicant states that, "Sheppard was chosen by Audi USA to be the dealer for the Eugene market. This move offers significant investment in the Eugene area and would provide many existing Lane County (and beyond) Audi owners with service and support." The proposal also includes the development of electric vehicle (EV) charging stations that are accessory to the motor vehicle sales and service use. The applicant states that the EV charging stations not only support Audi's commitment to EVs, but the location is "ideal" given its proximity to the Interstate 5 (I-5) corridor.

The subject property is currently zoned E-1 Campus Employment, which does not permit Motor Vehicle Sales/Rental/Service; whereas, in the requested zone, E-2 Mixed Use Employment, the use is permitted outright. However, because the current Campus Industrial land use designation does

not support a zone change to E-2, site-specific amendments to the land use diagrams of both the Metro Plan and Willakenzie Area Plan are also required. The proposed change to a Light-Medium Industrial plan designation is necessary to facilitate the requested zone change and ultimately develop the property with the applicant's intended use. As noted above, the applicant has stated that it intends to develop the property as an automobile dealership. However, nothing in the plan designation change or zone change requires that the property be developed with that specific use. The application before the Council is for a change to the Metro Plan and refinement plan designations and a zone change. If this application is approved, the subject property could be developed with any use permitted in the E-2 zone, as identified in EC Table 9.2450. Detailed maps showing the proposed plan amendments and zone change are included as Exhibits A-E of the draft ordinance (see Attachment B).

More details on this request can be found in the full record of application materials to date, which will be provided separately to Councilors on a thumb-drive. Otherwise, application materials can be made available to anyone in hardcopy or electronic format upon request.

Planning Commission Process & Recommendation

The Planning Commission held a public hearing on July 28, 2020 to consider the proposed amendments to the land use diagrams of the Metro Plan and Willakenzie Area Plan as well as the proposed zone change. The webcast of the meeting is available here. Prior to the public hearing, three pieces of written testimony were received, one in support of the proposal and two opposed. One person testified at the public hearing and spoke in favor of the proposal.

Following the public hearing, the Planning Commission deliberated on August 3, 2020 and unanimously voted to recommend approval of the proposed amendments and zone change. However, the Commission wanted to provide comments to Council expressing concerns about other uses of the property that would be permitted in the E-2 zone, in the event that an automobile dealership does not to come to fruition. Based on these concerns, the Commission included as part of their recommendation for approval that, if an auto dealership is not developed as intended, the City Council consider initiating a future process to revert the site to its current Campus Industrial designation and E-1 zoning.

City Council Process & Action

This request is subject to Metro Plan Amendment procedures at Eugene Code 9.7700-9.7735. Council's public hearing is also required to follow quasi-judicial procedures, and the decision must be based on the approval criteria from EC 9.7735, EC 9.8424, and EC 9.8865. As a reminder, Councilors will be required to disclose any ex-parte contacts that may have occurred related to this request, at the beginning of the hearing.

Notice of Council's public hearing on this request was provided on September 9, 2020, in accordance with Eugene Code requirements. No additional public testimony has been received since the Planning Commission hearing or in response to the most recent public notice. Any additional written testimony received in advance of the public hearing will be included in the record and forwarded to Councilors for consideration. Following close of the public hearing and record, Council is scheduled for deliberations and final action on October 12, 2020.

Draft Ordinance Revision

The version of the ordinance that was posted for this public hearing did not include a condition of approval related to the allowed number of vehicle trips for the site in the body of the ordinance. The condition is included in the proposed findings attached to the ordinance, but staff would like to explicitly include the condition in the ordinance itself. The version of the ordinance that includes the condition of approval and that staff will ultimately recommend for adoption is included as Attachment C, in which the proposed revisions are highlighted in Track Changes. The Planning Commission's recommendation was based on the inclusion of this proposed condition of approval and was considered during deliberations on August 3, 2020. The proposed condition of approval was proposed by the applicant for compliance with Statewide Planning Goal 12 and including it within the ordinance ensures future compliance in the event that the ordinance is adopted.

COUNCIL OPTIONS

No action is required at this time; however, options will be provided at the time of City Council deliberations and action scheduled for October 12, 2020.

CITY MANAGER'S RECOMMENDATION

This item is scheduled for a public hearing only. Following the public hearing and City's receipt of any testimony, the City Manager will make a recommendation to be included in the Council packet for action on October 12, 2020.

ATTACHMENTS

- A. Vicinity Map
- B. Proposed Ordinance and Exhibits (Original without Trip Cap Condition)

Exhibit A: Proposed Designation Map – Metro Plan's Plan Diagram

Exhibit B: Proposed Designation Map - Willakenzie Area Plan's (WAP) Land Use Diagram

Exhibit C: Proposed Designation Map – WAP's Land Use Diagram (Northeast Portion)

Exhibit D: Proposed Designation Map - WAP's Coburg-Crescent Subarea Diagram

Exhibit E: Proposed Zone Change Map

Exhibit F: Findings

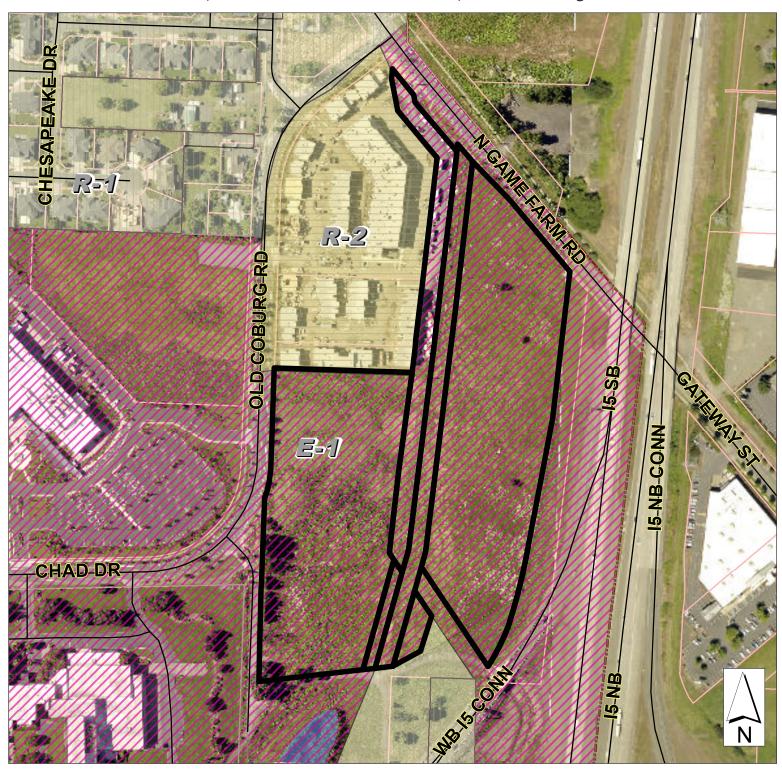
C. Revised Ordinance including Trip Cap Condition

FOR MORE INFORMATION

Staff Contact: Jeff Gepper, Senior Planner

Telephone: 541-682-5282

 Sheppard Motors [Eugene Audi] - (MA 20-1 / RA 20-1 / Z 20-1) Metro Plan Amendment, Refinement Plan Amendment, & Zone Change



Legend

■ Subject Property E-1 Campus Employment

Eugene UGB □ R-1 Low-Density Residential

□ Taxlots □ R-2 Medium-Density Residential

— Streets

Caution: This map is based on imprecise source data, subject to change, and for general reference only.

07/14/2020



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AN ORDINANCE AMENDING THE EUGENE-SPRINGFIELD METROPOLITAN AREA GENERAL PLAN DIAGRAM AND THE WILLAKENZIE AREA PLAN DIAGRAM TO REDESIGNATE THE PROPERTY IDENTIFIED AS ASSESSOR'S MAP 17-03-16-41, TAX LOTS 201, 300 AND 400 AND ASSESSOR'S MAP 17-09-16-44, TAX LOTS 400 AND 800 FROM CAMPUS INDUSTRIAL TO LIGHT MEDIUM INDUSTRIAL AND REZONE THE PROPERTY FROM E-1 CAMPUS EMPLOYMENT TO E-2 MIXED USE EMPLOYMENT.

The City Council of the City of Eugene finds as follows

- A. On January 17, 2020, Sheppard Motors, LLC submitted an application for a Type I amendment to the Eugene-Springfield Metropolitan Area General Plan (Metro Plan) plan diagram, a refinement plan amendment to the Willakenzie Area Plan land use diagram and subarea diagram for consistency with the Metro Plan, and a concurrent zone change to redesignate and rezone the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800. The applicant requested a Metro Plan designation change from the Campus Industrial designation to a Light-Medium Industrial designation. Approval of the Metro Plan amendment results in the automatic concurrent amendment of the Willakenzie Area Plan land use diagram and Coburg-Crescent Subarea Diagram, giving the subject property a Light-Medium Industrial designation under the Willakenzie Area Plan. The zone change requested by the applicant would rezone the subject property from E-1 Campus Employment to E-2 Mixed Use Employment.
- **B.** On July 28, 2020, the Eugene Planning Commission held a public hearing on the application. The Eugene Planning Commission recommended that the Eugene City Council adopt the proposed amendments to the Metro Plan plan diagram as shown in Exhibit A, and the Willakenzie Area Plan land use diagram as shown in Exhibit B.

NOW, THEREFORE,

THE CITY OF EUGENE DOES ORDAIN AS FOLLOWS:

<u>Section 1</u>. The Eugene-Springfield Metropolitan Area General Plan land use diagram is amended to redesignate the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, from Campus Industrial to Light-Medium Industrial, as depicted on Exhibit A attached hereto and incorporated herein by reference.

Section 2. Consistent with the provisions of section 9.7730(5) of the Eugene Code, 1971:

(a) The Willakenzie Land Use Diagram and Willakenzie Land Use Diagram (Northeast Portion) located between pages 19 and 20 of the Willakenzie Area Plan are amended to redesignate the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, from Campus Industrial to Light-Medium Industrial, as depicted on Exhibits B and C attached hereto and incorporated herein by this reference.

(b) The Coburg-Crescent Subarea Diagram located at page 62 of the Willakenzie Area Plan is amended to add "Light-Medium Industrial" to the legend for the diagram and to redesignate the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, from Campus Industrial to Light-Medium Industrial, as depicted on Exhibit D attached hereto and incorporated herein by this reference.

<u>Section 3</u>. The property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, is rezoned from E-1, Campus Employment to E-2 Mixed Use Employment, as depicted on Exhibit E attached hereto and incorporated herein by this reference.

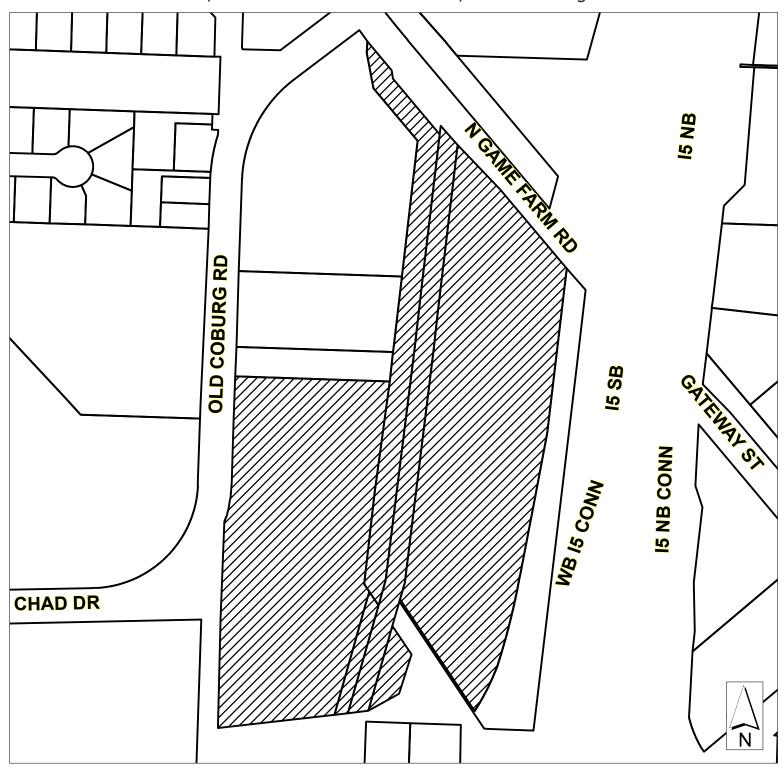
Section 4. The findings set forth in the attached Exhibit F are adopted in support of this Ordinance.

<u>Section 5</u>. If any section, subsection, sentence, clause, phrase, or portion of this Ordinance is for any reason held invalid or unconstitutional by any court of competent jurisdiction, that portion shall be deemed a separate, distinct, and independent provision and that holding shall not affect the validity of the remaining portions of this Ordinance.

Passed by the City Co	uncil this	Approved by the Mayor this		
day of	, 2020	day of	, 2020.	
City Recorder		Mayor		

Proposed Metro Plan Designation

Sheppard Motors [Eugene Audi] - City File: MA 20-1 / RA 20-1 / Z 20-1 Metro Plan Amendment, Refinement Plan Amendment, & Zone Change



Property to be redesignated from Campus Industrial to Light Medium Industrial on the Metro Plan's Plan Diagram



Proposed Refinement Plan Designation

Sheppard Motors [Eugene Audi] - City File: MA 20-1 / RA 20-1 / Z 20-1 Metro Plan Amendment, Refinement Plan Amendment, & Zone Change

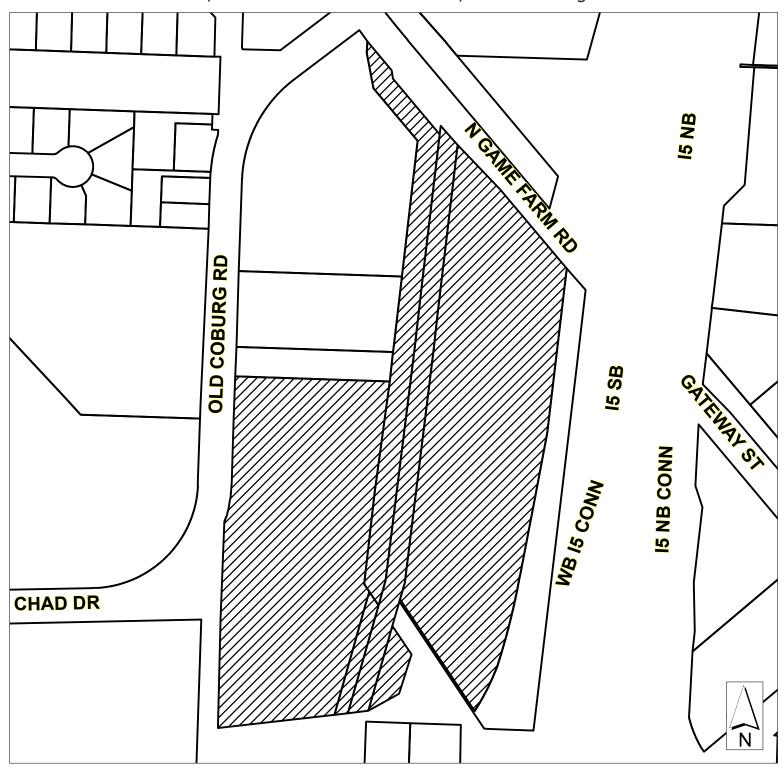


Property to be redesignated from Campus Industrial to Light-Medium Industrial on the Willakenzie Area Plan's Land Use Diagram



Proposed Refinement Plan Designation

Sheppard Motors [Eugene Audi] - City File: MA 20-1 / RA 20-1 / Z 20-1 Metro Plan Amendment, Refinement Plan Amendment, & Zone Change



Property to be redesignated from Campus Industrial to Light-Medium Industrial on the Willakenzie Area Plan's Land Use Diagram (Northeast Portion)



Proposed Refinement Plan Designation

Sheppard Motors [Eugene Audi] - City File: MA 20-1 / RA 20-1 / Z 20-1 Metro Plan Amendment, Refinement Plan Amendment, & Zone Change

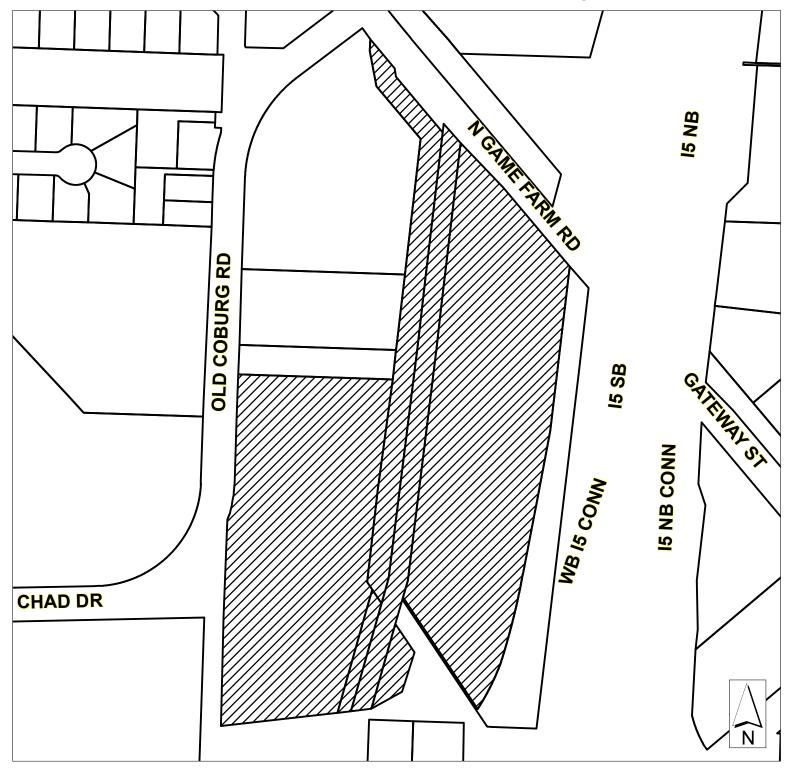


Property to be redesignated from Campus Industrial to Light-Medium Industrial on the Willakenzie Area Plan's Coburg-Crescent Subarea Diagram



Proposed Zone Change

Sheppard Motors [Eugene Audi] - City File: MA 20-1 / RA 20-1 / Z 20-1 Metro Plan Amendment, Refinement Plan Amendment, & Zone Change



Property to be rezoned from E-1 Campus Employment to E-2 Mixed Use Employment



FINDINGS IN SUPPORT OF AN ORDINANCE AMENDING THE EUGENE-SPRINGFIELD METROPOLITAN AREA GENERAL PLAN DIAGRAM AND THE WILLAKENZIE AREA PLAN DIAGRAM TO REDESIGNATE THE PROPERTY IDENTIFIED AS ASSESSOR'S MAP 17-03-16-41, TAX LOTS 201, 300 AND 400 AND ASSESSOR'S MAP 17-09-16-44, TAX LOTS 400 AND 800 FROM CAMPUS INDUSTRIAL TO LIGHT MEDIUM INDUSTRIAL AND REZONE THE PROPERTY FROM E-1 CAMPUS EMPLOYMENT TO E-2 MIXED USE EMPLOYMENT

APPLICATION OVERVIEW

Name (File Numbers): Sheppard Motors - Eugene Audi (MA 20-1 / RA 20-1 / Z 20-1)

Map No. / Tax Lots: 17-03-16-41 / 201, 300, & 400 & 17-09-16-44 / 400, 800

The applicant is seeking an amendment to the Eugene-Springfield Metropolitan Area General Plan (Metro Plan) land use diagram, a refinement plan amendment to the Willakenzie Area Plan land use diagrams for consistency with the Metro Plan, and a concurrent zone change. The requested changes are outlined in Table 1, below.

The applicant has applied for these changes in order to develop an automobile sales and service center with accessory electric vehicle (EV) charging stations. The subject property is currently zoned E-1 Campus Employment, which does not permit Motor Vehicle Sales/Rental/Service; whereas, in the requested zone, E-2 Mixed Use Employment, this use is permitted outright. The requested changes would allow for this applicant's intended use.

Sheppard Motors [Eugene Audi] Metro Plan/Refinement Plan Amendment & Zone Change						
Application (file no.)	Current	Proposed	Acres			
Metro Plan Amendment (MA 20-1)	Campus Industrial	Light Medium Industrial	16.72			
Refinement Plan Amendment (RA 20-1)	Campus Industrial	Light Medium Industrial	16.72			
Zone Change (Z 20-1)	E-1 Campus Employment	E-2 Mixed Use Employment	16.72			

Table 1: Current/Proposed Plan Designations and Zoning

The subject property is located between I-5 and Old Coburg Road, on the south side of North Game Farm Road. It consists of five separate, undeveloped tax lots with 5 different owners, all of whom have submitted their permission to proceed with this application. The total area of the subject property is approximately 16.72 acres.

FINDINGS

Based on substantial evidence in the record, the Eugene City Council finds as follows:

This request for a Metro Plan Amendment (Type I) is subject to the land use application procedures in the Eugene Code (EC) 9.7700-9.7735. The proposed Metro Plan Amendment also triggers the need for an amendment to the Willakenzie Area Plan (WAP), which is the applicable refinement plan for this area. The applicant has also requested a zone change. Per EC 9.8005, the requested refinement plan amendment and zone change are being processed concurrently. The following preliminary findings address details of the proposal in the context of compliance with the applicable approval criteria at EC 9.7735, EC 9.8424, and EC 9.8865. Those criteria are provided below (in **bolded text**), including findings addressing compliance with each.

The applicant's narrative specifically demonstrates how their intended use of the site for an Audi automobile dealership and electric vehicle (EV) charging stations complies with the applicable approval criteria. While it is helpful and relevant to know that the applicant intends to develop an Audi dealership and electric vehicle charging station, it is important to recognize that these findings will reflect how a change to the land use designation and zoning, and all potential uses resulting from said change, are consistent with the approval criteria. On occasion, the intended use of the site will be referenced as insight to how this specific use, as an example of what could be allowed, is supported or opposed by the applicable policies or relevant approval criteria.

METRO PLAN AMENDMENT

The applicant's requested Metro Plan Amendment proposes to change the land use designation of the subject property from Campus Industrial to Light Medium Industrial. The amendment qualifies as a Type I amendment as it only involves a change to the land use diagram and no text amendments to the plan are proposed or required. The following findings address the applicable approval criteria for the Metro Plan Amendment:

EC 9.7735 (1): The proposed amendment is consistent with the relevant Statewide Planning Goals.

Goal 1: Citizen Involvement - To develop a citizen involvement program that ensures the opportunity for citizens to be involved in all phases of the planning process.

The City's provisions for citizen involvement ensure the opportunity for citizens to be involved in all phases of the planning process and set out requirements for such involvement. The proposal does not include any changes to the City's citizen involvement program.

The City's land use code implements Statewide Planning Goal 1 through its noticing requirements, which include:

- A pre-application neighborhood/applicant meeting (12/19/2019)
- Notice to the Oregon Department of Land Conservation and Development (06/25/2020)
- Referrals and notice sent to Lane County and the City of Springfield (06/12/2020)
- Public notice for the Planning Commission public hearing to consider the applications, which includes: mailing notice to interested parties and adjacent property owners (06/26/2020); posting of the notice on-site (07/01/2020); and, publishing the notice in a local newspaper (07/08/2020).

All noticing was conducted in accordance with Eugene Code requirements. Consideration of the amendments began with a Planning Commission public hearing on July 28, 2020. Following action by the Planning Commission, the Eugene City Council held a public hearing to consider the plan amendment and zone change, which was duly noticed by September 11, 2020. Any written testimony received by the City discussing this application was made available to the Planning Commission and City Council for their consideration.

Based on these findings, the proposed Metro Plan Amendment is consistent with Statewide Planning Goal 1.

Goal 2: Land Use Planning - To establish a land use planning process and policy framework as a basis for all decisions and actions related to use of land and to assure an adequate factual base for such decisions and actions.

Consistent with Statewide Planning Goal 2, the requested Metro Plan Amendment is being processed according to Eugene's land use code, which specifies the procedure and criteria for consideration of the request. The requested Metro Plan amendment qualifies as a Type I amendment as defined in EC 9.7705 because the only requested change is to the Metro Plan's land use diagram, for lands located wholly within the City of Eugene. Consistent with EC 9.7715(1), the request for an amendment was initiated by a representative for the property owners. Per EC 9.7705(1), this Type I amendment requires approval by City of Eugene only. The subject property is entirely within the Eugene City limits and there is no regional impact associated with this request to amend the Metro Plan land use designation.

As the application follows the procedural requirements established by Eugene's land use code, the amendment is consistent with Statewide Planning Goal 2.

The Statewide Planning Goal 2 coordination requirement is met when the City engages in an exchange, or invites such an exchange, between the City and any affected governmental unit and when the City uses the information obtained in the exchange to balance the needs of its citizens. To comply with the Goal 2 coordination requirement, the City provided notice of the proposal and opportunity to comment to Lane County, Lane Council of Governments, City of Springfield, the Oregon Department of Transportation and the Oregon Department of Land Conservation and Development.

There are no exceptions to Statewide Planning Goal 2 required for this amendment. Therefore, the amendments are consistent with Statewide Planning Goal 2.

Goal 3: Agricultural Lands - To preserve agricultural lands.

The amendment is for property located within the urban growth boundary and does not affect any land designated for agricultural use. Based on this finding, Statewide Planning Goal 3 does not apply.

Goal 4: Forest Lands - To preserve forest lands.

The amendment is for property located within the urban growth boundary and does not affect any land designated for forest use. Based on this finding, Statewide Planning Goal 4 does not apply.

Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces - To protect natural resources and conserve scenic and historic areas and open spaces.

There are no Goal 5 resources located on the subject property. This amendment does not create or amend the City's list of Goal 5 resources, does not amend a code provision adopted in order to protect a significant Goal 5 resource or to address specific requirements of Goal 5, nor does it allow new uses that could be conflicting with a significant Goal 5 resource site. Therefore, Statewide Planning Goal 5 does not apply.

Goal 6: Air, Water and Land Resources Quality - To maintain and improve the quality of the air, water and land resources of the state.

The proposed change to the Metro Plan Diagram does not impact the existing regulations that implement the air, water, and land resources quality protections. Any future development will be subject to City regulations and other state and federal requirements, ensuring that future developments will be consistent with this Goal. Based on these findings, the Metro Plan amendment is consistent with Statewide Planning Goal 6.

Goal 7: Areas Subject to Natural Hazards - To protect people and property from natural hazards.

Statewide Planning Goal 7 requires that local government planning programs include provisions to protect people and property from the following natural hazards: floods, landslides, earthquakes and related hazards, tsunamis, coastal erosion and wildfires. Goal 7 prohibits development in natural hazard areas without appropriate safeguards. The subject property is not located within known areas of natural disasters or hazards. The subject property is outside the flood zone and is not subject to hazards normally associated with wildfires or tsunamis. Other hazards can be mitigated at the time of development based on applicable land use code provisions, building codes and building techniques. The amendment to the Metro Plan Diagram does not affect the City's restrictions on development in areas subject to natural disasters and hazards. Based on these findings, the amendment is consistent with Statewide Planning Goal 7.

Goal 8: Recreational Needs - To satisfy the recreational needs of the citizens of the state and visitors and, where appropriate, to provide for the siting of necessary recreational facilities including destination resorts.

Statewide Planning Goal 8 ensures the provision of recreational facilities to Oregon citizens and is primarily concerned with the provision of those facilities in non-urban areas of the state. The Metro Plan Diagram amendment does not affect the City's provisions for or access to recreation areas, facilities or recreational opportunities. Therefore, Statewide Planning Goal 8 does not apply.

Goal 9: Economic Development - To provide adequate opportunities throughout the state for a variety of economic activities vital to the health, welfare, and prosperity of Oregon's citizens.

Statewide Planning Goal 9 requires cities to evaluate the supply and demand of commercial and industrial land relative to community economic objectives. This amendment to the Metro Plan Diagram is only related to lands designated as industrial. The Administrative Rule for Statewide Planning Goal 9 (OAR 660 Division 9) requires that the City provide for at least an adequate supply of sites of suitable sizes, types, location, and service levels for a variety of industrial and commercial uses consistent with plan policies. The Employment Lands Supply Study 2012-2032 (ELSS) is included as appendix B in the City's comprehensive plan, Envision Eugene, and complies with the requirements of Goal 9 and the corresponding Administrative Rule. The map amendments do not add or subtract any industrial land from the adopted inventories.

The proposed change to the Metro Plan designation for the subject property does not have an impact on the City's availability of employment or industrial lands because all industrial land use land designations (Campus, Light Medium, and Heavy) are grouped together for the purposes of the City's ELSS. Therefore, properties within the broad category of industrial can be re-designated to another type of industrial without changing the amount of industrial land in the City's inventory. In this case, a re-designation from Campus Industrial to Light Medium Industrial results in no net change to the City's overall supply of industrially designated land.

OAR 660-009-010(4) has specific requirements for changes in plan designation that involve land in excess of two acres within an existing urban growth boundary from an industrial use designation to a non-industrial use designation, or another employment use designation to any other use designation. While the subject property is in excess of 2 acres, the proposed change is from one industrial designation (Campus) to another industrial designation (Light Medium). Therefore, this administrative rule requirement does not apply.

Given these facts, the requested Metro Plan Amendment will not adversely impact the City's ability to provide opportunities for a variety of economic activities. In the application materials, the applicant addresses the economic benefits of the proposed change, especially as it relates to the applicant's intended future development. The applicant asserts that the proposed

change will "provide three types of economic benefits to the City; [sic] 1) a significant increase in property tax revenue which would not be collected in the absence of the rezone, since as noted above, the current zoning has failed to attract any development, 2) direct benefits in the form of wages paid to the 30+ employees at the proposed facility, and 3) induced or indirect benefits created by the multiplier effect of employees spending wages locally."

Based on these findings, the amendment is consistent with Statewide Planning Goal 9.

Goal 10: Housing - To provide for the housing needs of citizens of the state.

The subject property does not include any lands designated for residential use in the City's Buildable Lands Inventory (BLI); therefore, the proposal does not include any changes that would impact the availability of residential lands for housing, nor does it impact the City's ability to provide for housing needs in the future. Based on these findings, Statewide Planning Goal 10 does not apply.

Goal 11: Public Facilities and Services - To plan and develop a timely, orderly and efficient arrangement of public facilities and services to serve as a framework for urban and rural development.

The Metro Plan Diagram amendment does not affect the City's provision of public facilities and services. Based on this finding, Statewide Planning Goal 11 does not apply. However, as a note, all necessary public services exist or are readily available in close proximity to the subject site.

Goal 12: Transportation - To provide and encourage a safe, convenient and economic transportation system.

OAR 660-012-0060, the Transportation Planning Rule (TPR), implements Goal 12 for proposed amendments to the Metro Plan diagram, such as this application. The TPR contains the following requirement:

OAR 660-012-0060(1) If an amendment to a functional plan, an acknowledged comprehensive plan, or a land use regulation (including a zoning map) would significantly affect an existing or planned transportation facility, then the local government must put in place measures as provided in section (2) of this rule, unless the amendment is allowed under section (3), (9) or (10) of this rule. A plan or land use regulation amendment significantly affects a transportation facility if it would:

- (a) Change the functional classification of an existing or planned transportation facility (exclusive of correction of map errors in an adopted plan);
- (b) Change standards implementing a functional classification system; or
- (c) Result in any of the effects listed in paragraphs (A) through (C) of this subsection based on projected conditions measured at the end of the planning period identified in the adopted TSP. As part of evaluating projected conditions, the amount of traffic projected

to be generated within the area of the amendment may be reduced if the amendment includes an enforceable, ongoing requirement that would demonstrably limit traffic generation, including, but not limited to, transportation demand management. This reduction may diminish or completely eliminate the significant effect of the amendment.

- (A) Types or levels of travel or access that are inconsistent with the functional classification of an existing or planned transportation facility;
- (B) Degrade the performance of an existing or planned transportation facility such that it would not meet the performance standards identified in the TSP or comprehensive plan; or
- (C) Degrade the performance of an existing or planned transportation facility that is otherwise projected to not meet the performance standards identified in the TSP or comprehensive plan.

Goal 12 requires a determination of whether the proposed Metro Plan Amendment will significantly impact an existing or planned transportation facility.

The applicant hired a Transportation Engineer, Chris Clemow, PE, PTOE, to prepare a TPR analysis to demonstrate consistency with Statewide Planning Goal 12 requirements. The analysis calculated an assumed "worst-case development" scenario to quantify potential transportation impacts. The assumption was based on the total site area, a rate of development based on nearby developed sites zoned E-1 Campus Employment, and a high traffic impact use allowed in the E-1 zone (i.e. clinic and general office). The result of the Transportation Engineer's calculation is that development under the current designation and zoning would potentially generate 231 peak hour trips. City staff concurred with the scope of the study, and the analysis is consistent with the agreed upon scope of work.

Based on this assumed trip generation, the applicant proposed a condition to limit maximum site development to generate no more than 231 new PM peak hour vehicle trips as determined by the most current edition of the Institute of Transportation Engineers Trip Generation Manual. Based on their analysis, the following condition is warranted to ensure compliance with the Transportation Planning Rule:

Trip Cap Condition of Approval

Site development shall be limited so as to generate no more than 231 PM peak hour vehicle trips as determined by the most current edition of the Institute of Transportation Engineers Trip Generation Manual. The City may allow development intensity beyond this maximum number of peak hour vehicle trips if the applicant submits to the appropriate approving agencies a transportation impact analysis demonstrating the proposed intensification of use is consistent with the Transportation Planning Rule (TPR) criteria outlined in Oregon Administrative Rule (OAR) 660 012-

0060. The applicant shall seek, and the City shall consider such approval using the City's Type II land use application procedure.

This trip cap condition cap provides an enforceable, ongoing requirement limiting traffic generation to a level consistent with the current Metro Plan designation as implemented through the current E-1 Campus Employment zoning, which was used as part of the land use assumptions in the 2035 Transportation System Plan (2035 TSP). The 2035 TSP addresses the projects, programs, and policies needed to support growth in population and jobs within Eugene's urban growth boundary as well as the travel associated with regional and state economic growth between now and the year 2035. As conditioned, the Metro Plan designation change (and zone change) will not increase trip generation, thereby demonstrating compliance with the requirements of the TPR.

Based on these findings, the proposal is consistent with Statewide Planning Goal 12.

Goal 13: Energy Conservation - To conserve energy.

The proposed change to the Metro Plan's land use diagram will not amend or otherwise involve any land use regulations that implement this Goal. Therefore, Statewide Planning Goal 13 does not apply.

That said, the proposed accessory use of the property to provide electric vehicle (EV) charging stations demonstrates the applicant's intent to conserve energy in support of Goal 13. As an example, Goal 13 supports compact and high-density land uses because it reduces fossil fuel consumption. By providing EV charging stations available to public, the applicant's intended use of the subject property encourages more EV users, thereby reducing fossil fuel consumption. Further, the applicant states that Audi has committed to supporting EV as an initiative to move away from traditional energy sources, such as fossil fuels.

Goal 14: Urbanization - To provide for an orderly and efficient transition from rural to urban land use, to accommodate urban population and urban employment inside urban growth boundaries, to ensure efficient use of land, and to provide for livable communities.

The Metro Plan diagram amendment does not affect the City's provisions regarding the transition of land from rural to urban uses. Based on this finding, Statewide Planning Goal 14 does not apply.

Goal 15: Willamette River Greenway - To protect, conserve, enhance and maintain the natural, scenic, historical, agricultural, economic and recreational qualities of lands along the Willamette River as the Willamette River Greenway.

The Metro Plan Diagram Amendment does not contain any changes that affect the Willamette River Greenway regulations, nor is the subject property located within the adopted Willamette Greenway boundary. Based on this finding, Statewide Planning Goal 15 does not apply.

Goals 16 – 19: Estuarine Resources; Coastal Shorelands; Beaches and Dunes; and Ocean Resources

There are no estuarine, beach and dune, coastal, or ocean resources related to subject property. Based on this finding, Statewide Planning Goals 16 through 19 do not apply.

Conclusion

Based on the findings above, and with the proposed trip cap condition of approval to ensure consistency with Goal 12 (TPR), the Metro Plan Amendment complies with the Statewide Planning Goals and the approval criterion at EC 9.7735(1) is met.

EC 9.7735(2): The proposed amendment does not make the Metro Plan internally inconsistent.

No policies within the Metro Plan appear to serve as mandatory approval criteria for this application, nor do any Metro Plan policies appear to be directly relevant to this site-specific Metro Plan Diagram amendment. Therefore, the proposed amendment does not present any conflict with Metro Plan policies nor make the Metro Plan internally inconsistent. Based on these findings, this criterion is met.

EC 9.7735(3): When the city-specific local comprehensive plan also applies, the proposed amendment is consistent with the city-specific local comprehensive plan.

The city-specific local comprehensive plan for the City of Eugene is the Envision Eugene Comprehensive Plan. The following policy from the Envision Eugene (EE) Comprehensive Plan provides relevant support for the amendment to the Metro Plan Diagram:

EE Policy 3.23: Flexible campus employment areas. Recognize changing market demands and accommodate land needs through flexible zoning for light industrial/campus employment areas, including Greenhill Technology Park, Willow Creek Circle and Chad Drive.

This policy specifically recognizes the challenges presented by existing by zoning restrictions in the area of the subject property. The applicant contends that the existing E-1 zoning has not responded well to market conditions and has not provided opportunities to meet market demand. They note that the subject property has been designated Campus Industrial and zoned E-1 Campus Employment since 2013 and has remained vacant for 7 years since that time, as has most of the E-1 zoned land in the vicinity. While the policy specifically related to flexible zoning, the proposed Metro Plan diagram change is necessary to facilitate the zone change.

The Transportation chapter of Envision Eugene states that the Eugene 2035 Transportation System Plan (TSP) serves as the transportation element for the comprehensive plan. As noted in the findings related to Statewide Planning Goal 12, the Metro Plan Diagram amendment is consistent with the City's TSP, and therefore consistent with the transportation element of

Envision Eugene. No transportation policies appear to be directly relevant to this site-specific Metro Plan Amendment, nor do they serve as mandatory approval criteria for the amendment.

Based on these findings, the proposed Metro Plan Amendment is consistent with Envision Eugene, the City's local comprehensive plan.

REFINEMENT PLAN AMENDMENT

The proposed Metro Plan Amendment also triggers the need for an amendment to the Land Use Diagram, the Land Use Diagram (Northeast Portion), and the Coburg-Crescent Subarea Diagram in the Willakenzie Area Plan (WAP), which is the applicable refinement plan for this area. The subject property is in the Crescent-Coburg Subarea in the North Region, as identified in the WAP. The WAP's land use diagram designates the property as Campus Industrial. Per EC 9.7730(5)(b), since no text amendment is required, when the amendment to the Metro Plan Diagram is approved, the refinement plan designation changes automatically to Light Medium Industrial to remain consistent with the Metro Plan. The following findings address the applicable approval criteria for the related refinement plan amendment:

EC 9.8424(1): The refinement plan amendment is consistent with all of the following:

(a) Statewide planning goals.

The findings addressing consistency with the Statewide Planning Goals included above under Metro Plan Amendment approval criterion EC 9.7735(1), are incorporated herein by reference. Based on those findings, the amendment to the land use diagram for the Willakenzie Area Plan is consistent with the Statewide Planning Goals.

(b) Applicable provisions of the comprehensive plan.

The findings above under Metro Plan Amendment approval criteria EC 9.7735(2) and EC 9.7735(3) are incorporated herein by reference and the amendment to the land use diagram for the Willakenzie Area Plan is consistent with the provisions of the Metro Plan and Envision Eugene.

(c) Remaining portions of the refinement plan.

Only the three WAP diagrams listed above in the Willakenzie Area Plan will be amended through the procedures identified at EC 9.7730(5). No other amendments to the WAP are proposed or required. No polices listed in the WAP appear to serve as mandatory approval criteria for this land use diagram amendment nor do any refinement plan policies require further analysis beyond that provided above for the Metro Plan Amendment.

EC 9.8424(2): The refinement plan amendment addresses one or more of the following:

- (a) An error in the publication of the refinement plan.
- (b) New inventory material which relates to a statewide planning goal.

- (c) New or amended community policies.
- (d) New or amended provisions in a federal law or regulation, state statute, state regulation, statewide planning goal, or state agency land use plan.
- (e) A change of circumstances in a substantial manner that was not anticipated at the time the refinement plan was adopted.

An amendment to the plan designation on the Metro Plan diagram constitutes a "new or amended community policy." Per the findings pertaining to the Metro Plan diagram amendment at EC 9.7735, incorporated herein by reference, the designation change is consistent with all Statewide Planning Goals and the existing Metro Plan policies. Therefore, the refinement plan land use diagram must be amended to remain consistent with the amended Metro Plan Diagram. Based on these findings, this criterion is met.

ZONE CHANGE

The applicant's request includes a concurrent zone change from E-1 Campus Employment to E-2 Mixed Use Employment, to bring the zoning into conformance with the proposed Light Medium Industrial plan designation. The following findings address the applicable approval criteria for the zone change request:

EC 9.8865(1): The proposed change is consistent with applicable provisions of the Metro Plan. The written text of the Metro Plan shall take precedence over the Metro Plan diagram where apparent conflicts or inconsistencies exist.

According to EC 9.2405, the requested E-2 zone implements the Metro Plan's Light Medium Industrial land use designation. Therefore, the zone change is consistent with a change to the Metro Plan Diagram to designate the subject property as Light Medium Industrial. There are no Metro Plan polices that serve as mandatory approval criteria for this zone change or require further analysis beyond that provided above for the requested Metro Plan Amendment.

Based on these findings, and with approval of the Metro Plan Diagram Amendment, this criterion is met.

EC 9.8865(2): The proposed zone change is consistent with applicable adopted refinement plans. In the event of inconsistencies between these plans and the Metro Plan, the Metro Plan controls.

The subject property is within the boundaries of the Willakenzie Area Plan (WAP), which is the applicable adopted refinement plan for the area of this request. The subject property is in the Crescent-Coburg Subarea in the North Region, as identified in the WAP.

The WAP identifies the subject property as being designated for Campus Industrial. However, according to the Metro Plan Amendment procedures at EC 9.7730(5)(b), where, as here, the Metro Plan diagram is amended and that Metro Plan amendment does not require a

refinement plan text amendment, the refinement plan's land use diagram is automatically amended to remain consistent with the Metro Plan. There are no text amendments to the WAP proposed or otherwise required in this instance. Therefore, the WAP's land use diagram is automatically amended to remain consistent with Metro Plan diagram. Amendment of the WAP land use diagram to designate the subject property as Light Medium Industrial is consistent with E-2 Mixed Use Employment zoning. No polices listed in the WAP appear to serve as mandatory approval criteria for this zone change or to require further analysis beyond that provided above for the requested Metro Plan Amendment and Refinement Plan Amendment.

Based on these findings, and with approval of the amendment to land use diagram for the WAP, this criterion is met.

EC 9.8865(3): The uses and density that will be allowed by the proposed zoning in the location of the proposed change can be served through the orderly extension of key urban facilities and services.

Key urban facilities and services are defined in the Metro Plan as: wastewater service, stormwater service, transportation, water service, fire and emergency medical services, police protection, City-wide parks and recreation programs, electric service, land use controls, communication facilities, and public schools on a district-wide basis (see Metro Plan, page V-3). The following summary addresses the availability of these key urban services and facilities as required under this criterion.

<u>Wastewater</u>: Public wastewater service is currently available for the subject property from a wastewater line located in Old Coburg Road. Wastewater standards will be reviewed at the time of future development for any extension of service to the subject property.

<u>Stormwater</u>: Existing stormwater conveyance lines are located in both North Game Farm Road and Old Coburg Road, as well as to the south of the site. Stormwater standards will be reviewed at the time of future development for any extension of service to the subject property.

<u>Streets</u>: The subject property has frontage on Old Coburg Road and North Game Farm Road, which are classified as a Major Collector and Minor Arterial streets respectively, per Figure 60 of the Eugene 2035 Transportation System Plan (2035 TSP). Compliance with applicable street standards will be addressed at the time of future development.

<u>Solid Waste</u>: Collection service is provided by private entities. Regional disposal sites and the Short Mountain Landfill are operated by Lane County.

<u>Water and Electric</u>: Water and electrical services, operated by Eugene Water and Electric Board (EWEB) are available for extension to the property. Any future development will require

coordination with EWEB staff to ensure that water and electric services comply with City standards and EWEB requirements.

<u>Public Safety</u>: Police protection for the subject property is consistent with service provision through the City. Fire protection will be provided by the Eugene Springfield Fire Department. Emergency medical services are currently provided on a regional basis by the cities of Eugene and Springfield.

<u>Transportation</u>: The subject property is accessible to pedestrians, bicycles, and vehicles via the surrounding street network. Two public transit stops are located adjacent to the subject property. Sidewalks are present along all street frontages of the subject property.

<u>Parks and Recreation</u>: Parks and recreation programs are provided on a City-wide basis. The inclusion of the subject property in the City is sufficient evidence to demonstrate the minimum level of this key urban service is met.

<u>Planning and Development Services</u>: Planning and building permit services are provided for all properties located within the urban growth boundary by the City of Eugene. The Eugene Code, Chapter 9, will provide the required land use controls for future development of the subject property.

<u>Communication</u>: A variety of telecommunication providers offer communications services throughout the Eugene/Springfield area; therefore, these services are available, and this key urban service requirement is met.

<u>Public Schools</u>: The subject property is within Eugene School District 4J. As access to schools is evaluated on a district wide basis, the property's location within the school district is sufficient evidence to demonstrate the minimum level of this key urban service is met.

Based on these findings, this criterion is satisfied.

EC 9.8865(4): The proposed zone change is consistent with the applicable siting requirements set out for the specific zone in:

(b) EC 9.2430 Employment and Industrial Zone Siting Requirements.

The specific siting standards for the E-2 Mixed Use Employment zone are listed under EC 9.2430(2) and provided for ease of reference below.

EC 9.2430(2): E-2 Mixed Use Employment. This zone is limited to areas designated Light Medium Industrial in the comprehensive plan and those that meet either (a) or (b) of the following minimum siting requirements:

- (a) Property has frontage on an arterial street.
- (b) Contiguous to parcels currently zoned E-2 or C-2 Community Commercial.

E-2 zoning is limited to areas designated Light Medium Industrial and the subject property is designated Light Medium Industrial by the Metro Plan Diagram amendment approved as part of this application package. The subject property has frontage on North Game Farm Road, which is classified as a Minor Arterial street by the Eugene 2035 Transportation System Plan. Therefore, the zone change complies with EC 9.2430(2)(a).

Based on these findings, with approval of the proposed Metro Plan Diagram amendment, the siting requirements of EC 9.2430 are satisfied, and this criterion is met.

EC 9.8865(5): In cases where the NR zone is applied ...

This criterion does not apply because the proposed zone change does not include the NR zone.

OAR 660-012-0060 - Transportation Planning Rule

While not an approval criterion included in Eugene Code, zone change applications are required to demonstrate compliance with the State's Transportation Planning Rule under OAR 660-012-0060. Consistent with the findings and trip cap condition under the Statewide Planning Goal 12, incorporated herein by reference, the proposed zone change is consistent with the Transportation Planning Rule.

CONCLUSION

Based on the available information and evidence, and the preceding findings of compliance with the applicable approval criteria, the proposed Metro Plan Amendment, Refinement Plan Amendment, and Zone Change comply with the applicable approval criteria, subject to the following condition of approval:

Trip Cap Condition of Approval

Site development shall be limited so as to generate no more than 231 PM peak hour vehicle trips as determined by the most current edition of the Institute of Transportation Engineers Trip Generation Manual. The City may allow development intensity beyond this maximum number of peak hour vehicle trips if the applicant submits to the appropriate approving agencies a transportation impact analysis demonstrating the proposed intensification of use is consistent with the Transportation Planning Rule (TPR) criteria outlined in Oregon Administrative Rule (OAR) 660 012-0060. The applicant shall seek, and the City shall consider such approval using the City's Type II land use application procedure.

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AN ORDINANCE AMENDING THE EUGENE-SPRINGFIELD METROPOLITAN AREA GENERAL PLAN DIAGRAM AND THE WILLAKENZIE AREA PLAN DIAGRAM TO REDESIGNATE THE PROPERTY IDENTIFIED AS ASSESSOR'S MAP 17-03-16-41, TAX LOTS 201, 300 AND 400 AND ASSESSOR'S MAP 17-09-16-44, TAX LOTS 400 AND 800 FROM CAMPUS INDUSTRIAL TO LIGHT MEDIUM INDUSTRIAL AND REZONE THE PROPERTY FROM E-1 CAMPUS EMPLOYMENT TO E-2 MIXED USE EMPLOYMENT.

The City Council of the City of Eugene finds as follows

- A. On January 17, 2020, Sheppard Motors, LLC submitted an application for a Type I amendment to the Eugene-Springfield Metropolitan Area General Plan (Metro Plan) plan diagram, a refinement plan amendment to the Willakenzie Area Plan land use diagram and subarea diagram for consistency with the Metro Plan, and a concurrent zone change to redesignate and rezone the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800. The applicant requested a Metro Plan designation change from the Campus Industrial designation to a Light-Medium Industrial designation. Approval of the Metro Plan amendment results in the automatic concurrent amendment of the Willakenzie Area Plan land use diagram and Coburg-Crescent Subarea Diagram, giving the subject property a Light-Medium Industrial designation under the Willakenzie Area Plan. The zone change requested by the applicant would rezone the subject property from E-1 Campus Employment to E-2 Mixed Use Employment.
- **B.** On July 28, 2020, the Eugene Planning Commission held a public hearing on the application. The Eugene Planning Commission recommended that the Eugene City Council adopt the proposed amendments to the Metro Plan plan diagram as shown in Exhibit A, and the Willakenzie Area Plan land use diagram as shown in Exhibit B.

NOW, THEREFORE,

THE CITY OF EUGENE DOES ORDAIN AS FOLLOWS:

<u>Section 1</u>. The Eugene-Springfield Metropolitan Area General Plan land use diagram is amended to redesignate the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, from Campus Industrial to Light-Medium Industrial, as depicted on Exhibit A attached hereto and incorporated herein by reference.

Section 2. Consistent with the provisions of section 9.7730(5) of the Eugene Code, 1971:

(a) The Willakenzie Land Use Diagram and Willakenzie Land Use Diagram (Northeast Portion) located between pages 19 and 20 of the Willakenzie Area Plan are amended to redesignate the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, from Campus Industrial to Light-Medium Industrial, as depicted on Exhibits B and C attached hereto and incorporated herein by this reference.

Recommended (With Trip Cap)

(b) The Coburg-Crescent Subarea Diagram located at page 62 of the Willakenzie Area Plan is amended to add "Light-Medium Industrial" to the legend for the diagram and to redesignate the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, from Campus Industrial to Light-Medium Industrial, as depicted on Exhibit D attached hereto and incorporated herein by this reference.

<u>Section 3</u>. The property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800, is rezoned from E-1, Campus Employment to E-2 Mixed Use Employment, as depicted on Exhibit E attached hereto and incorporated herein by this reference.

Section 4. The findings set forth in the attached Exhibit F are adopted in support of this Ordinance.

Section 5. Based on the findings set forth in Exhibit F attached hereto and adopted as findings in support of this Ordinance, the following limitation on development of the property identified as Assessor's Map 17-03-16-41, Tax Lots 201, 300 and 400 and Assessor's Map 17-09-16-44, Tax Lots 400 and 800 is hereby imposed:

Site development shall be limited so as to generate no more than 231 PM peak hour vehicle trips as determined by the most current edition of the Institute of Transportation Engineers Trip Generation Manual. The City may allow development intensity beyond this maximum number of peak hour vehicle trips if the applicant submits to the appropriate approving agencies a transportation impact analysis demonstrating the proposed intensification of use is consistent with the Transportation Planning Rule (TPR) criteria outlined in Oregon Administrative Rule (OAR) 660 012-0060. The applicant shall seek, and the City shall consider such approval using the City's Type II land use application procedure.

<u>Section 56</u>. If any section, subsection, sentence, clause, phrase, or portion of this Ordinance is for any reason held invalid or unconstitutional by any court of competent jurisdiction, that portion shall be deemed a separate, distinct, and independent provision and that holding shall not affect the validity of the remaining portions of this Ordinance.

Passed by the City Council this	Approved by the Mayor this		
, 2020	, 2020.		
City Recorder	 Mayor		

EUGENE CITY COUNCIL AGENDA ITEM SUMMARY



Public Hearing: 1059 Willamette Redevelopment

Meeting Date: September 21, 2020

Department: Planning and Development

Agenda Item Number: 3

Staff Contact: Amanda D'Souza

www.eugene-or.gov Contact Telephone Number: 541-682-5540

ISSUE STATEMENT

The public is invited to comment on a) whether the 1059 Willamette project should move forward, b) if so, how it should be funded, and c) draft criteria to be used in the Request for Proposals (RFP) for the site. Following the September 21 Public Hearing, City Council/Agency Board will have a Work Session scheduled for September 30 to consider whether to include Urban Renewal or other City funds in the RFP and to approve the RFP criteria.

BACKGROUND

The building served as the Lane Community College (LCC) Downtown Center until 2012 and has been vacant since the new LCC Downtown Campus opened at 10th and Olive Streets. The City of Eugene's Urban Renewal Agency (Agency) identified the property as one of four projects in the 2016 Downtown Urban Renewal Plan amendment to be eligible for Agency resources to assist in the property's redevelopment. In April 2019, the City submitted a letter of interest to LCC for purchase of the site. In May 2019, the LCC Board approved sale of the site to the City of Eugene.

At the January 29, 2020 Work Session, Council discussed the redevelopment of 1059 Willamette, including the option to create a mixed-income housing development. At the Work Session, Council approved the use of federal Community Development Block Grant (CDBG) funds to acquire the building for multi-family housing development through the Land Acquisition for Affordable Housing Program, also called the land bank program. After performing due diligence required by CDBG regulations, the City acquired the site in April 2020. Council also approved the use of a Request for Proposals (RFP) process for disposition of the site at the January Work Session.

The planned redevelopment project is a mix of income-qualified units and market-rate units, where 51 percent of the units are targeted to households at 80 percent of AMI^a, and 49 percent of the units are market-rate. These households are an underserved population - there are very few options for households earning between 60 percent and 80 percent AMI, and in most cases, they would not qualify for other affordable housing options. (See Attachment A for more information on mixed-income developments, including current CDBG income limits based on household size.)

^a Workforce housing is a term used to describe housing for households that earn too much to qualify for subsidized affordable housing, but have difficulty finding adequate housing within their budget. The term 'moderate-income housing' more accurately describes the housing category, as many households that qualify for subsidized affordable housing are in the workforce.

RFP Timeline

On July 15, Council directed staff to move forward with the RFP timeline in Attachment B. This timeline combines the required steps from three different processes: a) the land bank disposition process (approved for this property at the January 29 Work Session), b) the 2018 Councilapproved disposition process for City-owned real property, and c) the process laid out by the 2016 Downtown Urban Renewal Plan for the use of Urban Renewal funds. A brief summary of the process for this project is in the "next steps" section below.

Once the RFP closes, the submitted proposals would be presented to the public for comment. An Evaluation Committee will score the proposals (based on the process approved by Council in January 2020). The Evaluation Committee for land bank sites typically includes the Council representative on the Housing Policy Board, community member representatives with development or housing expertise, and a member of the applicable neighborhood association.

RFP Criteria

The use of CDBG funds to purchase the site requires an affordable housing component in the redevelopment project: CDBG requires that a minimum of 51 percent of the units serve populations earning up to 80 percent of AMI.

The draft RFP criteria that will be used to score and rank and proposals are in Attachment A. Highlights of the proposed criteria include:

- Compliance with CDBG-related federal requirements (e.g., income and rent limits; mitigating actions to satisfy environmental regulations);
- Demonstrated experience with similar projects; and
- Timeliness and feasibility of proposed project, including financials.

Per the approved RFP timeline, staff has asked for feedback from stakeholders, including Downtown Neighborhood Association, Downtown Eugene, Inc., Downtown Eugene Merchants, Friends of Downtown, and affordable housing providers. The public is asked to provide feedback on the criteria at the Public Hearing. Council will be asked to finalize the criteria at the September 30 Work Session.

Potential Public Funding Sources and Uses

Mixed-income housing projects generally face a financial gap due to the limited rental income and inability to access traditional affordable housing resources (see Attachment A for more information). The City and/or the Urban Renewal Agency can support a mixed-income housing development at 1059 Willamette in several ways. See Attachment C for a description of potential incentives, listed here in brief:

- Provide the property at no cost, which is typical of the land bank program;
- Demolish the building and make the site 'shovel-ready';
- Cover System Development Charges and other permit fees;
- Cover EWEB's downtown electric-network connection fee; and
- Multi-Unit Property Tax Exemption (MUPTE).

At the July 15 Work Session, Council reviewed potential funding sources that could be used to support the project and requested additional information that was provided in a memorandum dated July 27. This information is provided in Attachment C.

The potential sources include:

- Downtown Urban Renewal
- MUPTE-related funds
- Affordable Housing Trust Fund/Construction Excise Tax

Downtown Urban Renewal

The Downtown Urban Renewal Plan outlines a number of community engagement activities that must be completed before the Agency Board can authorize the use of tax increment funds on this project:

- 1) An opportunity for the community to share aspirations and vision for the project;
- 2) A presentation by staff summarizing the public engagement, cost estimates, and funding mechanisms;
- 3) A public hearing on whether the project should move forward and how it should be funded; and
- 4) Council/Agency Board deliberation about using Urban Renewal funds for the project and subsequent action.

The public engagement conducted in January prior to acquisition fulfilled Step #1. The July 15 Work Session fulfilled Step #2. This public hearing is Step #3. Council/Agency Board will have the opportunity to deliberate and take action on including Urban Renewal (or other) funds in the RFP at the September 30 Work Session (Step #4). Following Step #4, the Council/Agency Board will have further opportunity to discuss and take action on the specific use of Urban Renewal funds both when selecting the proposal and when finalizing deal points.

Proposed Next Steps

Following the Public Hearing, Council is scheduled to discuss the RFP and funding options at the September 30 Work Session. Based on the approved RFP timeline (Attachment B), next steps are:

- A. Sept. 30 Work Session: finalize the RFP criteria; consider action to include Urban Renewal (or other) funds for the project through the RFP [Step #4, as required by the Downtown Urban Renewal Plan]
- B. RFP Issued
- C. *Public Engagement:* community input on proposals; evaluation committee scores and ranks proposals using approved criteria
- D. Work Session: selection of development proposal
- E. Work Session: approval of deal points, including terms related to incentives such as Urban Renewal depending on Agency Board direction from step A
- F. Budaet Action
- G. MUPTE Application public engagement and Council action (if applicable)

PREVIOUS COUNCIL DIRECTION

July 27, 2020 City Council Meeting

The Agency Board passed a motion to fully fund the Farmers Market, fund Open Space improvements related to the Town Square (including a free-standing restroom in the Park Blocks), and specified that a "minimal" amount of the estimated remaining \$1.1M should be spent on Open Space projects.

City Council discussed the use of the Affordable Housing Trust Fund. Council approved an allocation for the \$800,000 collected in FY20 for use in FY21. Council allocated \$500,000 to renter and homeowner assistance programs, and \$300,000 to housing development projects.

July 15, 2020 Work Session

City Council directed staff to move forward with the proposed RFP timeline, including implementing a public engagement plan, and to bring back updated criteria and a financial incentives package for Council consideration. Council also directed staff to schedule a Public Hearing to solicit public comment on whether the project should move forward and the appropriate funding mechanisms for the project.

MOTION AND VOTE: Councilor Semple, seconded by Councilor Yeh, moved to direct the City Manager to schedule a Public Hearing on the 1059 Willamette project in order to solicit public feedback on whether the project should move forward, as well as the appropriate funding mechanisms for the project. The City Manager is further directed to implement the proposed public engagement process. PASSED 8:0

January 29, 2020 Work Session

City Council authorized the purchase of the property at 1059 Willamette using CDBG funds. Council also approved the Land Acquisition for Affordable Housing property disposition process for the site's redevelopment.

May 29, 2018 City Council Meeting

City Council approved the *Eugene-Springfield One-Year Action Plan, the One-Year Supplemental Plan for the 2015 Consolidated Plan.* This plan identifies a strategy of increasing the supply of affordable housing using land acquisition. The plan identifies sources and uses of funding to implement these strategies.

June 13, 2016 City Council Work Session

City Council adopted Ordinance 20564 adopting an amended Urban Renewal Plan for the Downtown Urban Renewal District. In this plan, 1059 Willamette (formerly "Old LCC") was identified as a project eligible to receive Urban Renewal dollars, with housing as a potential use.

ATTACHMENTS

- A. Draft RFP Criteria & Additional Background
- B. Approved RFP Process and Timeline
- C. Potential Public Funding Uses and Sources

FOR MORE INFORMATION

Staff Contact: Amanda D'Souza Telephone: 541-682-5540

Staff E-Mail: Adsouza@eugene-or.gov

Draft RFP Criteria and Additional Background

On January 29, 2020, Council approved the use of a Request for Proposals (RFP) process for disposition of the 1059 Willamette property. The following is a draft of criteria that will be used to evaluate responses to the RFP. Council will finalize the RFP criteria at a future work session, prior to issuance of the RFP. The draft criteria are:

Experience and Qualifications

Preferred applicants or teams will have:

- A proven track record of completing successful, high quality redevelopment projects in urban settings (including information about project costs);
- Demonstrated preference for use of local contractors and/or Minority and Womenowned businesses enterprises;
- Demonstrate use of cost-effective green building measures; and
- Demonstrated experience in serving the targeted population(s) and with the proposed form of development.; and
- Evidence of financial capacity.

Project Concept and Design

Required:

- 51% of the units must be affordable to households earning up to 80% AMI. The remaining units may be offered at market-rate rents;
- Present site plans and renderings that show the project is suitable for the target population(s) and project location;
- Must comply with City code for C-3 zoning; and
- Comply with the federal environmental review requirements.

Preferred concepts will:

- Incorporate elements that contribute to an active, inviting, and safe pedestrian environment;
- Demonstrate appropriate integration and relational elements with neighborhood context and existing and future development; and
- Provide a parking assessment and a financeable plan to accommodate the parking and transportation needs of the proposed uses.

Timeliness & Feasibility

Required:

- Development timeline must demonstrate completion and lease up no later than April 30, 2025;
- Demonstrate understanding of market potential for the proposed concept(s); and
- Provide a reasonable project budget that minimizes need for public assistance.

Preferred concepts will:

- Demonstrate completion significantly earlier than April 30, 2025 deadline; and
- Demonstrate leveraging of other resources in project budget.

Additional Public Benefits

Preference will be given to proposals that:

- Integrate art or opportunities for public creativity;
- Demonstrate intention or plan to solicit services from local contractors and/or Minority and Women-owned business enterprises;
- Use cost effective green building measures; and
- Provide services promoting self-sufficiency and independent living that are available to residents in affordable housing units.

Consistency with City Policies and Goals.

The <u>Downtown Urban Renewal Plan</u> and the <u>Downtown Plan</u> are the primary policy documents that guide public and private redevelopment in the Downtown Eugene area. Other plans and policy documents also provide guidance including <u>2020-2025 Consolidated Plan</u>, <u>Envision Eugene</u>, and the <u>Climate Action Plan 2.0</u>. Any proposed development concept must be consistent with the policies and goals for Downtown Eugene as reflected in these documents.

Additional Background

RFP Submission Requirements

Through the RFP process, development teams would submit proposals for the property that include a description of the project size and scope, a site plan, architectural renderings, and a pro forma outlining the financing plan. The pro forma would demonstrate the sources and uses of funds for the proposed development, anticipated rental income and expected operating costs. The proposals would provide City Council and the Agency Board with enough detail about a potential development to make decisions about awarding resources.

Mixed-Income Housing

Given the property's strategic location across from the LTD Eugene Station and the identified need through the Housing Tools and Strategies process and Envision Eugene for a range of affordable housing options and more compact urban development in the core of downtown, the site is ideally suited for redevelopment as housing. The use of Community Development Block Grant funds requires that the site be used for housing and that at least 51% of the units must be affordable to households earning 80% of Area Median Income (AMI) (see below for information on income requirements). The City of Eugene is proposing redevelopment of the site into a mixed income housing project, where 51% of the units would meet the CDBG income requirements, and the other 49% could be rented at market rates.

As part of project scoping, staff interviewed local housing developers to better understand the financial feasibility of this type of mixed-income development and conducted a financial 'proforma' evaluation. A financial gap is anticipated because:

1. Rents are limited for over half of the units, so they are affordable for households earning no more than 80 percent AMI. Those rents are substantially lower than market-rate rents for a new housing development.

2. Traditional tools available to support affordable housing, such as HOME funds, Low Income Housing Tax Credits (LIHTC), and Low-Income Rental Housing Property Tax Exemptions (LIRHPTE), require rents to be affordable to households at 60 percent AMI and below. These traditional resources would not be available for a project targeting households at 80 percent of AMI.

The approach under consideration would be piloting a new mixed-income residential development. By adding new, more affordable options, housing mobility is encouraged, which can relieve pressure on the stock of lowest income housing options that have the highest demand in our community. Additionally, the project provides a more affordable option for rent-burdened residents paying more than 30 percent of their income on housing, allowing them to reduce costs, save money, and work towards greater financial stability and the potential of home ownership.

Income Requirements

Households at 80% of AMI are underserved - there are very few options for households earning between 60% and 80% AMI, and in most cases, they would not qualify for other affordable housing options. Table A below shows the CDBG income limits based on household size. Affordable rents plus utility costs are no more than 30% of household income.

Table A. 2020 CDBG Income Limits, effective July 1, 2020

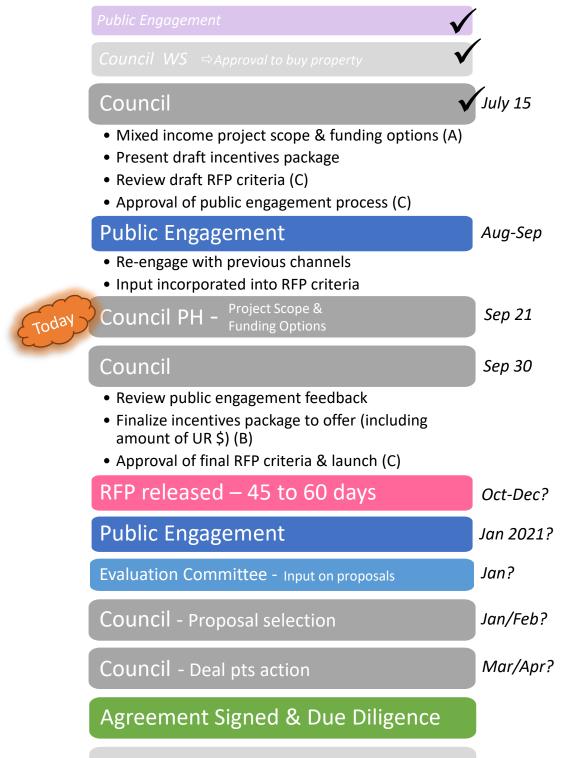
Persons in Household	1	2	3	4	5	6	7
Low Income - 80% AMI	\$39,200	\$44,800	\$50,400	\$56,000	\$60,500	\$65,000	\$69,450

Evaluation Committee

An Evaluation Committee will score the proposals (based on the land bank and RFP process approved by Council in January 2020). The Evaluation Committee for land bank sites typically includes the Council representative on the Housing Policy Board, community member representatives with development or housing expertise, and a member of the applicable neighborhood association. The Committee will use the finalized RFP criteria to evaluate proposals.

RFP Process and Timeline

The timeline below combines the 3 related process required for 1) disposing of the property, 2) utilizing Urban Renewal funds, and 3) Land Banking. The circled letters below tie to the specific processes. This timeline was approved at the July 15 work session.



Public Engagement

Both the Council-approved property disposition process and the Downtown Urban Renewal Plan amendment require public engagement opportunities. The public will also have opportunities to participate in the disposition process. Prior to the City Council work session in January 2020 to approve acquisition of the site and the RFP process, staff performed public outreach to propose the concept of a mixed income residential development. A variety of community stakeholders participated in a public meeting to provide input about the proposed development concept, including members of the Downtown Neighborhood Association, Downtown Eugene, Inc., Downtown Eugene Merchants, and Friends of Downtown. Individual outreach was provided to housing providers, service providers, and adjacent neighbors. The overarching comment received prior to acquisition was that workforce housing was an appropriate use for the property.

Once proposals are received, the community will have an opportunity to provide comments on proposals. A summary of public outreach and input will be provided to Council during their consideration of proposals.

Evaluation Committee

The Evaluation Committee for land bank sites typically includes the Council representative on the Housing Policy Board, community member representatives with development or housing expertise, and a member of the respective neighborhood association. The Evaluation Committee will be tasked with scoring and ranking submitted proposals. The Committee will use the RFP criteria in their evaluations (see Attachment A for draft RFP criteria).

Potential Public Funding Uses and Sources

At the July 15, 2020 work session, Council asked staff to provide additional information on potential uses of public funds in the proposed project, and alternative available funds that could be used to support the project. This was provided subsequently in a memo.

Potential Uses of Public Funds

Staff have identified a variety of development costs that the City and the Agency can use to fill the anticipated financial gap—so that the mixed-income housing project becomes financially feasible. Table 1 summarizes the uses and their estimated amounts. All of the uses listed below are eligible for Urban Renewal funds.

Table 1. Potential uses of public funds

Incentive	Estimated Cost	Timing
Demolish the building & create a shovel-ready site	\$900,000	Prior to disposition
		(FY21 or FY22)
Development fees		
System Development Charges	\$700,000	During permitting
Permits and other City fees	\$450,000	process (FY22 or
Connection fee-EWEB downtown electric network	\$200,000	iater)
Total	\$2,250,000	

The costs provided in Table 1 are estimates, because we will not know their true cost until we have a development proposal. The development fees will vary based on the size of the development. These figures are based on a 5-story structure; the actual structure may be shorter or taller. The RFP will not specify a required structure size or the number of units. The developers will identify a development plan that they determine is feasible.

Demolition would likely occur prior to disposition of the site and is estimated to occur in FY21 or FY22. The contribution for development fees would occur during the permitting process, which would likely occur in FY22 or later.

The project will also be eligible for a Multi-Unit Property Tax Exemption (MUPTE), which would reduce the owner's property tax payments for up to ten years. A MUPTE is *not* a cash outlay from the City/Agency. Instead, it delays the collection of property tax revenue associated with new assessed value.

Available Funding Sources

Staff identified funding sources that could be used to implement a mixed-income housing project, to complement the CDBG funds used to acquire the site, summarized in Table 2. The table lists the fund and its source, an estimate of the amount available, and factors that constrain the use of the funds and other opportunities to use the funds.

Table 2. Available funding sources

Funding Name / Source	Amount	Constraints & Opportunities for Funding Resource
Downtown Urban Renewal / Tax Increment	\$1.1 million*	 Funds must be used in the Downtown Urban Renewal District, in accordance with the Plan. Per the Agency Board's July 27 direction, a "minimal" amount of this is for Open Space projects. Required approval process to access funds: Public Hearing (9/21) and then direction (scheduled for 9/30) in addition to budget action.
Affordable Housing Trust Fund / Construction Excise Tax (CET)	\$300,000 in FY21**	 The funds are for housing development serving households with incomes up to 100% AMI. Funds can be used throughout Eugene. Funding is collected annually and varies with dollar value of new construction.
MUPTE funds / Moderate Income Housing Fee	\$400,000 (estimated)	 Will be paid by the Gordon Lofts apartment development in FY22. City ordinance states that funds are to be used for moderate-income housing. Funds can be used throughout Eugene.

^{*} At the July 27 Work Session, the Agency Board passed a motion to fully fund the Farmers Market, fund Open Space improvements related to the Town Square (including a free-standing restroom in the Park Blocks), and specified that a "minimal" amount of the remaining \$1.1M should be spent on Open Space projects.

The City recently submitted a grant to the Economic Development Administration (EDA) for the Farmers Market pavilion as a part of a funding opportunity created by the CARES Act. If awarded, the grant would fund \$3.2M of the pavilion cost. In addition, the City was previously awarded a grant from the EDA for the EUGNet fiber project and estimates the Agency should receive reimbursement grant funds of approximately \$1M, if the funds are reimbursed. If the grant is awarded and/or we receive the reimbursement, there would potentially be more Urban Renewal funds that could be available to the 1059 Willamette project.

This project is not eligible for bond or levy funds. Funding options such as General Fund Reserves and Parking Funds are not currently viable options, due to the economic impacts of COVID-19.

^{**}At the July 27 Work Session related to Affordable Housing Trust Fund, Council approved an allocation for the \$800,000 collected in FY20 for use in FY21. Council allocated \$500,000 to renter and homeowner assistance programs, and \$300,000 to housing development projects.

EUGENE CITY COUNCIL AGENDA ITEM SUMMARY



Public Hearing: An Ordinance Extending the Term of Ordinance No. 20170 Granting to Northwest Natural Gas Company, a Corporation, a Non-Exclusive Natural Gas Franchise, to May 11, 2021.

Meeting Date: September 21, 2020 Agenda Item Number: 4
Department: Central Services Staff Contact: Ethan Nelson

<u>www.eugene-or.gov</u> Contact Telephone Number: 541-682-5245

ISSUE STATEMENT

The purpose of this public hearing is to provide an opportunity for public comment regarding the proposed ordinance extending the Northwest Natural Gas Right of Way Franchise Agreement until May 11, 2021. Without the extension, the franchise agreement will expire on November 11, 2020. This ordinance would only extend the term of the franchise; all other current franchise terms and conditions would remain the same.

BACKGROUND

Franchise agreements between local governments and utilities govern the use of the public right of way to ensure safety, coordinated access, and the stability of public infrastructure. Typical franchise agreements outline the terms and fees under which utility companies can utilize the public right of way for their business. Fees are typically calculated on a percentage of the revenues derived from sales of the utility company to customers within the service area.

In October 1999, the City Council approved Ordinance 20170 (Attachment A) that:

- Increased the compensation rate from 4 percent to 5 percent of gross revenues;
- Granted a franchise term of 20 years with possible renegotiation every five years;
- Provided updated audit language and facility relocation and abandonment provisions;
- Added "favored cities" language, which requires NWNG to notify the City should they agree to pay any other city in Oregon a franchise fee that exceeds 5 percent of gross revenues.

Currently, the City receives \$1.4 million in General Fund revenues from this franchise annually. Revenue from NWNG franchise fees have been trending at this level over the past few years based on flat/declining NWNG rates in the area.

Franchise Negotiation Update

At the July 29, 2020 Work Session, Council directed the City Manager to prepare an ordinance and schedule a public hearing in September 2020, to extend Northwest Natural

Gas's Franchise Agreement for 6 months and to schedule a work session in early September 2020 for an update on the negotiations. The Agenda Item Summary from July 29th provides a chronological summary of negotiations to date.

As was provided during the September 9 Council Work Session, staff from the City and NWNG, including at times Executive Leadership, held four 2-hour meetings between the July 29th and September 9th Council meetings and have weekly 2-hour meetings scheduled through the fall. These meetings have been incredibly helpful to build deeper understanding between parties and set the tone for collaborative discussions.

PREVIOUS COUNCIL DIRECTION

November 14, 2018, Work Session

This work session provided the City Council with information regarding the review process for the right of way Franchise Agreement with NWNG and discussed options for including CAP2.0 in the negotiations.

January 30, 2019, Work Session

Staff reviewed questions submitted by the Eugene Sustainability Commission to the City Council regarding the regulation of natural gas in Eugene.

May 22, 2019, Work Session

Council held a work session as a follow-up to the previous work session about NWNG's Franchise Agreement with the City and Climate Action Plan 2.0 discussions; NWNG presented its Deep Decarbonization presentation to Council.

May 29, 2019, Work Session

Council directed the City Manager to schedule a public hearing on a possible one-year extension of the Franchise Agreement with NWNG.

July 22, 2019, Work Session

Council adopted an Ordinance Extending the Term of Ordinance No. 20170 for six months until May 11, 2020.

March 9, 2020 Public Hearing

Public hearing followed by Council discussion on proposed Ordinance to extend the Franchise Agreement with NWNG another six months.

April 8, 2020 Council Meeting

City Council adopted the Ordinance extending the Franchise Agreement until November 11, 2020.

July 29, 2020 Council Meeting

City Council directed the City Manager to prepare an ordinance and schedule a public hearing in September 2020, to extend Northwest Natural Gas's Franchise Agreement for 6 months and to schedule a work session in early September 2020 for an update on the negotiations.

COUNCIL OPTIONS

This item is scheduled for public hearing only. Council action on the proposed ordinance to extend the franchise term is scheduled for September 28, 2020.

CITY MANAGER'S RECOMMENDATION

No recommendation is provided at this time. A recommendation will be provided for the scheduled action on September 28, 2020.

ATTACHMENTS

A. Ordinance 20170

B. Proposed Ordinance

FOR MORE INFORMATION

Staff Contact: Ethan Nelson Telephone: 541-682-5245

Staff E-Mail: <u>Enelson@eugene-or.gov</u>

ORDINANCE NO. 20120

AN ORDINANCE GRANTING TO NORTHWEST NATURAL GAS COMPANY, A CORPORATION, A TWENTY (20) YEAR NON-EXCLUSIVE RIGHT AND FRANCHISE TO LAY, MAINTAIN AND OPERATE FACILITIES IN THE PUBLIC WAY WITHIN THE CITY OF EUGENE, OREGON; PROVIDING FOR THE PAYMENT OF COMPENSATION TO THE CITY; AND REPEALING ORDINANCE NO. 18489, PASSED BY THE CITY COUNCIL AUGUST 27, 1979, AND APPROVED BY THE MAYOR SEPTEMBER 3, 1979.

THE CITY OF EUGENE DOES ORDAIN AS FOLLOWS:

<u>Section 1</u>. This Ordinance shall be known and may be cited as The Northwest Natural Gas Company Franchise Ordinance.

Section 2. Definitions.

For the purpose of this Ordinance the following terms, phrases, words and their derivation shall have the meaning given herein. When not inconsistent with the context, words used in the present tense include the future, words in the plural number include the singular number, and words in the singular number include the plural number. The word "shall" is always mandatory and not merely directory.

- (1) "City" is the City of Eugene, Oregon.
- (2) "Company" is Northwest Natural Gas Company, the grantee of rights under this Franchise.
 - (3) "Council" is the City Council of the City of Eugene.
- (4) "Person" is any person, firm, partnership, association, corporation, company or organization of any kind.
 - (5) "Code" is the Eugene Code, 1971, including all amendments thereto.
- (6) "Public way" is any street, road, alley, right-of-way, pedestrian or bicycle easement or utility easement for public use that is controlled by City.
- (7) "GIS format" is the format of electronic information, as established by the City Engineer for incorporation into City's Geographic Information System (GIS).
- (8) "Facilities" includes gas mains, pipes, boxes, reducing and regulation stations, laterals, conduits and connections, including service connections, together with all of the necessary or useful appurtenances for the transmission and distribution of gas to City and its inhabitants and to other customers and territory beyond the limits of City.
- (9) "Gross revenues" means revenues earned by Company from operations within City, including but not limited to revenues from the sale and/or transportation of natural gas consumed within City and revenues earned from the use, rental or lease of operating facilities of Company other than residential-type space and water heating equipment, less the net writeoff of uncollectible accounts directly related to such revenues. Gross revenues shall not include:

- (a) Revenues paid directly by the United States of America or any of its agencies;
- (b) Proceeds from the sale of bonds, mortgages or other evidence of indebtedness, securities or stocks; or
- (c) Sales at wholesale by one utility to another when the utility purchasing the service is not the ultimate customer.

Section 3. Grant of Authority.

City hereby grants to Company the right and privilege to lay, maintain, and operate facilities in and under the public ways of City, subject to the terms of this Ordinance for a period of twenty years. This grant of authority shall not be exclusive, and City reserves the right to grant similar use of such public ways to any person or corporation at any time during the period of this Franchise.

Section 4. Compliance with Applicable Laws and Ordinances.

Company shall at all times during the period of this Franchise, be subject to all lawful exercise of the police power of City, and to such reasonable regulation as City shall hereinafter by resolution or ordinance provide.

Section 5. Conditions - Occupancy of Public Ways.

Company, subject to the prior approval of the City Manager or designee, and requirements of all applicable ordinances, regulations and adopted City policies, may make necessary excavations in public ways for the purpose of laying, operating and maintaining its mains, pipes and appurtenances. Company shall furnish and file with the City Engineer of City, which shall, to the extent technologically feasible, be in a data format prescribed by the City Engineer to allow integration into City's Geographic Information System (GIS), maps showing the location of all such mains, pipes, and appurtenances within City, both for its existing system and future plans for the system. The City Engineer may require such information, including (GIS) format, or other drawings, surveys and plans, as deemed necessary to conform to the requirements of the Code and related administrative rules. Company shall bring maps up to date annually or upon such shorter notice as the City Engineer may reasonably require.

City reserves the right to stop any work on a public way if the City Manager or designee determines that the work has a serious adverse effect on traffic flow or endangers public safety. The right to stop work is absolute and cannot be challenged by Company even if Company's work hours and/or traffic control plans have been previously approved by City.

Section 6. Removal and Restoration.

Whenever any of Company's facilities shall unnecessarily inconvenience the public or private property owners, City may require the removal or change of location of any such

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facility. Any removal or relocation of facilities made for the convenience of the public shall be at Company's expense. Whenever Company excavates or in any manner disturbs or interferes with any public way within City, Company shall restore the same as required by the Code.

Section 7. City Free to Use Public Ways.

Nothing in this Ordinance shall be construed to prevent City from sewering, grading, paving, repairing, altering, or doing any work that it finds necessary or desirable in or on any public way. Should City find it in the public interest to permanently or temporarily remove or change the location of any of Company's facilities, Company shall, upon request and reasonable notice from the Director of Public Works, do all necessary work at Company's sole cost and expense as promptly as the circumstances will reasonably permit. If Company fails so to do, City may cause such work to be done and Company shall pay all costs incurred by City in performing such work within thirty (30) days of the date City notifies Company of the cost thereof.

Section 8. Company to Defend and Hold City Harmless.

Company shall defend, indemnify and save harmless City, its employees, officers and agents, from any and all claims, damages, costs, liabilities, and expenses to which it or they may be subjected by reason of any act or neglect of Company, its agents or employees, or which may in any manner arise out of the construction, maintenance, operation or use of any property of Company in any public way.

Section 9. Default and Termination.

If Company fails to comply with or perform any of the requirements imposed on it by this Ordinance and City gives written notice specifying the nature of Company's default and demanding that such default be remedied within a reasonable time to be fixed in such notice, the rights and privileges granted by this Ordinance may be terminated and annulled by City if Company fails to remedy its default within the time specified.

Section 10. Franchise Fee.

As compensation to City for the franchise hereby granted, Company shall pay to City an amount equivalent to five percent (5%) of Company's gross revenues. If the Code in effect at the time the revenue is earned does not allow payment of a franchise fee or business privilege tax or combined franchise fee and business privilege tax in an amount of five percent of gross revenues or some greater amount, then the franchise fee shall be the maximum amount allowed by the Code; provided that, if the Code is amended thereafter to increase the allowable franchise fee, business privilege tax or combined franchise fee and business privilege tax, the increased rate, not to exceed five percent, shall be paid on all gross revenues earned after the effective date of the amendment. If Company agrees to pay any other city in Oregon a franchise fee that exceeds five percent of gross revenue, City may require Company to pay the same percentage of its gross

revenue to City, so long as the Code allows payment of the higher percentage. Payment shall be made within forty-five (45) days following the end of each quarter of each calendar year. Within forty-five (45) days after the termination of this franchise, compensation shall be paid for the period elapsing since the close of the last quarter for which compensation has been paid. Upon thirty days' written notice by either party to the other, the basis for calculation of the franchise fee, the definition of gross revenues and other terms of this franchise shall be subject to renegotiation and redetermination at the end of the first three-year period of the franchise term and again at the end of each five-year period thereafter during the franchise term. The principles governing the renegotiation shall include, but not necessarily be limited to, making the franchise consistent with federal, state and local law in effect at the time of the renegotiation.

Section 11. Reports by Company.

Company shall furnish to City with each quarterly payment of compensation a statement by an officer of Company showing the amount of gross revenues of Company for the quarter covered by the payment, computed on the basis set forth in Section 10, and the calculation of the payment for the quarter, including a description of and the amount for each exclusion from gross revenue, as allowed under Section 10. The books and records showing Company's gross revenues from the gas sales referred to in Section 10 shall always be open to inspection by City's Finance Officer, or by any other authorized representative of City for the purpose of ascertaining the amount payable to City under Section 10, or to verify any statement or report submitted by Company pursuant to the provisions of this Section. City, or its authorized representative, shall have the right to audit Company's books and records to verify that the franchise fee has been correctly calculated and paid by Company. Company shall reimburse City for the reasonable costs of such audit if the audit discloses that Company has paid 95% or less of the fee owing for the period of the audit.

Company shall, upon request, furnish to City a list of all customers within the corporate limits of City who have contracted with Company for transportation and delivery of natural gas separate from the purchase of natural gas. This report shall include the names of all such customers and the volume of gas which was transported by Company on behalf of each customer for the period covered by the report.

Section 12. Company to Pay All City Taxes and Fees.

Nothing contained in this franchise shall give Company any credit against any non-discriminatory business tax or ad valorem property tax now or hereafter levied against real or personal property within City, or against any local improvement assessment imposed on Company, or against any permit fees or inspection fees required by the construction codes or other ordinances of City which are or may hereafter be adopted.

Section 13. Valuation for Eminent Domain.

In the event City should desire to acquire the property of Company in City and

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adjacent territory by purchase, condemnation, or otherwise, the price to be paid by City shall exclude the value of the franchise or other prerogatives of sovereignty granted by City and connected with property of Company in the City.

Section 14. Abandonment.

Company shall at all times maintain all of its facilities in a good state of repair, and shall subscribe to a utility notification and locate service. If Company ceases to make use of its facilities in the public way for the purposes authorized by this franchise ordinance for a continuous period of six months or more, with no intention of using those facilities in that location in the future, the facilities shall be deemed abandoned; no facilities shall be considered abandoned if they are reserved for future use. If facilities have been in the public way for more than one year without being used, they shall be presumed to be abandoned unless Company provides to City objective evidence of Company's intent to use the facilities within the next year. Company shall maintain records of all abandoned facilities and, upon receipt of a locate request, shall locate those facilities, labelling them as abandoned. Upon 60 days written notice to Company at the address indicated in its acceptance of this ordinance, City may require Company to remove abandoned facilities and restore the public way, at Company's sole cost and expense. If Company fails to remove the facilities and restore the public way within the 60-day period, City may, at its option and in its sole discretion, remove the facilities from the public way and require Company to pay for the full cost of removal and restoration of the public way. If Company removes the facilities from the public way but fails to restore the public way to its prior condition, City may complete the repairs and bill Company for the full cost thereof.

Section 15. Acceptance by Company.

This Ordinance shall take effect thirty days after its adoption by the Council and approval by the Mayor, provided that prior to the expiration of those thirty days, Company files with City's Finance Officer its written acceptance of this Ordinance and the obligations it imposes. If no such acceptance is filed, this Ordinance shall become null and void.

Section 16. Repeal of Ordinance 18489.

From and after the effective date of this Ordinance, Ordinance 18489 of the City of Eugene, passed by the Council on August 27, 1979, and approved by the Mayor September 3, 1979, shall be, and the same is hereby repealed.

Passed by the City Council this

11th day of October, 1999

City Recorder

Approved by the Mayor this

1/4 day of October, 1999

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ORDINANCE NO
AN ORDINANCE EXTENDING THE TERM OF ORDINANCE NO. 20170 GRANTING TO NORTHWEST NATURAL GAS COMPANY, A CORPORATION, A NON-EXCLUSIVE NATURAL GAS FRANCHISE, TO MAY 11, 2021.
The City Council of the City of Eugene finds that:
A. On October 11, 1999, the City Council adopted Ordinance No. 20170 granting to Northwest Natural Gas Company ("NWNG") a twenty-year non-exclusive right and franchise to lay, maintain and operate facilities in and under the public ways within the City of Eugene, Oregon. The Franchise was set to expire on November 11, 2019.
B. On July 22, 2019, the City Council adopted Ordinance No. 20620 granting to NWNG a franchise extension up to and through May 11, 2020. On April 8, 2020, the City Council adopted Ordinance 20627 granting to NWNG another franchise extension up to and through November 11, 2020.
C. The City of Eugene and NWNG have been negotiating in good faith since Fall 2019 regarding franchise renewal and potential franchise terms. Despite the parties' diligence, due to the number of potential franchise terms and relevant issues, many of which are novel for franchise negotiations, the parties have not yet concluded their franchise negotiations. Additionally, the onset of the COVID-19 pandemic in March 2020, temporarily stalled negotiations.
D . Extending the term of the Franchise for six months would allow time for the City of Eugene and NWNG to complete franchise renewal negotiations.
E. The City of Eugene has determined that it serves the public welfare to extend the term of the current franchise up to and through May 11, 2021.
NOW, THEREFORE,
THE CITY OF EUGENE DOES ORDAIN AS FOLLOWS:
Section 1. The franchise granted to NWNG in Ordinance No. 20170 shall be extended up to and through May 11, 2021. This extension shall be effective upon NWNG's written acceptance.

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Section 2. Other than the duration of the franchise set forth in this Ordinance, all other terms and conditions of Ordinance No. 20170 shall continue in full force and effect.

Passed by the City Council this	Approved by the Mayor this		
day of September, 2020	, 2020		
City Recorder	Mayor		