

City of High Point

*Britt Moore, Chair
Jason, Ewing, Wesley Hudson
Victor Jones*



Meeting Agenda

Thursday, July 11, 2019

4:00 PM

3rd Floor Conference Room

Finance Committee

*Britt Moore, Chair
Jason, Ewing, Wesley Hudson
Victor Jones*

FINANCE COMMITTEE - Council Member Moore, Chair

[2019-295](#) Agreement - NCDOT-New Traffic Signal N. University Parkway and Davis Ave
Council is requested to approve an agreement with NCDOT in the amount of \$11,177 for cost participation in the purchase of traffic signal pole and mast arm assemblies to be installed at the intersection of N. University Parkway and Davis Avenue.

Attachments: [1. MA for Traffic Signal University Davis 071519](#)

[2019-296](#) Contract - Matthews Specialty Vehicles - High Point Library Bookmobile
Council is requested to award a contract to Matthews Specialty Vehicles in the amount of \$136,100 for the purchase of a new bookmobile using the Houston-Galveston Area Council (HGAC) national contract AM10-18. In addition, the High Point Library received a \$50,000 grant from the State for this purchase.

Attachments: [2. Library Bookmobile \(7-15-19\)](#)

[2019-297](#) Contract - Carolina Industrial Equipment - Truck Mounted Vacuum
Council is requested to award a contract to Carolina Industrial Equipment in the amount of \$204,960 for the purchase of a Freightliner truck with ODB- Model DCL800SM-25 Vacuum Leaf & Debris Collector for use by the Stormwater Division of Public Services. Recommendation also includes declaring old equipment as surplus and disposing through the online auction process.

Attachments: [3. Leaf Vacuum Truck](#)

[2019-298](#) Contract - Advantage Truck Center - Side Loading Refuse Trucks
Council is requested to award a contract to Advantage Truck Center in the amount of \$923,227.29 for the purchase of three (3) Autocar Trucks with New Way Side Loading Refuse bodies for use by the Environmental Services Division and declare the old trucks as surplus and disposing through the online auction process.

Attachments: [4. Side Loading Refuse Trucks](#)

[2019-299](#) Contract - Buckeye Bridge LLC - Tanglebrook Sanitary Sewer Outfall
Council is requested to award a contract to Buckeye Bridge, LLC in the amount of \$963,589.10 for a 12-inch diameter sanitary sewer outfall extension as part of the northwest expansion plan in the Tanglebrook Road and Joyce Circle vicinity.

Attachments: [5. Tanglebrook Sanitary Sewer Outfall](#)

[2019-300](#) Contract - A&D Environmental Services Inc-Eastside Wastewater Treatment Plant Primary Clarifiers
Council requested to approve an emergency purchase order in the amount of \$186,476.99 to utilize A&D Environmental Services Inc. to remove a

significant amount of grit & grease from the primary clarifiers due to a June 7-8, 2019 rain event at the Eastside WWTP, causing grit and grease to clog the primary sludge pumps and four (4) primary clarifiers.

Attachments: [6. Eastside WWTP A&D Environmental Services Primary Clarifiers](#)

[2019-301](#)

Contract - MidAtlantic Salt, LLC - Bulk Road Salt

Council is requested to award a contract to Mid-Atlantic Salt, LLC in the amount of \$73,450.00 annually for the purchase of Bulk Road Salt for a three (3) year period with option to renew for two (2) additional one-year periods beginning July 1, 2019 thru June 30, 2022. Total contract award for three years is \$220,350.00.

Attachments: [8. Mid-Atlantic Salt, LLC Salt Supplier](#)

[2019-302](#)

Contract - Chandler Concrete Co.- Childers Concrete Co.

City Council is requested to award a contract to Chandler Concrete Company (Primary Supplier) for the purchase of various concrete materials in the annual amount of \$116,300.00 for a total contract award of \$348,900.00. The contract is for a three-year period with the option to renew for two additional one-year periods beginning July 1, 2019 thru May 31, 2022. City Council is also requested to award a contract to Childers Concrete Company (Secondary Supplier) in the event that the Primary Supplier cannot provide the needed concrete materials.

Attachments: [9. Concrete Supplier City Wide \(Primary & Secondary\)](#)

[2019-303](#)

Contract - Motorola Solutions Inc. - Radios

Council is requested to award a contract to Motorola Solutions Inc. in the amount of \$457,014.90 for the purchase of Motorola portable and mobile radios to replace older radios as part of the annual replacement program. The new radios will be used in the Public Works and Electric departments.

Attachments: [10. Motorola Radio Purchase](#)

[2019-304](#)

Contract - Motorola 5 Year Service Agreement - Radio System

Council is requested to approve a five (5) year service agreement with Motorola Inc. in the amount of \$1,724,790. to provide annual updates and support for the 800 MhZ Radio System, payable over five (5) years.

Attachments: [11. Motorola 5 Year Service Agreement](#)

[2019-305](#)

Resolution - Introducing Bond Orders Authorizing Street & Sidewalk Bonds, Parks & Recreation Bonds, Housing Bonds and a Public Hearing on the Bond Orders

Council is requested to approve a resolution making certain findings related to the authorization and issuance of bonds of the City and filing of an application for said bonds with the Local Government Commission and establish a public hearing date of Monday, August 19 @ 5:30pm to receive public comments on the calling of the voter referendum on the bonds.

Attachments: [12. Bond Orders and Hearing](#)

PENDING ITEMS[2018-169](#)

Amendment to License Agreement - Cingular Wireless PSC, LLC (AT&T)
City Council is requested to approve an Amendment to the License Agreement with Cingular Wireless PCS, LLC (AT&T) which allows the location of communication equipment at the City's Ward Water Plant; and authorize the City Manager to execute the agreement.

Attachments: [7. Amendment to Lease Agreement - Crown Castle](#)

ADJOURNMENT

CITY OF HIGH POINT

AGENDA ITEM



**Title: Agenda Item – Eastside WWTP Primary Clarifiers
A&D Environmental Services Inc.**

From: Terry Houk – Public Services Director
Derrick Boone – Asst. Director Public Services
Dawn Molnar- Wastewater Superintendent

Meeting Date: July 15, 2019

Public Hearing: No

Advertising Date: N/A

Advertised By: N/A

PURPOSE:

To utilize A&D Environmental Services Inc. to remove a significant amount of grit and grease from the primary clarifiers at the Eastside Wastewater Treatment Plant.

BACKGROUND:

The Eastside WWTP and surrounding area received 8 inches of rain the night of June 7, 2019 through early morning June 8, 2019. In a 2-hour time (approximately 9:15 pm – 11:30 pm, June 7) approximately 6 inches of rain was received at the plant. As a result of the rain event, a large amount of grit and grease washed through the sewer collection system and into the Eastside WWTP. The large amount of the grit and grease clogged the primary sludge pumps and the primary clarifiers. The Public Services contracted with A&D Environmental in a emergency situation to clean out the significant accumulation of solids from the four (4) primary clarifiers in order to maintain the wastewater treatment process and prevent the primaries from turning septic.

BUDGET IMPACT:

Funding is available in the FY 2018/2019 and FY 2019/2020 Budgets.

RECOMMENDATION / ACTION REQUESTED:

The Public Services Department is recommending that Council approve the emergency purchase order to A&D Environmental Services Inc. in the amount of \$186,476.99.



Primary Clarifier #1- Grit/solids accumulated above the bottom of the rake arm.



A&D Environmental cleaning out one of the four clarifiers.



Picture of a primary clarifier after being cleaned out.



INVOICE

PLEASE REMIT TO

A&D ENVIRONMENTAL SERVICES INC
PO Box 484
High Point, NC 27261
Phone: (336) 434-7750
www.adenviro.com

INVOICE NUMBER SVC012836

INVOICE DATE 6/26/2019

PO NUMBER 99295

TOTAL DUE \$186,476.99

DUE DATE 7/26/2019

BILL TO

High Point, City of
Attn: Accounts Payable
PO Box 230
High Point, NC 27261
Phone: (336) 822-4773

LOCATION

East Water Treatment Plant
5878 Riverdale Rd
Jamestown, NC 27282

Service Call 1906-0260 CLEAN CLARIFIER NH DISPOSAL

Salesperson	Customer Number	Order Date	Completion Date	Payment Terms	Shipping Method
Darren Lee Meeks	1047	6/14/2019	6/26/2019	N30	

Detail of Charges

Date	Description	Waste Profile	Unit	Quantity	Unit Price	Line Total
6/14/2019	On Site Services			10.00	\$595.00	\$5,950.00
6/15/2019	On Site Services	Task		6.50	\$595.00	\$3,867.50
6/17/2019	On Site Services	Task1		11.00	\$595.00	\$6,545.00
	Task Comment: Crew # 1					
6/17/2019	On Site Services	Task2		10.00	\$595.00	\$5,950.00
	Task Comment: Crew # 2					
6/18/2019	On Site Services	Task3		12.50	\$595.00	\$7,437.50
6/19/2019	On Site Services	Task4		9.00	\$595.00	\$5,355.00
	Task Comment: Crew # 1					
6/19/2019	On Site Services	Task5		9.00	\$595.00	\$5,355.00
	Task Comment: Crew # 2					
6/20/2019	On Site Services	Task6		11.50	\$595.00	\$6,842.50
6/21/2019	On Site Services	Task7		10.75	\$595.00	\$6,396.24
	Task Comment: Crew # 1					
6/21/2019	On Site Services	Task8		10.75	\$595.00	\$6,396.24
	Task Comment: Crew # 2					
6/22/2019	On Site Services	Task9		6.25	\$595.00	\$3,718.74

Past due amounts are subject to finance charges of 1.5% per month, plus all costs of collections.
Mastercard and Visa accepted, subject to an additional charge of 3%

Remit Payments to:
P.O. Box 484
High Point, NC 27261

Electronic Payments made to:
CIBC
120 S. LaSalle St., Chicago, IL 60602
(312) 564-2000
Routing # 071006486 Acct # 2248890

6/24/2019	On Site Services	Task10	10.50	\$595.00	\$6,247.50
Task Comment: Crew # 1					
6/24/2019	On Site Services	Task11	10.50	\$595.00	\$6,247.50
Task Comment: Crew # 2					
6/25/2019	On Site Services	Task12	11.25	\$595.00	\$6,693.74
6/26/2019	Non Haz; Non DOT; Bulk Container	NC20190252	927.13	\$95.00	\$88,077.35
Task Comment: 62 Loads From 06/14/19 To 06/25/19 - See Manifest Detail Sheet Enclosed / Tons					
Subtotal					\$171,079.81
ESI					\$15,397.18
Total Tax					\$0.00
Amount Paid					\$0.00
Total					\$186,476.99

**Past due amounts are subject to finance charges of 1.5% per month, plus all costs of collections.
Mastercard and Visa accepted, subject to an additional charge of 3%**

Remit Payments to:
P.O. Box 484
High Point, NC 27261

Electronic Payments made to:
CIBC
120 S. LaSalle St., Chicago, IL 60602
(312) 564-2000
Routing # 071006486 Acct # 2248890

Call # 1906-0260
City Of High Point
East Water Treatment Plant
Manifest Detail List

Date	Manifest #	Tons
6/14/2019	30596	15.66
	30600	16.29
6/15/2019	30083	15.76
	30597	15.99
	30599	16.88
6/17/2019	20649	15.69
	20650	14.40
	20651	17.08
	20652	15.08
	30598	15.05
6/18/2019	20642	15.97
	20643	15.96
	20644	15.09
	20645	15.02
	20648	11.91
6/19/2019	20634	4.09
	20635	11.55
	20636	14.45
	20637	14.05
	20638	14.45
	20639	15.50
	20640	13.64
	20641	15.69
6/20/2019	20679	15.53
	20680	14.07
	20681	14.26
	20682	14.78
	20683	14.89
	20684	13.16
	20685	14.21
	20686	15.72

Call # 1906-0260
City Of High Point
East Water Treatment Plant
Manifest Detail List

Date	Manifest #	Tons
6/21/2019	20687	15.24
	20688	13.58
	20689	16.48
	20690	11.63
	20691	17.17
	20692	15.75
	20693	15.79
	20694	13.45
	20695	16.92
	20696	11.87
	20697	15.21
6/22/2019	20698	15.04
	20700	14.33
	20701	13.40
6/24/2019	20702	16.96
	20703	8.27
	20704	14.36
	20705	17.06
	20706	15.99
	20707	17.54
	20708	15.72
	20709	17.55
6/25/2019	20451	10.05
	20710	16.88
	20711	18.26
	20712	15.40
	20713	18.59
	20714	17.92
	20715	16.29
	20716	15.74
	20717	16.82
Total	Tons	927.13

CITY OF HIGH POINT

AGENDA ITEM



Title: Request to consider reinstatement of Board Member

From: Lee Burnette, Planning & Development
Director

Meeting Date: February 4, 2019

**Public
Hearing:** No

**Advertising
Date:** N/A

Advertised By: N/A

Attachments: Memorandum

PURPOSE:

To consider the reinstatement of a P&Z member that lost status as a voting member due to unexcused absences in accordance with attendance requirements of the City's Development Ordinance.

BACKGROUND:

Memorandum explaining the request is attached.

BUDGET IMPACT:

There is no budget impact.

RECOMMENDATION / ACTION REQUESTED:

Staff requests that City Council consider the reinstatement of this board member.

January 22, 2019

To: Honorable Mayor and City Council
From: G. Lee Burnette, AICP, Director
Subject: **Board Attendance**

Each year attendance on the Planning and Zoning Commission (P&Z), Board of Adjustment (BOA) and Historic Preservation Commission (HPC) is reviewed by staff to determine compliance with the attendance requirements of Development Ordinance. The Development Ordinance's attendance requirements do not allow regular board members to miss 33% or more of the regular meetings in a calendar year or miss 3 consecutive regular meetings. When this occurs, the member loses status as a voting member of the board until reinstated by the City Council or until another appointment is made. In 2018, one member of these boards had unexcused absences that totaled 33% or more of the regular meetings.

From the P&Z, Andy Putnam missed 6 of the 11 regular meetings in 2018. Mr. Putnam, who works First Citizens, was promoted to a position within the company with regional responsibilities. Beginning in July last year, he was required to travel and train, which resulted in him missing those P&Z regular meetings. Mr. Putnam states that he now has more flexibility in his work schedule and can attend the P&Z regular meetings. I discussed these absences with Mr. Putnam and he expressed a strong interest in continuing to serve on the P&Z.

These absences were not excused under the terms of the attendance requirements because these absences were due to work-related conflicts. This requires the City Council to review this matter and determine whether to reinstate Mr. Putnam's full membership status or make another appointment and replace Mr. Putnam. Listed below is Mr. Putnam's attendance record from 2016 through 2018. I ask that City Council consider the reinstatement of Mr. Putnam to the P&Z.

Member	Board	Area	2016	2017	2018
Andy Putnam	P&Z	AL or 6	9 of 12	10 of 12	5 of 11

CITY OF HIGH POINT

AGENDA ITEM



Title: Concrete Supplier City Wide (Primary & Secondary)

From: Terry Houk – Public Services Director

Robby Stone – Asst. Director Public Services

Meeting Date: July 15, 2019

Public Hearing: N/A

Advertising Date: March 9, 2016

Advertised By: Purchasing

Attachments: Bid Recommendation Form
Bid Tab

PURPOSE: The City budgets on an annual basis for suppliers to provide materials to city crews. City crews that are in need of concrete, will have the availability to have this material supplied to them when performing maintenance functions that require different types of concrete.

BACKGROUND: The city retains material suppliers for different types of concrete to be used by crews for sidewalk, curb and gutter repairs. At the May 24th, 2019 bid opening of the two bids received, Chandler Concrete Company was the low bidder. Their prices are competitive with historical pricing for this type of supplied material.

BUDGET IMPACT: Funds are available in the FY19-20 budget.

RECOMMENDATION / ACTION REQUESTED: City Council is requested to award a contract to Chandler Concrete Company (Primary Supplier) for the purchase of various concrete materials in the annual amount of \$116,300.00 for a total contract award of \$348,900.00. The contract is for a three-year period with the option to renew for two additional one-year periods beginning July 1, 2019 thru May 31, 2022. City Council is also requested to award a contract to Childers Concrete Company (Secondary Supplier) in the event that the Primary Supplier cannot provide the needed concrete materials.

BID TABULATION
Bid # 58-060619
Concrete Citywide (Primary & Secondary Contract)

				Childers Concrete Company		Chandler Concrete Co. Inc.	
	Material	Qty	UM	Each	Extension	Each	Extension
A	Class A W/28 Day 3000 PSI	700	CY	\$130.00	\$ 91,000.00	\$ 122.00	\$ 85,400.00
B	Class A High - Early	100	CY	\$135.00	\$ 13,500.00	\$ 132.00	\$ 13,200.00
C	Class B W/28 Day 2500 PSI	25	CY	\$130.00	\$ 3,250.00	\$ 120.00	\$ 3,000.00
D	Class B High - Early	25	CY	\$135.00	\$ 3,375.00	\$ 130.00	\$ 3,250.00
E	Flowable Backfill Mix	25	CY	\$120.00	\$ 3,000.00	\$ 110.00	\$ 2,750.00
F	Class AA W/28 Day 4500 PSI	25	CY	\$145.00	\$ 3,625.00	\$ 129.00	\$ 3,225.00
G	Class AA High Early	25	CY	\$150.00	\$ 3,750.00	\$ 139.00	\$ 3,475.00
H	Add for Retarding Agent (Full Dos	25	CY	\$ 4.00	\$ 100.00	\$ 2.50	\$ 62.50
I	Add for Accelerating Agent 1%	25	CY	\$ 4.00	\$ 100.00	\$ 7.00	\$ 175.00
J	Add for Accelerating Agent 2%	25	CY	\$ 8.00	\$ 200.00	\$ 14.00	\$ 350.00
K	Small Load Delivery Charge	25	EA	\$100.00	\$ 2,500.00	\$ 50.00	\$ 1,250.00
L	Fiber	25	CY	\$ 6.00	\$ 150.00	\$ 6.50	\$ 162.50
					\$125,461.00		\$116,300.00



**FORMAL BID RECOMMENDATION
REQUEST FOR COUNCIL APPROVAL**

DEPARTMENT: **Public Services**

COUNCIL AGENDA DATE: **Jul 15, 2019**

BID NO.: **58-060619** CONTRACT NO.: DATE OPENED: **May 24, 2019**

DESCRIPTION:

The city retains material suppliers for different types of concrete to be used by crews for sidewalk, curb and gutter repairs. At the May 24th, 2019 bid opening of the two bids received, Chandler Concrete Company was the low bidder. Their prices are competitive with historical pricing for this type of supplied material.

PURPOSE:

The City budgets on an annual basis for suppliers to provide materials to city crews. City crews that are in need of concrete, will have the availability to have this material supplied to them when performing maintenance functions that require different types of concrete.

COMMENTS:

Chandler Concrete Company was the second low bidder and will be awarded the secondary supplier if the primary supplier is unavailable to provide the needed concrete materials.

RECOMMEND AWARD TO: **Chandler Concrete Company** AMOUNT: **348,900.00**

JUSTIFICATION:

Chandler Concrete Company was the low bidder.

ACCOUNTING UNIT	ACCOUNT	ACTIVITY	CATEGORY	BUDGETED AMOUNT
Various				348,900.00
TOTAL BUDGETED AMOUNT				348,900.00

DEPARTMENT HEAD: **Terry Houk** Digitally signed by Terry Houk
DN: cn=Terry Houk, o=City of High Point, ou=Public Services, email=terry.houk@highpointnc.gov, c=US
Date: 2019.07.08 09:11:36 -0400 DATE: **Jul 8, 2019**

The Purchasing Division concurs with recommendation submitted by the **Public Services** and recommends award to the lowest responsible, responsive bidder **Chandler Concrete Co.** in the amount of \$ **348,900.00**.

PURCHASING MANAGER: **Erik Conti** Digitally signed by Erik Conti
Date: 2019.07.09 15:42:50 -0400 DATE: **Jul 9, 2019**

Approved for Submission to Council
FINANCIAL SERVICES DIRECTOR: **Bobby Fitzjohn** Digitally signed by Bobby Fitzjohn
Date: 2019.07.10 10:17:07 -0400 DATE: **Jul 10, 2019**

CITY MANAGER: **Greg Demko** Digitally signed by Greg Demko
DN: cn=Greg Demko, o=High Point, ou=High Point, email=greg.demko@highpointnc.gov, c=US
Date: 2019.07.10 10:39:28 -0400 DATE: **Jul 10, 2019**

CITY OF HIGH POINT

AGENDA ITEM



Title: Tanglebrook Sanitary Sewer Outfall

From: Terry Houk – Public Services Director
Derrick Boone – Public Services Asst. Director

Meeting Date: July 15, 2019

Public Hearing: N/A

Advertising Date: April 26, 2019 / May 19, 2019
Advertised By: Purchasing

Attachments: Attachment A – Award Recommendation & Certified Bid Tab
Attachment B – Project Map

PURPOSE:

The Public Services Department has budgeted for a 12-inch diameter sanitary sewer outfall extension as part of the northwest expansion plan in the Tanglebrook Road and Joyce Circle vicinity. The outfall extension will total approximately 4,000 linear feet of gravity sanitary sewer line.

BACKGROUND:

This project is part of an overall expansion of sanitary sewer availability in the City's northwestern jurisdiction. The new 4,000 linear feet of 12-inch diameter gravity sewer outfall will service current residential properties and provide service for future residential and/or commercial properties that come to the area.

BUDGET IMPACT:

Funds for this project are available in the FY 2019-2020 budget.

RECOMMENDATION / ACTION REQUESTED:

The Public Services Department recommends awarding the contract to Buckeye Bridge, LLC in the amount of \$963,589.10.

June 21, 2019

Re: City of High Point, NC
Tanglebrook Outfall
Sewer System Improvements
Bid No. 64-061919
DMP Project No. 180103 (BF)

Mr. Derrick Boone, Assistant Director
Public Services Department
City of High Point
PO Box 230
High Point, NC 27261

Dear Derrick:

Bids were received by the Purchasing Department on June 19, 2019 for the above referenced project. A total of three (3) bids were submitted and read, as summarized below.

Bidder	Total Bid
Buckeye Bridge, LLC Canton, NC	\$ 963,589.10
Yates Construction Company, Inc. Stokesdale, NC	\$ 1,092,328.00
BridgePoint Civil, LLC Goldsboro, NC	\$ 1,287,812.00

A detailed tabulation of all bids received is attached.

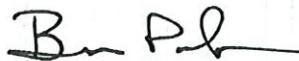
The low bid submitted by Buckeye Bridge, LLC is higher than the original estimated construction cost. This increased cost is most likely attributed to Contractor's workload(s), resource availability and increasing material costs.

The lowest bidder, Buckeye Bridge, LLC, is a properly licensed general contractor, has successfully performed similar projects in the past and is capable of performing the work called for in this project. We would therefore recommend the City Council award a contract to Buckeye Bridge, LLC in the amount of \$ 963,589.10.

If you have any questions or need additional information, please feel free to call.

Sincerely,

DAVIS • MARTIN • POWELL & ASSOCIATES



Ben Palmer, PE

c: File (enc)

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FORMAL BID RECOMMENDATION
REQUEST FOR COUNCIL APPROVAL

DEPARTMENT: Public Services

COUNCIL AGENDA DATE: July 15, 2019

BID NO.: 64-061919 CONTRACT NO.: DATE OPENED: Jun 19, 2019

DESCRIPTION:

Tanglebrook Sewer Outfall Project

PURPOSE:

The Public Services Department has budgeted for a 12 inch diameter sanitary sewer outfall extension as part of the northwest expansion plan in the Tanglebrook Road and Joyce Circle vicinity. The outfall extension will total approximately 4,000 linear feet of gravity sanitary sewer line.

COMMENTS:

This project is part of an overall expansion of sanitary sewer availability in the City's northwestern jurisdiction. The new 4,000 linear feet of 12 inch diameter gravity sewer outfall will service current residential properties and provide service for future residential and commercial properties in the area.

RECOMMEND AWARD TO: Buckeye Bridge, LLC AMOUNT: \$963,589.10

JUSTIFICATION:

Buckeye Bridge, LLC was the low bidder of the three (3) qualified bids that were submitted at bid opening on 6/19/19.

ACCOUNTING UNIT	ACCOUNT	ACTIVITY	CATEGORY	BUDGETED AMOUNT
421779	533701	421181030005	40202	\$963,589.10
TOTAL BUDGETED AMOUNT				\$963,589.10

DEPARTMENT HEAD: Terry Houk Digitally signed by Terry Houk
DN: cn=Terry Houk, o=City of High Point, ou=Public Services, email=terry.houk@highpointnc.gov, c=US
Date: 2019.07.03 11:22:46 -0400 DATE: Jul 3, 2019

The Purchasing Division concurs with recommendation submitted by the Public Services Dept. and recommends award to the lowest responsible, responsive bidder Buckeye Bridge, LLC in the amount of \$ 963,589.10.

PURCHASING MANAGER: Erik Conti Digitally signed by Erik Conti
Date: 2019.07.03 13:58:51 -0400 DATE: Jul 3, 2019

Approved for Submission to Council
FINANCIAL SERVICES DIRECTOR: Bobby Fitzjohn Digitally signed by Bobby Fitzjohn
Date: 2019.07.10 10:16:17 -0400 DATE: Jul 10, 2019

CITY MANAGER: Greg Demko Digitally signed by Greg Demko
DN: cn=Greg Demko, o=High Point, ou=High Point, email=greg.demko@highpointnc.gov, c=US
Date: 2019.07.10 10:19:48 -0400 DATE: Jul 10, 2019

BID TABULATION

DAVIS • MARTIN • POWELL
ENGINEERS & SURVEYORS
1: 336-866-4421 | F: 336-866-4458 | License: F-0245
6415 Old Frank Road, High Point, NC 27255 | www.dmp-inc.com



Buckeye Bridge, LLC 654 Buckeye Cove Road Canton, NC	Yates Construction Co., Inc 9220 NC 65 Stokesdale, NC	BridgePoint Civil, LLC 3733 N US Hwy 117 Goldsboro, NC
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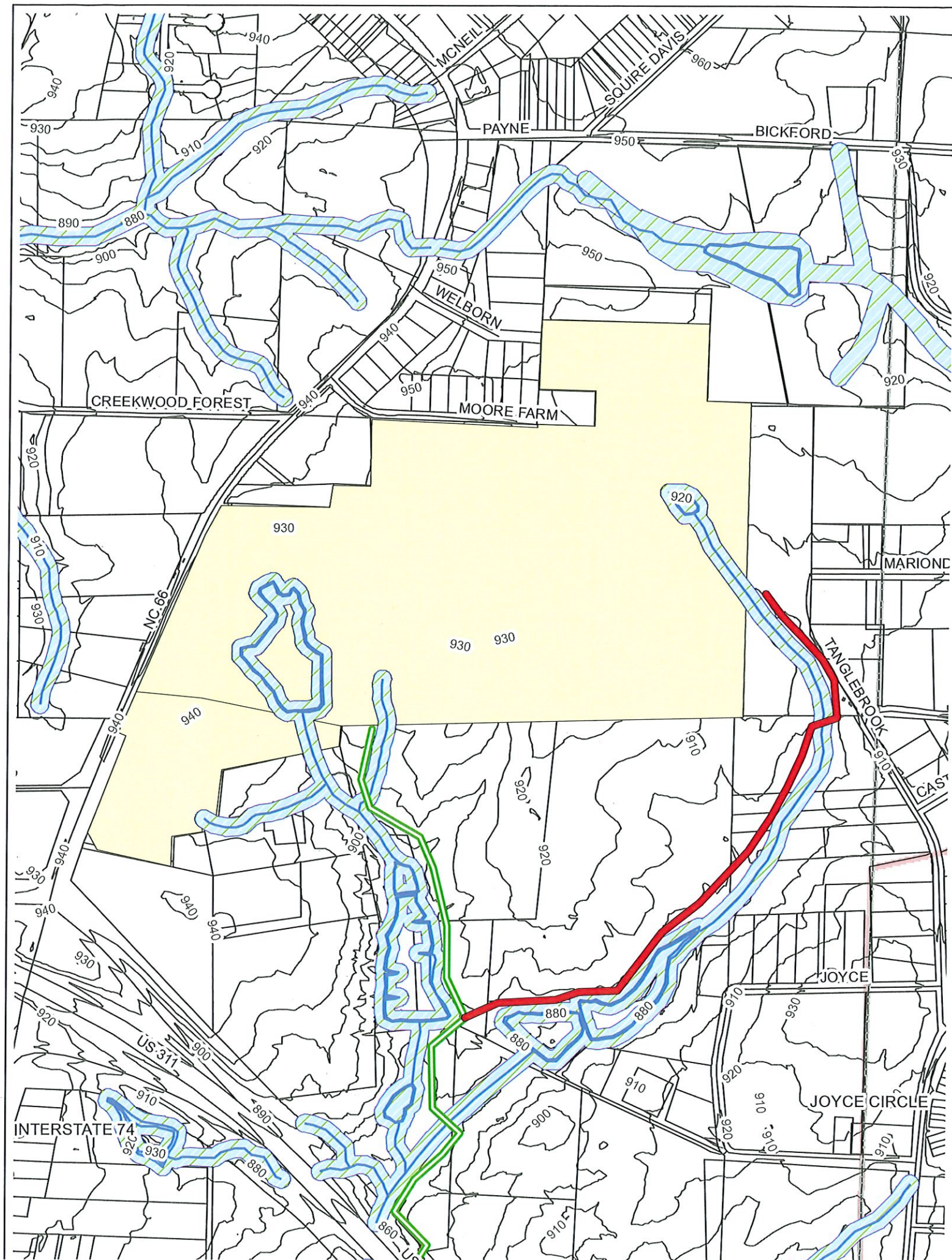
BID	ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT
1		Mobilization (Max. 3% of Bid)	1	LS	\$28,905.00	\$28,905.00	\$32,683.00	\$32,683.00	\$38,600.00	\$38,600.00
2		Clearing and Grubbing	3.1	AC	\$16,213.00	\$50,260.30	\$25,000.00	\$77,500.00	\$16,000.00	\$49,600.00
3		8" DIP Sewer (8-10' cut)	5	LF	\$121.40	\$607.00	\$84.00	\$420.00	\$269.00	\$1,345.00
4		12" DIP Sewer (0-6' cut)	245	LF	\$119.60	\$29,302.00	\$94.00	\$23,030.00	\$156.00	\$38,220.00
5		12" DIP Sewer (6-8' cut)	1,157	LF	\$123.30	\$142,658.10	\$115.00	\$133,055.00	\$162.00	\$187,434.00
6		12" DIP Sewer (8-10' cut)	1,500	LF	\$130.20	\$195,300.00	\$130.00	\$195,000.00	\$173.00	\$259,500.00
7		12" DIP Sewer (10-12' cut)	177	LF	\$139.70	\$24,726.90	\$140.00	\$24,780.00	\$192.00	\$33,984.00
8		12" DIP Sewer (12-14' cut)	171	LF	\$153.70	\$26,282.70	\$160.00	\$27,360.00	\$209.00	\$35,739.00
9		12" DIP Sewer (14-16' cut)	209	LF	\$178.90	\$37,390.10	\$175.00	\$36,575.00	\$235.00	\$49,115.00
10		12" DIP Sewer (16-18' cut)	235	LF	\$197.30	\$46,365.50	\$200.00	\$47,000.00	\$307.00	\$72,145.00
11		12" DIP Sewer (18-20' cut)	60	LF	\$237.50	\$14,250.00	\$250.00	\$15,000.00	\$366.00	\$21,960.00
12		12" DIP Sewer Inside Encasement	80	LF	\$117.10	\$9,368.00	\$75.00	\$6,000.00	\$142.00	\$11,360.00
13		4" Dia Sewer MH (0-6' depth)	1	Ea	\$3,028.00	\$3,028.00	\$2,700.00	\$2,700.00	\$3,950.00	\$3,950.00
14		4" Dia Sewer MH (8-10' depth)	10	Ea	\$3,654.00	\$36,540.00	\$3,500.00	\$35,000.00	\$5,600.00	\$56,000.00
15		4" Dia Sewer MH (10-12' depth)	6	Ea	\$3,899.00	\$23,394.00	\$3,900.00	\$23,400.00	\$6,400.00	\$38,400.00
16		4" Dia Sewer MH (12-14' depth)	1	Ea	\$4,077.00	\$4,077.00	\$4,500.00	\$4,500.00	\$7,300.00	\$7,300.00
17		4" Dia Sewer MH (16-18' depth) w/Outside Drop	1	Ea	\$10,974.00	\$10,974.00	\$7,500.00	\$7,500.00	\$14,400.00	\$14,400.00
18		4" Dia Sewer MH (18-20' depth)	1	Ea	\$6,728.00	\$6,728.00	\$7,500.00	\$7,500.00	\$9,800.00	\$9,800.00
19		Manhole Vent stack	10	VF	\$354.00	\$3,540.00	\$200.00	\$2,000.00	\$375.00	\$3,750.00
20		24" Steel Encasement Pipe installed by bore & jack - In Soil	40	LF	\$447.00	\$17,880.00	\$1,100.00	\$44,000.00	\$660.00	\$26,400.00
21		24" Steel Encasement Pipe installed by bore & jack - Not In Soil	40	LF	\$1,477.00	\$59,080.00	\$1,600.00	\$64,000.00	\$1,250.00	\$50,000.00
22		Trench Rock Removal	825	Cy	\$70.00	\$57,750.00	\$70.00	\$57,750.00	\$70.00	\$57,750.00
23		Trench Stabilization Stone	1,000	Ton	\$41.70	\$41,700.00	\$42.00	\$42,000.00	\$32.00	\$32,000.00
24		Select Backfill Borrow Material	300	CY	\$49.30	\$14,790.00	\$80.00	\$24,000.00	\$28.00	\$8,400.00
25		Driveway Stone	200	Ton	\$35.60	\$7,120.00	\$42.00	\$8,400.00	\$50.00	\$10,000.00
26		Temporary Silt Fence	4,050	LF	\$3.00	\$12,150.00	\$5.00	\$20,250.00	\$6.00	\$24,300.00
27		Temporary Earth Berm (includes matting)	1,340	LF	\$6.10	\$8,174.00	\$25.00	\$33,500.00	\$8.00	\$10,720.00
28		Temporary Construction Entrance	3	Ea	\$1,035.00	\$3,105.00	\$5,000.00	\$15,000.00	\$3,850.00	\$11,550.00
29		Temporary Stone Outlets @ Silt Fence	33	Ea	\$114.00	\$3,762.00	\$375.00	\$12,375.00	\$350.00	\$11,550.00
30		Erosion Control Matting	200	SY	\$4.00	\$800.00	\$5.00	\$1,000.00	\$6.00	\$1,200.00
31		Temporary Clean Water Diversion Crossings	5	Ea	\$3,209.00	\$16,045.00	\$7,000.00	\$35,000.00	\$16,250.00	\$81,250.00
32		ROW Easement Restoration including seeding & mulching	3.1	Ac	\$4,425.00	\$13,717.50	\$3,500.00	\$10,850.00	\$3,500.00	\$10,850.00
33		Video Inspection	1	LS	\$11,035.00	\$11,035.00	\$20,000.00	\$20,000.00	\$17,000.00	\$17,000.00
34		Easement Marker	32	Ea	\$87.00	\$2,784.00	\$100.00	\$3,200.00	\$70.00	\$2,240.00
		TOTAL BID AMOUNT				\$963,589.10		\$1,092,328.00		\$1,287,812.00



THIS IS TO CERTIFY THAT THIS TABULATION IS CORRECT AND A TRUE AND ACCURATE COPY OF THE BIDS SUBMITTED. THIS THE 19th DAY OF JUNE, 2019.

DAVIS • MARTIN • POWELL & ASSOCIATES

By: *Ben Palmer*
Ben Palmer, PE



CITY OF HIGH POINT

AGENDA ITEM



Title: Text Amendment 18-06
(City of High Point)

From: Lee Burnette, Planning & Development
Director

Meeting Date: February 4, 2019

Public Hearing: Yes

Advertising Date: January 24, 2019, and
January 30, 2019

Advertised By: Planning & Development

Attachments: A. Planning and Zoning Commission Recommendation
B. Staff Report
C. Text Amendment Ordinance

PURPOSE:

A request by the City Attorney to amend various sections of the Development Ordinance, pertaining to sign regulations, to maintain compliance with state and federal laws. This request proposes to amend Section 3.8.7.E Gateway Corridor Overlay, Section 5.7.7 Exempt Signs, Section 5.7.8 Signs Not Requiring a Sign Permit, Section 5.7.9 Freestanding Signs Requiring a Sign Permit, Section 5.7.11 Outdoor Advertising Sign Requiring a Sign Permit, to add Section 5.7.14 Savings Clause and to amend various sign related definition in Section 10.4.

BACKGROUND:

The staff report and the Planning & Zoning Commission's recommendation are enclosed.

BUDGET IMPACT:

There is no budget impact.

RECOMMENDATION / ACTION REQUESTED:

- A. Staff recommended **approval** of this request, as outlined in the attached staff report.
- B. On January 22, 2019, a public hearing was held before the Planning and Zoning Commission regarding Text Amendment 18-06. The Planning & Zoning Commission recommended **approval** of this request, as outlined in the staff report and recommended by staff, by a vote of 6-0.

PLANNING AND ZONING COMMISSION RECOMMENDATION

City of High Point

Text Amendment 18-06

At its January 22, 2019 public hearing, the Planning and Zoning Commission reviewed a request to amend various sections of the Development Ordinance, pertaining to sign regulations, to maintain compliance with state and federal laws. All members of the Commission were present except for Mr. Ozzie Hough and Ms. Angela McGill. Mr. Robert Robbins, Development Services Administrator, presented the text amendment and recommended approval as outlined in the staff report

Speaking on the request:

Speaking in favor of the request was Mr. Chad Essick, attorney with Poyner-Spruill LLC, 301 Fayetteville Street, Suite 1900, Raleigh, NC. He is assisting the City Attorney in this matter and provided an overview of the legal aspects of this amendment and how it is intended to address recent US Supreme Court and Circuit Court rulings pertaining to sign regulations and the freedom of speech.

Also speaking was Mr. Bobby Soule, VP/GM at Lamar Outdoor Advertising, 433 Coopers Hawk Drive, Asheville, NC. He asked various questions pertaining to whether the proposed text amendment would allow the placement of billboards in the City of High Point. Mr. Lee Burnette, Planning Director, addressed these questions, noting that the amendment would remove the differences between on-site and off-site signage.

Planning & Zoning Commission Action

Consistency & Reasonableness Statements

The Commission stated that the recommended changes are deemed necessary to correct potential deficiencies in City sign regulations and they do not conflict with adopted policies. Furthermore, the Commission stated that the request is reasonable as the City must ensure that adopted sign regulations are compliant with applicable State & federal laws.

The Planning & Zoning Commission adopted these statements by a vote of 6-0.

Text Amendment

The Commission recommended **approval** of Text Amendment 18-06, as recommended by staff, by a vote of 6-0.

**CITY OF HIGH POINT
PLANNING AND DEVELOPMENT DEPARTMENT**

**STAFF REPORT
TEXT AMENDMENT 18-06
January 22, 2019**

Request	
Applicant: City of High Point City Attorney – JoAnne Carlyle	Affected Ordinance Sections: Section 3.8.7.E. Gateway Corridor Overlay General Standards; Section 5.7.7. Exempt Signs; Section 5.7.8. Signs Not Requiring a Sign Permit; Section 5.7.9. Freestanding Signs Requiring a Sign Permit; Section 5.7.11. Outdoor Advertising Sign Requiring a Sign Permit; Section 5.7.14. Savings Clause (<i>new</i>); and Section 10.4. Definitions.
Proposal: A request by the City Attorney to amend various sections of the Development Ordinance pertaining to sign regulations to ensure compliance with applicable State and federal laws.	

Background

The City's sign regulations have not been comprehensively updated since 1992 and a project to comprehensively rewrite those regulations is currently underway. The case law governing sign regulations has changed in recent years and is constantly evolving. The City Attorney is recommending these changes to ensure compliance with current law. These changes are separate from the more comprehensive regulatory change that will be recommended by the sign regulation rewrite project. The sign regulation rewrite project will continue to move forward as planned.

Details of Proposal

The recommended changes would:

1. Remove the distinction between on-site and off-site signage in the regulations;
2. Clarify that both commercial and noncommercial speech are permitted on signs;
3. Delete Section 5.7.11. regarding outdoor advertising signs;
4. Add a Savings Clause that states the regulatory intent and clarifies that the content of the message on a sign is not a consideration in determining whether a sign is permitted under the sign regulations; and
5. Delete or modify several associated sign definitions.

Analysis

The proposed text amendment is in response to recent changes in the laws governing sign regulations. These changes are recommended by the City Attorney upon the advice of the outside legal counsel retained to assist the City in this matter. They are aimed at eliminating any distinction

between on-site and off-site signage, commercial and noncommercial speech, and different forms of noncommercial speech. Because these changes are being made to address recent changes in the law, the City Attorney recommends these interim changes be adopted immediately and any further changes and refinements can be considered during the ongoing comprehensive sign regulation rewrite project.

Consistency with Adopted Policy Guidance:

Whether and the extent to which the proposed text amendment is appropriate and is consistent with the City's adopted policy guidance.

The recommended changes are deemed necessary to correct potential deficiencies in City sign regulations and they do not conflict with adopted policies.

Reasonableness/Public Interest:

An approval of the proposed text amendment is considered reasonable and in the public interest.

The City must ensure that adopted sign regulations are compliant with applicable State & federal laws.

Recommendation

Staff recommends approval.

Required Action

Planning and Zoning Commission:

The NC General Statutes require that the Planning and Zoning Commission place in the official record a statement of consistency with the City's adopted plans when making its recommendation. This may be accomplished by adopting the statements in the Analysis section of this report or by adopting its own statement.

City Council:

The NC General Statutes require that the City Council also place in the official record a statement of consistency with the City's adopted plans and explain why the action taken is considered to be reasonable and in the public interest when rendering its decision in this case. This may be accomplished by adopting the statements in the Analysis section of this report or by adopting its own statement.

Report Preparation

This report was prepared by Planning and Development Department staff member Robert L. Robbins, AICP and reviewed by G. Lee Burnette, AICP, Director.

AN ORDINANCE AMENDING THE CITY OF HIGH POINT DEVELOPMENT ORDINANCE.

WHEREAS, the City Council of the City of High Point adopted the “City of High Point Development Ordinance” on May 16, 2016, with an effective date of January 1, 2017, and subsequently amended; and

WHEREAS, public hearings were held before the Planning and Zoning Commission on January 22, 2019 and before the City Council on February 4, 2019 regarding **Text Amendment 18-06**; and

WHEREAS, notice of the public hearings was published in the High Point Enterprise on January 9, 2019 for the Planning and Zoning Commission public hearing and on January 23, 2019 and January 30, 2019 for the City Council public hearing pursuant to Chapter 160A-364 of the General Statutes of North Carolina.

NOW THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF HIGH POINT, NORTH CAROLINA:

SECTION 1.

Section 3.8 *Overlay Zoning Districts*, subsection 3.8.7.E. regarding the Gateway Corridor Overlay (GCO), of the City of High Point Development Ordinance shall be amended as follows:

E. General Standards

1. GCO district standards for a specific gateway corridor shall follow the policy direction in the gateway corridor plan approved by the City Council. The GCO district shall, at a minimum, address the following elements:

- ~~(a)~~**1.** The name and boundaries of the overlay district.
- ~~(b)~~**2.** The development along the corridor to which the overlay district applies (typically all new development and certain expansions and remodels).
- ~~(c)~~**3.** Any variations from the requirements of the underlying general zoning district(s).
- ~~(d)~~**4.** The uses allowed in the district, if appropriate.
- ~~(e)~~**5.** The development and form standards of the overlay district, including some or all of the following:
 - ~~(1)~~**(a)** Dimensions (height, setbacks, build-to-lines, etc.);
 - ~~(2)~~**(b)** Streetscape landscaping;
 - ~~(3)~~**(c)** Sidewalks and pedestrian circulation features;
 - ~~(4)~~**(d)** Off-street parking;
 - ~~(5)~~**(e)** Landscaping and tree preservation/reforestation;

- ~~(6)(f)~~ Open space set-asides;
 - ~~(7)(g)~~ Signage;
 - ~~(8)(h)~~ Exterior lighting;
 - ~~(9)(i)~~ Building design and form; and
 - ~~(10)(j)~~ Road access and traffic circulation.
- ~~(f)6.~~ The extent to which a general or district-specific standard may be modified.

~~2. Outdoor advertising signs are prohibited in the GCO.~~

SECTION 2.

Section 5.7.7 *Exempt Signs*, of the City of High Point Development Ordinance shall be amended as follows:

5.7.7. EXEMPT SIGNS

The following signs are exempt from the requirements of this section except that a lighted sign requires an electrical permit:

- A. A governmental sign.
- ~~B. A work of art with no commercial message.~~
- ~~C.B.~~ Lights and decorations with no commercial message that are temporarily displayed on ~~traditionally accepted~~ civic, patriotic or religious holidays.
- ~~D.C.~~ A hand carried sign.
- ~~E.D.~~ A sign located on the interior of a building, court, lobby, athletic field, stadium, or other structure which is not intended to be seen from the exterior of the building or structure.
- ~~F. A sign located on or affixed to an athletic field scoreboard that is not oriented toward the playing field, unless the sign:~~
 - ~~1. Is an off site sign or outdoor advertising sign;~~
 - ~~2. Is larger than, or protrudes from the scoreboard;~~
 - ~~3. Is a projecting sign; or~~
 - ~~4. Is illuminated.~~

- G.E.** A sign affixed to a vehicle or trailer used on a regular basis for ~~in~~ the normal transport of goods or persons ~~where the sign is incidental and accessory to the primary use of the vehicle or trailer.~~
- H.F.** A sign affixed to the window of a vehicle ~~displaying information on the terms of sale for the vehicle.~~
- I.G.** A sign not legible from a public or private street.
- J.H.** A flag without a commercial message with an area of not more than 60 square feet. ~~Flags of the United States, North Carolina, local governmental jurisdictions, foreign nations having diplomatic relations with the United States, and any other flags adopted or sanctioned by the local governing body, except they are subject to the laws found in the U.S.C, Title 4, Chapter 1, Title 18, Chapter 33 and Title 36, Chapter 10.~~
- K.I.** A window sign painted on or attached to a window, covering a maximum of 25% of the window area.
- L.J.** A sign painted on an active public water tower.

SECTION 3.

Table 5.7.8.B: *Requirements For A Sign Not Requiring A Sign Permit*, of the City of High Point Development Ordinance shall be amended as follows:

TABLE 5.7.8.B: REQUIREMENTS FOR A SIGN NOT REQUIRING A SIGN PERMIT					
SIGN TYPE	NUMBER PERMITTED	AREA (SQ. FT.)	SETBACK (FEET)	MAXIMUM HEIGHT (FEET)	ILLUMINATION
Flags, emblems, insignia of corporate, political, professional, fraternal, civic, or educational organization in all districts	1/frontage	60	R/W	<u>640</u>	Indirect

The remainder of the table is unchanged.

SECTION 4.

Section 5.7.8 *Signs Not Requiring A Sign Permit*, subsection B.2. *Additional Specific Standards*, of the City of High Point Development Ordinance shall be amended as follows:

- (e) Temporary religious, philosophical, educational, real estate, yard sale, construction, ~~a~~ and political ~~off-site~~ signs shall comply with the following standards:
 - (1) Be located outside the street right-of-way, or at least 6 feet from the back of curb or edge of pavement where no curb exists;
 - (2) Not be placed in public street medians or traffic islands;
 - (3) Not interfere with or obstruct pedestrian or vehicular traffic, or obstruct safe sight distances at intersections;
 - (4) Not be placed on private land without the consent of the landowner or occupant; ~~and,~~
 - ~~(5) Be posted only within the hours from noon on a Friday to noon on the following Monday.~~

SECTION 5.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, of the City of High Point Development Ordinance shall be amended as follows:

PART A.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, subsection A.1, *Location Standards* shall be amended as follows:

- 1. **Location Standards**
 - (a) It shall be allowed only on a lot with ~~as an accessory to~~ an existing principal use.
 - ~~(b) Except where otherwise specified, all signs shall be restricted to an on-site location.~~
 - ~~(c)~~(b) If greater than 6 feet in height, it shall not be located within 100 feet of a residential district.

~~(d)~~(c) Where 2 or more establishments at the same location receive approval of directional signs, the signs shall share the same support structure.

PART B.

Table 5.7.9.B: *Requirements For A Freestanding Sign Requiring A Sign Permit, shall be amended as follows:*

TABLE 5.7.9.B: REQUIREMENTS FOR A FREESTANDING SIGN REQUIRING A SIGN PERMIT							
ZONING DISTRICT OR SIGN TYPE		MAXIMUM NUMBER PER LOT FRONTAGE	AREA (SQ FT)		SETBACK FROM ROW (FEET)	MAX HEIGHT (FEET)	AREA COMPUTATION (SQUARE FEET PER EACH LINEAR FOOT OF LOT FRONTAGE)
			MAX	MIN [1]			
SIGN STANDARDS BY ZONING DISTRICT							
RC District	development identification sign	1/street frontage	300 <u>200</u>	200 <u>n/a</u>	10	30 [3]	n/a
Off-premise directional signs in the GB, LI, HI districts		1 total	8	n/a	n/a	6	n/a

The remainder of the table is unchanged.

PART C.

Section 5.7.9, *Freestanding Signs Requiring A Sign Permit*, subsection B.3. *Specific Standards By Sign Type* shall be amended by deleting paragraphs **(d) Instructional Sign (All Districts)** and **(e) Off-Site Directional Sign in the GB, LI and HI Districts** in their entirety, and re-lettering paragraphs (f) *Special Promotion Sign (All Districts)*, (g) *Electronic Changeable Copy Sign Requiring A Permit* and (h) *Video Signs – Freestanding* as **(d)**, **(e)** and **(f)** respectively.

PART D.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, subsection B.3. *Specific Standards By Sign Type* shall be amended as follows:

~~(g)~~(e) Electronic Changeable Copy Sign Requiring a Permit

(1) General Standards

(iii) Location and Type

Electronic changeable copy signs shall be located ~~on-site~~, as a portion of, and on the same support structure with a legal conforming accessory freestanding sign. Such signs shall not be added to a sign that is nonconforming, nor shall any part of an existing nonconforming sign be converted to an electronic changeable copy sign.

The remainder of this subsection is unchanged.

PART E.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, subsection B.3. *Specific Standards By Sign Type* shall be amended as follows:

~~(h)~~(f) Video Signs – Freestanding

(1) General Standards

(iii) Location

Video signs shall be allowed only on a lot with an existing principal use ~~shall be located on-site~~. No part of a freestanding video sign shall be closer than 25 feet from intersecting street rights-of-way. No encroachment by any part of the sign face, its base or support structure into the street right-of-way is permitted. Such signs shall not be incorporated with, or added to, any other freestanding sign, nor shall any other freestanding sign be converted to a video sign.

~~(3) — Only On-Site Advertising Permitted
Video signs shall only be used to advertise goods or
services available on-site, or to provide information
related to on-site businesses, promotions or events.~~

The remainder of this subsection is unchanged.

SECTION 6.

Section 5.7.11 *Outdoor Advertising Sign Requiring A Sign Permit*, of the City of High Point Development Ordinance shall be deleted in its entirety. Sections 5.7.12 *Sign For Historic Structures or Properties*, 5.7.13 *Common Signage Plan*, and 5.7.14 *Encroachment Agreement For Entrance Sign* shall be re-numbered as Sections 5.7.11., 5.7.12., and 5.7.13. respectively.

SECTION 7.

A new Section 5.7.14. entitled *Savings Clause* shall be added to the City of High Point Development Ordinance, which shall read as follows:

5.7.14. SAVINGS CLAUSE

Subject to the property owner's consent, a noncommercial message of any type may be substituted in whole or in part for the message displayed on any sign for which the sign structure or mounting device is legal, without consideration of message content. Any change to the structure or mounting device, or the refacing of a sign shall be subject to the requirements of Section 5.7. Signage, a common signage plan, and permitting, as may be applicable. The purpose of this provision is to prevent any inadvertent favoring of commercial speech over noncommercial speech, and to prevent favoring of any particular noncommercial message over any other noncommercial message.

SECTION 8.

Section 10.4 *Definitions*, of the City of High Point Development Ordinance shall be amended as follows:

SIGN, GOVERNMENTAL	A sign erected by or on behalf of a governmental body to post a legal notice, identify public property, convey public information <u>of significant importance</u> , and direct or regulate pedestrian or vehicular traffic.
SIGN, OFF-SITE	A sign which directs attention to a business, commodity, service, entertainment, or attraction sold, offered, or existing elsewhere than upon the lot where the sign is displayed.
SIGN, OFF-SITE DIRECTIONAL	A sign that indicates only the name and/or logo and direction to businesses, churches, hospitals, colleges, or similar campus uses.
SIGN, ON-SITE	A sign which directs attention to a business, commodity, service, entertainment, or attraction sold, offered, or existing on the same lot where the sign is displayed; provided, an on-site sign may also display a noncommercial message.
SIGN, OUTDOOR ADVERTISING (BILLBOARD)	A sign which directs attention to a business, commodity, service, entertainment, or attraction sold, offered, or existing elsewhere than the lot where the sign is displayed.
SIGN, TEMPORARY OFF-SITE	A sign that is displayed in a location different than the principal use it is advertising, is not permanently mounted, and in place for only a limited period of time.
SIGN, WARNING	An on-site sign with no commercial message that displays information pertinent to the safety or legal responsibilities of the public such as signs warning of high voltage, "no trespassing," and similar directives.

The remainder of this section is unchanged.

SECTION 9.

Should any section of provision of this ordinance be declared invalid, such decision shall not affect the validity of the remaining portions of this ordinance.

SECTION 10.

All ordinances or parts of ordinances in conflict with the provisions of this ordinance are hereby repealed.

SECTION 11.

This ordinance shall become effective upon adoption.

**Adopted by the City Council
City of High Point, North Carolina
The 4th day of February 2019**

By: _____

Jay W. Wagner, Mayor

ATTEST:

Lisa B. Vierling, City Clerk

CITY OF HIGH POINT

AGENDA ITEM



Title: Motorola 5 Year Service Agreement

From: Steve Lingerfelt, Director of Information
Technology Services

Meeting Date: July 15, 2019

Public Hearing: No

**Advertising Date /
Advertised By:**

Attachments: Motorola Solutions Inc. Service Agreement Quote

PURPOSE:

The City needs to purchase a Motorola Service Agreement for the 800 MhZ Radio System.

BACKGROUND:

Information Technology Services is recommending the City of High Point purchase a five year service plan from Motorola to support the existing radio system. The service agreement will provide annual updates and support for the system for the next five years.

BUDGET IMPACT:

The City of High Point will use existing funds in the FY 2019-20 budget to purchase the Service contract from Motorola Solutions, Inc. The total cost of the contract is \$1,724,790 payable over five years. Payments are as follows:

Year 1	\$ 333,741
Year 2	\$ 339,184
Year 3	\$ 344,790
Year 4	\$ 350,564
Year 5	\$ 356,511

RECOMMENDATION / ACTION REQUESTED:

The Department of Information Technology Services recommends approval of the contract and that the appropriate City official and/or employee be authorized to execute all necessary documents.

Financial Services

Purchasing Division



Requisition #

CITY OF HIGH POINT
SOLE SOURCE JUSTIFICATION FORM
(For Items Costing **\$10,000.00 or More**)
Statutory Reference N.C.G.S. 143-129(e)6

Vendor:

Item(s):

Justification:

Five year maintenance contract needed to provide software and hardware support and maintenance for the 800 MHz radio system.

Estimated expenditure for the above item(s):

Accounting Unit and Account(s):

CHECK ALL ENTRIES BELOW THAT APPLY TO THE PROPOSED PURCHASE.
ATTACH A MEMO CONTAINING JUSTIFICATION AND SUPPORT DOCUMENTATION.

1. ☐ Performance or price competition for a product are not available.
2. ☒ A needed product is available from only one source of supply.
3. ☒ Standardization or compatibility is the overriding consideration.
4. ☐ The parts/equipment are required from this source to permit standardization.
5. ☐ None of the above applies. A detailed explanation and justification for this sole source request is contained in attached memo and support documentation.

The undersigned requests that competitive procurement be waived and that the vendor identified as the supplier of the material or service described in this sole source justification be authorized as a sole source for the material or service.

Department Head/Authorized Personnel Digitally signed by Steve Lingerfelt
Date: 2019.07.03 14:07:42 -04'00'

Department/Division Date

APPROVAL PROCESS

Purchasing Manager Digitally signed by Erik Conti
Date: 2019.07.03 15:23:35 -04'00'

Financial Services Director Digitally signed by Bobby Fitzjohn
Date: 2019.07.05 08:12:01 -04'00'

City Council (\$30,000 – Up) Digitally signed by Greg Demko
Date: 2019.07.05 09:45:12 -04'00'



SERVICE AGREEMENT

1299 E Algonquin Road
Schaumburg, IL 60196
(800) 247-2346

Contract Number: USC000003806
Contract Modifier: R14-NOV-18 15:52:53

Date: 04-DEC-2018

Company Name: High Point, City Of
Attn.:
Billing Address: P O Box 230
City, State, Zip Code: High Point, NC 27261
Customer Contact: Lee Stanley
Phone: 336-883-3404

P.O.#: N/A
Customer #: 1011296383
Bill to Tag#: 0001
Contract Start Date: 01-JUL-2019
Contract End Date: 30-JUN-2024
Payment Cycle: ANNUALLY
Currency: USD

QTY	MODEL/OPTION	SERVICES DESCRIPTION	MONTHLY EXT	EXTENDED AMT
	LSV01S00493A	***** Recurring Services ***** ASTRO SYS ESST_W_AR	\$46,365.89	\$556,390.60
	SVC01SVC2012C	SP - CONTRACT ADMINISTRATION SERVICE	\$409.38	\$4,912.56
	SVC02SVC0201A	ASTRO SUA II UO IMPLEMENTATION SERVICES	\$17,484.07	\$209,808.85
	SVC02SVC0433A	ASTRO SUA II FIELD IMPLEMENTATN SVC	\$14,042.29	\$168,507.29
	SVC04SVC0178A	SYS UPGRADE AGRMT II-SITE	\$13,086.18	\$785,170.70
Sub Total			\$91,387.79	\$1,724,790.00
Taxes			\$4,013.01	\$90,555.39
Grand Total			\$95,400.80	\$1,815,345.39
SPECIAL INSTRUCTIONS - ATTACH STATEMENT OF WORK FOR PERFORMANCE DESCRIPTIONS This Service Agreement reflects a 5% discount for the five year execution.			THIS SERVICE AMOUNT IS SUBJECT TO STATE AND LOCAL TAXING JURISDICTIONS WHERE APPLICABLE, TO BE VERIFIED BY MOTOROLA SOLUTIONS	

I received Statements of Work that describe the services provided on this Agreement. Motorola's Service Terms and Conditions, a copy of which is attached to this Service Agreement, is incorporated herein by this reference.

AUTHORIZED CUSTOMER SIGNATURE

TITLE

DATE

CUSTOMER (PRINT NAME)

MOTOROLA REPRESENTATIVE (SIGNATURE)

TITLE

DATE

EARL DELK

MOTOROLA REPRESENTATIVE (PRINT NAME)

PHONE

Company Name : High Point, City Of
Contract Number : USC000003806
Contract Modifier : R14-NOV-18 15:52:53
Contract Start Date : 01-JUL-2019
Contract End Date : 30-JUN-2024

Service Terms and Conditions

Motorola Solutions Inc. ("Motorola") and the customer named in this Agreement ("Customer") hereby agree as follows:

Section 1. APPLICABILITY

These Maintenance Service Terms and Conditions apply to service contracts whereby Motorola will provide to Customer either (1) maintenance, support, or other services under a Motorola Service Agreement, or (2) installation services under a Motorola Installation Agreement.

Section 2. DEFINITIONS AND INTERPRETATION

2.1. "Agreement" means these Maintenance Service Terms and Conditions; the cover page for the Service Agreement or the Installation Agreement, as applicable; and any other attachments, all of which are incorporated herein by this reference. In interpreting this Agreement and resolving any ambiguities, these Maintenance Service Terms and Conditions take precedence over any cover page, and the cover page takes precedence over any attachments, unless the cover page or attachment states otherwise.

2.2. "Equipment" means the equipment that is specified in the attachments or is subsequently added to this Agreement.

2.3. "Services" means those installation, maintenance, support, training, and other services described in this Agreement.

Section 3. ACCEPTANCE

Customer accepts these Maintenance Service Terms and Conditions and agrees to pay the prices set forth in the Agreement. This Agreement becomes binding only when accepted in writing by Motorola. The term of this Agreement begins on the "Start Date" indicated in this Agreement.

Section 4. SCOPE OF SERVICES

4.1. Motorola will provide the Services described in this Agreement or in a more detailed statement of work or other document attached to this Agreement. At Customer's request, Motorola may also provide additional services at Motorola's then-applicable rates for the services.

4.2. If Motorola is providing Services for Equipment, Motorola parts or parts of equal quality will be used; the Equipment will be serviced at levels set forth in the manufacturer's product manuals; and routine service procedures that are prescribed by Motorola will be followed.

4.3. If Customer purchases from Motorola additional equipment that becomes part of the same system as the initial Equipment, the additional equipment may be added to this Agreement and will be billed at the applicable rates after the warranty for that additional equipment expires.

4.4. All Equipment must be in good working order on the Start Date or when additional equipment is added to the Agreement. Upon reasonable request by Motorola, Customer will provide a complete serial and model number list of the Equipment. Customer must promptly notify Motorola in writing when any Equipment is lost, damaged, stolen or taken out of service. Customer's obligation to pay Service fees for this Equipment will terminate at the end of the month in which Motorola receives the written notice.

4.5. Customer must specifically identify any Equipment that is labeled intrinsically safe for use in hazardous environments.

4.6. If Equipment cannot, in Motorola's reasonable opinion, be properly or economically serviced for any reason, Motorola may modify the scope of Services related to that Equipment; remove that Equipment from the Agreement; or increase the price to Service that Equipment.

4.7. Customer must promptly notify Motorola of any Equipment failure. Motorola will respond to Customer's notification in a manner consistent with the level of Service purchased as indicated in this Agreement.

Section 5. EXCLUDED SERVICES

5.1. Service excludes the repair or replacement of Equipment that has become defective or damaged from use in other

than the normal, customary, intended, and authorized manner; use not in compliance with applicable industry standards; excessive wear and tear; or accident, liquids, power surges, neglect, acts of God or other force majeure events.

5.2. Unless specifically included in this Agreement, Service excludes items that are consumed in the normal operation of the Equipment, such as batteries or magnetic tapes.; upgrading or reprogramming Equipment; accessories, belt clips, battery chargers, custom or special products, modified units, or software; and repair or maintenance of any transmission line, antenna, microwave equipment, tower or tower lighting, duplexer, combiner, or multicoupler. Motorola has no obligations for any transmission medium, such as telephone lines, computer networks, the internet or the worldwide web, or for Equipment malfunction caused by the transmission medium.

Section 6. TIME AND PLACE OF SERVICE

Service will be provided at the location specified in this Agreement. When Motorola performs service at Customer's location, Customer will provide Motorola, at no charge, a non-hazardous work environment with adequate shelter, heat, light, and power and with full and free access to the Equipment. Waivers of liability from Motorola or its subcontractors will not be imposed as a site access requirement. Customer will provide all information pertaining to the hardware and software elements of any system with which the Equipment is interfacing so that Motorola may perform its Services. Unless otherwise stated in this Agreement, the hours of Service will be 8:30 a.m. to 4:30 p.m., local time, excluding weekends and holidays. Unless otherwise stated in this Agreement, the price for the Services exclude any charges or expenses associated with helicopter or other unusual access requirements; if these charges or expenses are reasonably incurred by Motorola in rendering the Services, Customer agrees to reimburse Motorola for those charges and expenses.

Section 7. CUSTOMER CONTACT

Customer will provide Motorola with designated points of contact (list of names and phone numbers) that will be available twenty-four (24) hours per day, seven (7) days per week, and an escalation procedure to enable Customer's personnel to maintain contact, as needed, with Motorola.

Section 8. INVOICING AND PAYMENT

8.1 Customer affirms that a purchase order or notice to proceed is not required for the duration of this service contract and will appropriate funds each year through the contract end date. Unless alternative payment terms are stated in this Agreement, Motorola will invoice Customer in advance for each payment period. All other charges will be billed monthly, and Customer must pay each invoice in U.S. dollars within twenty (20) days of the invoice date.

8.2 Customer will reimburse Motorola for all property taxes, sales and use taxes, excise taxes, and other taxes or assessments that are levied as a result of Services rendered under this Agreement (except income, profit, and franchise taxes of Motorola) by any governmental entity. The Customer will pay all invoices as received from Motorola. At the time of execution of this Agreement, the Customer will provide all necessary reference information to include on invoices for payment in accordance with this Agreement.

8.3 At the end of the first year of the Agreement and each year thereafter, a CPI percentage change calculation shall be performed. Should the annual inflation rate increase greater than 5% during the previous year, Motorola shall have the right to increase all future maintenance prices by the CPI increase amount exceeding 5%. The Midwest Region Consumer Price Index (https://www.bls.gov/regions/mountain-plains/news-release/consumerpriceindex_midwest.htm), All items, Not seasonally adjusted shall be used as the measure of CPI for this price adjustment. Measurement will take place once the annual average for the new year has been posted by the Bureau of Labor Statistics

Section 9. WARRANTY

Motorola warrants that its Services under this Agreement will be free of defects in materials and workmanship for a period of ninety (90) days from the date the performance of the Services are completed. In the event of a breach of this warranty, Customer's sole remedy is to require Motorola to re-perform the non-conforming Service or to refund, on a pro-rata basis, the fees paid for the non-conforming Service. MOTOROLA DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Section 10. DEFAULT/TERMINATION

10.1. If either party defaults in the performance of this Agreement, the other party will give to the non-performing party a written and detailed notice of the default. The non-performing party will have thirty (30) days thereafter to provide a written plan to cure the default that is acceptable to the other party and begin implementing the cure plan immediately after plan approval. If the non-performing party fails to provide or implement the cure plan, then the injured party, in addition to any other rights available to it under law, may immediately terminate this Agreement effective upon giving a written notice of

termination to the defaulting party.

10.2. Any termination of this Agreement will not relieve either party of obligations previously incurred pursuant to this Agreement, including payments which may be due and owing at the time of termination. All sums owed by Customer to Motorola will become due and payable immediately upon termination of this Agreement. Upon the effective date of termination, Motorola will have no further obligation to provide Services.

10.3 If the Customer terminates this Agreement before the end of the Term, for any reason other than Motorola default, then the Customer will pay to Motorola an early termination fee equal to the discount applied to the last three (3) years of Service payments for the original Term.

Section 11. LIMITATION OF LIABILITY

Except for personal injury or death, Motorola's total liability, whether for breach of contract, warranty, negligence, strict liability in tort, or otherwise, will be limited to the direct damages recoverable under law, but not to exceed the price of twelve (12) months of Service provided under this Agreement. ALTHOUGH THE PARTIES ACKNOWLEDGE THE POSSIBILITY OF SUCH LOSSES OR DAMAGES, THEY AGREE THAT MOTOROLA WILL NOT BE LIABLE FOR ANY COMMERCIAL LOSS; INCONVENIENCE; LOSS OF USE, TIME, DATA, GOOD WILL, REVENUES, PROFITS OR SAVINGS; OR OTHER SPECIAL, INCIDENTAL, INDIRECT, OR CONSEQUENTIAL DAMAGES IN ANY WAY RELATED TO OR ARISING FROM THIS AGREEMENT OR THE PERFORMANCE OF SERVICES BY MOTOROLA PURSUANT TO THIS AGREEMENT. No action for contract breach or otherwise relating to the transactions contemplated by this Agreement may be brought more than one (1) year after the accrual of the cause of action, except for money due upon an open account. This limitation of liability will survive the expiration or termination of this Agreement and applies notwithstanding any contrary provision.

Section 12. EXCLUSIVE TERMS AND CONDITIONS

12.1. This Agreement supersedes all prior and concurrent agreements and understandings between the parties, whether written or oral, related to the Services, and there are no agreements or representations concerning the subject matter of this Agreement except for those expressed herein. The Agreement may not be amended or modified except by a written agreement signed by authorized representatives of both parties.

12.2. Customer agrees to reference this Agreement on any purchase order issued in furtherance of this Agreement, however, an omission of the reference to this Agreement will not affect its applicability. In no event will either party be bound by any terms contained in a Customer purchase order, acknowledgement, or other writings unless: the purchase order, acknowledgement, or other writing specifically refers to this Agreement; clearly indicate the intention of both parties to override and modify this Agreement; and the purchase order, acknowledgement, or other writing is signed by authorized representatives of both parties.

Section 13. PROPRIETARY INFORMATION; CONFIDENTIALITY; INTELLECTUAL PROPERTY RIGHTS

13.1. Any information or data in the form of specifications, drawings, reprints, technical information or otherwise furnished to Customer under this Agreement will remain Motorola's property, will be deemed proprietary, will be kept confidential, and will be promptly returned at Motorola's request. Customer may not disclose, without Motorola's written permission or as required by law, any confidential information or data to any person, or use confidential information or data for any purpose other than performing its obligations under this Agreement. The obligations set forth in this Section survive the expiration or termination of this Agreement.

13.2. Unless otherwise agreed in writing, no commercial or technical information disclosed in any manner or at any time by Customer to Motorola will be deemed secret or confidential. Motorola will have no obligation to provide Customer with access to its confidential and proprietary information, including cost and pricing data.

13.3. This Agreement does not grant directly or by implication, estoppel, or otherwise, any ownership right or license under any Motorola patent, copyright, trade secret, or other intellectual property, including any intellectual property created as a result of or related to the Equipment sold or Services performed under this Agreement.

Section 14. FCC LICENSES AND OTHER AUTHORIZATIONS

Customer is solely responsible for obtaining licenses or other authorizations required by the Federal Communications Commission or any other federal, state, or local government agency and for complying with all rules and regulations required by governmental agencies. Neither Motorola nor any of its employees is an agent or representative of Customer in any governmental matters.

Section 15. COVENANT NOT TO EMPLOY

Revised June 16, 2018

During the term of this Agreement and continuing for a period of two (2) years thereafter, Customer will not hire, engage on contract, solicit the employment of, or recommend employment to any third party of any employee of Motorola or its subcontractors without the prior written authorization of Motorola. This provision applies only to those employees of Motorola or its subcontractors who are responsible for rendering services under this Agreement. If this provision is found to be overly broad under applicable law, it will be modified as necessary to conform to applicable law.

Section 16. MATERIALS, TOOLS AND EQUIPMENT

All tools, equipment, dies, gauges, models, drawings or other materials paid for or furnished by Motorola for the purpose of this Agreement will be and remain the sole property of Motorola. Customer will safeguard all such property while it is in Customer's custody or control, be liable for any loss or damage to this property, and return it to Motorola upon request. This property will be held by Customer for Motorola's use without charge and may be removed from Customer's premises by Motorola at any time without restriction.

Section 17. GENERAL TERMS

17.1. If any court renders any portion of this Agreement unenforceable, the remaining terms will continue in full force and effect.

17.2. This Agreement and the rights and duties of the parties will be interpreted in accordance with the laws of the State in which the Services are performed.

17.3. Failure to exercise any right will not operate as a waiver of that right, power, or privilege.

17.4. Neither party is liable for delays or lack of performance resulting from any causes that are beyond that party's reasonable control, such as strikes, material shortages, or acts of God.

17.5. Motorola may subcontract any of the work, but subcontracting will not relieve Motorola of its duties under this Agreement.

17.6. Except as provided herein, neither Party may assign this Agreement or any of its rights or obligations hereunder without the prior written consent of the other Party, which consent will not be unreasonably withheld. Any attempted assignment, delegation, or transfer without the necessary consent will be void. Notwithstanding the foregoing, Motorola may assign this Agreement to any of its affiliates or its right to receive payment without the prior consent of Customer. In addition, in the event Motorola separates one or more of its businesses (each a "Separated Business"), whether by way of a sale, establishment of a joint venture, spin-off or otherwise (each a "Separation Event"), Motorola may, without the prior written consent of the other Party and at no additional cost to Motorola, assign this Agreement such that it will continue to benefit the Separated Business and its affiliates (and Motorola and its affiliates, to the extent applicable) following the Separation Event.

17.7. THIS AGREEMENT WILL RENEW, FOR AN ADDITIONAL ONE (1) YEAR TERM, ON EVERY ANNIVERSARY OF THE START DATE UNLESS EITHER THE COVER PAGE SPECIFICALLY STATES A TERMINATION DATE OR ONE PARTY NOTIFIES THE OTHER IN WRITING OF ITS INTENTION TO DISCONTINUE THE AGREEMENT NOT LESS THAN THIRTY (30) DAYS OF THAT ANNIVERSARY DATE. At the anniversary date, Motorola may adjust the price of the Services to reflect its current rates.

17.8. If Motorola provides Services after the termination or expiration of this Agreement, the terms and conditions in effect at the time of the termination or expiration will apply to those Services and Customer agrees to pay for those services on a time and materials basis at Motorola's then effective hourly rates.

17.9 This Agreement may be executed in one or more counterparts, all of which shall be considered part of the Agreement. The parties may execute this Agreement in writing, or by electronic signature, and any such electronic signature shall have the same legal effect as a handwritten signature for the purposes of validity, enforceability and admissibility. In addition, an electronic signature, a true and correct facsimile copy or computer image of this Agreement shall be treated as and shall have the same effect as an original signed copy of this document.

CITY OF HIGH POINT

AGENDA ITEM



Title: Side Loading Refuse Trucks

From: Gary Smith, Fleet Director

Public Hearing: N/A

Attachments: Quote

Meeting Date: July 15, 2019

Advertising Date / N/A

Advertised By: N/A

PURPOSE:

The Environmental Services Division has three side loading refuse trucks in need of replacement due to age and hours. Using the NC Sheriffs' Association Procurement contract # 20-1-0506, three Autocar trucks with New Way Side Loading Refuse bodies from Advantage Truck Center are being recommended for council approval.

BACKGROUND:

The Environmental Services Division is currently using three Mack trucks with the New Way side loading bodies that have between 9,500-10,000+ hours. These trucks are used daily for residential garbage collection and need to be moved into the spare motorpool due to age and hours. Solid Waste has a total of thirteen side loading trucks and this will give them additional spare trucks to have while their trucks are being serviced and repaired. The Autocar truck with New Way side loading refuse body configuration is like the ones they are currently using and will meet their needs. The price of \$307,742.43 is for one truck, refuse body installation, and delivery. Total cost for three is \$923,227.29. Estimated delivery is 180-240 days.

BUDGET IMPACT:

Funds are available in 2019-20 budget

RECOMMENDATION / ACTION REQUESTED:

The Fleet Services Department recommends purchasing the three Autocar trucks with New Way side loading refuse bodies from Advantage Truck Center. Recommendation also includes declaring three current spare trucks as surplus and disposing through the online auction process.



North Carolina Sheriffs' Association
Heavy Equipment Procurement Program
Price Sheet Award Agreement

Heavy Equipment Procurement Program
Bid 20-04-0506

We are pleased to announce the North Carolina Sheriffs' Association has successfully completed its statewide competitive award for heavy equipment effective May 18, 2019.

Congratulations, your dealership has been included on the association's price sheet contract controlled by the North Carolina Sheriffs' Association's Solicitation for Bids and Contract Terms and Conditions.

By the award of this contract based on your dealership's bid for Solicitation Number 20-04-0506, all terms and conditions set forth in the Solicitation for Bids and Contract Terms and Conditions are incorporated herein by reference and agreed to by the Contractor and the North Carolina Sheriffs' Association.

Ken Adkins

Signature of Authorized Representative

Ken Adkins

Printed Name of Authorized Representative

Youngs Truck Center, DBA Advantage Truck Center

Contractor/Dealership Name (Please Print)

5/17/19

Date

[Signature]
Signature of NCSA Contract Administrator

Jason D. Bennett

Printed Name of NCSA Contract Administrator

May 18, 2019

Date

Prepared By Bruce Stadler
Quote Id : Stock ASL with ret
Phone : (704)597-0551
Order : 20016770
Lead Unit Sales Order : 20016770
Model : 2019 - ACX64 Class 8

Prepared For Bruce Stadler
Advantage Truck Center

06/21/2019

Quote Summary

Values are in U.S. Dollar

EQUIPMENT	EACH	TOTAL
ACX64 Class 8	\$300,196.43	\$300,196.43
SINGLE RIGHT HAND DRIVE CAB		
QUANTITY	1	
ADDITIONAL PURCHASED COVERAGES	\$4,846.00	\$4,846.00
EPA SURCHARGE	\$0.00	\$0.00
ADDITIONAL PRICE ADJUSTMENT	\$0.00	\$0.00
FACTORY CONTRACT MODIFICATION	\$0.00	\$0.00
OUTSIDE CONTRACT FREIGHT	\$0.00	\$0.00
MISC/ORDER CHANGE FEES	\$750.00	\$750.00
ADDITIONAL SURCHARGE	\$0.00	\$0.00
NORTH AMERICAN FREIGHT VIA DESIGNATED SHIPPER	\$1,950.00	\$1,950.00
TOTAL EQUIPMENT PRICE	\$307,742.43	\$307,742.43
OTHER CHARGES	EACH	TOTAL
FET AMOUNT TOTAL	\$0.00	\$0.00
STATE TAX/OTHER FEES	\$0.00	\$0.00
TOTAL QUOTE	\$307,742.43	\$307,742.43

--- With TRANS.
RETARDER
\$ 300,788.14 + Without
TRANS.
RETARDER

Dealer Signature

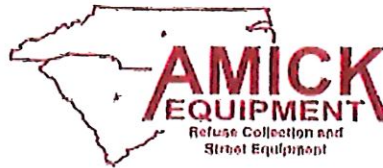
Customer Signature

Date

Date

- By signing the Quote Summary, Customer approves the information contained in the Quote, subject to final approval by Autocar. Autocar endeavors to provide but does not guarantee error-free Quotes. All price quotations are for informational purposes only, and prices are subject to change without notice. Final prices will be reflected on the invoice for the Autocar chassis or on a document expressly evidencing Autocar's intent to be bound. Autocar may substitute comparable components for those listed on any quote. Estimates of unloaded weight distribution are provided for informational purposes only, are not guaranteed by Autocar and do not take into account vehicle application, body type or other modifications. Autocar is not responsible for modifications to the Autocar chassis after shipment from the Autocar assembly plant. Modifications by body builders and other upfitters or converters may void the Autocar limited warranty in whole or in part.

- Autocar will deliver the Autocar chassis to the designated agent for delivery.



Tuesday, June 18, 2019

Quote Number: 535

Front splash shield.
Clean out chute extensions, both sides.

1 NCSA 6% discount on base unit and options. (\$8945.23) (\$11,445.23) (\$11,445.23)

Amick Municipal Discount (\$2500.00)

Delivered to Autocar dealership for PDI.

Delivery is 120 to 150 days after the chassis is received at New Way.

Total: \$137,641.98

Quoted By: Cameron Low Date: 6/18/2019

Cameron Low

This quote good for: 90 days

Production and delivery will take approximately: * Delivery Time Frame 120 to 150 days AR chassis

Amick Equipment payment terms: **Payment due upon delivery.**

* Please be aware. Delivery time is based on current production lead time. This is an estimate and may increase or decrease due to chassis availability, body production, transport or other unforeseen issues.

** Unless itemized above, price does not include any state, local or federal taxes.



NCSA Bid# 19-03-0504R

Lot# 46 Sideloader Refuse Body

Amick Equipment makes every effort when quoting your new equipment to meet all Federal, State and Local weight requirements. It is up to the end-user NOT to exceed the weight limits for your area regardless of chassis GVRW. Over weight equipment can lead to DOT fines, damage to the equipment or injury to the operator and others. All refuse and street equipment has the potential to be over weight if improperly operated

Thank you for considering Amick Equipment as a vendor. We will do our best to meet and exceed your expectations.

P.O. Box 1965 Lexington, SC 29071-1965 Toll-Free (800) 922-3795 Fax (803) 359-0925 www.amickequipment.com



**FORMAL BID RECOMMENDATION
REQUEST FOR COUNCIL APPROVAL**

DEPARTMENT: Fleet Services

COUNCIL AGENDA DATE: July 15, 2019

BID NO.: NC Sheriff's Association CONTRACT NO.: 20-1-0506 DATE OPENED:

DESCRIPTION:

Autocar with New Way 31 yard Side Loading Refuse Body

PURPOSE:

The Environmental Services Division is currently using three Mack trucks with the New Way side loading bodies that have between 9,500-10,000+ hours. These trucks are used daily for residential garbage collection and need to be moved into the spare motorpool due to age and hours.

COMMENTS:

The price of \$307,742.43 is for one truck, refuse body installation, and delivery. Total cost for three is \$923,227.29. Estimated delivery is 180-240 days.

RECOMMEND AWARD TO: Advantage Truck Center AMOUNT: \$ 923,227.29

JUSTIFICATION:

Using this bid allows the City of High Point to take advantage of the volume discount offered through the NC Sheriffs' Association contract.

ACCOUNTING UNIT	ACCOUNT	ACTIVITY	CATEGORY	BUDGETED AMOUNT
501271	532401			\$ 923,227.29
TOTAL BUDGETED AMOUNT				\$ 923,227.29

DEPARTMENT HEAD: Gary L. Smith Digitally signed by Gary L. Smith
DN: cn=Gary L. Smith, o=City of High Point, ou=Fleet
Services, email=gary.smith@highpointnc.gov, c=US
Date: 2019.07.02 12:49:35 -0400 DATE: Jul 2, 2019

The Purchasing Division concurs with recommendation submitted by the Fleet Services and recommends award to the lowest responsible, responsive bidder Advantage Truck Ctr. in the amount of \$ 923,227.29.

PURCHASING MANAGER: Erik Conti Digitally signed by Erik Conti
Date: 2019.07.02 14:01:41 -0400 DATE: Jul 2, 2019

Approved for Submission to Council
FINANCIAL SERVICES DIRECTOR: Bobby Fitzjohn Digitally signed by Bobby Fitzjohn
Date: 2019.07.02 15:12:46 -0400 DATE: Jul 2, 2019

CITY MANAGER: Greg Demko Digitally signed by Greg Demko
Date: 2019.07.02 16:26:22 -0400 DATE: 7/2/2019

AN ORDINANCE AMENDING THE CITY OF HIGH POINT DEVELOPMENT ORDINANCE.

WHEREAS, the City Council of the City of High Point adopted the “City of High Point Development Ordinance” on May 16, 2016, with an effective date of January 1, 2017, and subsequently amended; and

WHEREAS, public hearings were held before the Planning and Zoning Commission on January 22, 2019 and before the City Council on February 4, 2019 regarding **Text Amendment 18-06**; and

WHEREAS, notice of the public hearings was published in the High Point Enterprise on January 9, 2019 for the Planning and Zoning Commission public hearing and on January 23, 2019 and January 30, 2019 for the City Council public hearing pursuant to Chapter 160A-364 of the General Statutes of North Carolina.

NOW THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF HIGH POINT, NORTH CAROLINA:

SECTION 1.

Section 3.8 *Overlay Zoning Districts*, subsection 3.8.7.E. regarding the Gateway Corridor Overlay (GCO), of the City of High Point Development Ordinance shall be amended as follows:

E. General Standards

~~1.~~ GCO district standards for a specific gateway corridor shall follow the policy direction in the gateway corridor plan approved by the City Council. The GCO district shall, at a minimum, address the following elements:

- ~~(a)~~1. The name and boundaries of the overlay district.
- ~~(b)~~2. The development along the corridor to which the overlay district applies (typically all new development and certain expansions and remodels).
- ~~(c)~~3. Any variations from the requirements of the underlying general zoning district(s).
- ~~(d)~~4. The uses allowed in the district, if appropriate.
- ~~(e)~~5. The development and form standards of the overlay district, including some or all of the following:
 - ~~(1)~~(a) Dimensions (height, setbacks, build-to-lines, etc.);
 - ~~(2)~~(b) Streetscape landscaping;
 - ~~(3)~~(c) Sidewalks and pedestrian circulation features;
 - ~~(4)~~(d) Off-street parking;
 - ~~(5)~~(e) Landscaping and tree preservation/reforestation;

- ~~(6)~~(f) Open space set-asides;
 - ~~(7)~~(g) Signage;
 - ~~(8)~~(h) Exterior lighting;
 - ~~(9)~~(i) Building design and form; and
 - ~~(10)~~(j) Road access and traffic circulation.
- ~~(f)~~6. The extent to which a general or district-specific standard may be modified.

2. ~~Outdoor advertising signs are prohibited in the GCO.~~

SECTION 2.

Section 5.7.7 *Exempt Signs*, of the City of High Point Development Ordinance shall be amended as follows:

5.7.7. EXEMPT SIGNS

The following signs are exempt from the requirements of this section except that a lighted sign requires an electrical permit:

- A. A governmental sign.
- ~~B. A work of art with no commercial message.~~
- ~~C.B.~~ Lights and decorations with no commercial message that are temporarily displayed on ~~traditionally accepted~~ civic, patriotic or religious holidays.
- ~~D.C.~~ A hand carried sign.
- ~~E.D.~~ A sign located on the interior of a building, court, lobby, athletic field, stadium, or other structure which is not intended to be seen from the exterior of the building or structure.
- ~~F. A sign located on or affixed to an athletic field scoreboard that is not oriented toward the playing field, unless the sign:~~
 - ~~1. Is an off site sign or outdoor advertising sign;~~
 - ~~2. Is larger than, or protrudes from the scoreboard;~~
 - ~~3. Is a projecting sign; or~~
 - ~~4. Is illuminated.~~

- G.E.** A sign affixed to a vehicle or trailer used on a regular basis for in the normal transport of goods or persons ~~where the sign is incidental and accessory to the primary use of the vehicle or trailer.~~
- H.F.** A sign affixed to the window of a vehicle ~~displaying information on the terms of sale for the vehicle which does not exceed the size of the window.~~
- I.G.** A sign not legible from a public or private street.
- J.H.** A flag without a commercial message with an area of not more than 60 square feet. Flags of the United States, North Carolina, local governmental jurisdictions, foreign nations having diplomatic relations with the United States, and any other flags adopted or sanctioned by the local governing body, except they are subject to the laws found in the U.S.C, Title 4, Chapter 1, Title 18, Chapter 33 and Title 36, Chapter 10.
- K.I.** A window sign painted on or attached to a window, covering a maximum of 25% of the window area.
- L.J.** A sign painted on an active public water tower.

SECTION 3.

Table 5.7.8.B: *Requirements For A Sign Not Requiring A Sign Permit*, of the City of High Point Development Ordinance shall be amended as follows:

TABLE 5.7.8.B: REQUIREMENTS FOR A SIGN NOT REQUIRING A SIGN PERMIT					
SIGN TYPE	NUMBER PERMITTED	AREA (SQ. FT.)	SETBACK (FEET)	MAXIMUM HEIGHT (FEET)	ILLUMINATION
Flags, emblems, insignia of corporate, political, professional, fraternal, civic, or educational organization in all districts	1/frontage	60	R/W	<u>640</u>	Indirect

The remainder of the table is unchanged.

SECTION 4.

Section 5.7.8 *Signs Not Requiring A Sign Permit*, shall be amended as follows:

PART A.

Section 5.7.8.A. *General Standards for Signs Not Requiring a Permit*, shall be amended as follows:

- ~~1. Except where otherwise specified, all signs shall be restricted to an on-site location.~~
2. Signs that include lighting or are illuminated shall be subject to an approved building permit for electrical service.

PART B.

Section 5.7.8.B.2. *Additional Specific Standards*, shall be amended as follows:

- (e) Temporary religious, philosophical, educational, real estate, yard sale, construction, ~~a~~ and political ~~off-site~~ signs shall comply with the following standards:
 - (1) Be located outside the street right-of-way, or at least 6 feet from the back of curb or edge of pavement where no curb exists;
 - (2) Not be placed in public street medians or traffic islands;
 - (3) Not interfere with or obstruct pedestrian or vehicular traffic, or obstruct safe sight distances at intersections;
 - (4) Not be placed on private land without the consent of the landowner or occupant; ~~and,~~
 - ~~(5) Be posted only within the hours from noon on a Friday to noon on the following Monday.~~

SECTION 5.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, of the City of High Point Development Ordinance shall be amended as follows:

PART A.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, subsection A.1, *Location Standards* shall be amended as follows:

1. Location Standards

- (a) It shall be allowed only on a lot with ~~as an accessory to~~ an existing principal use.
- ~~(b) Except where otherwise specified, all signs shall be restricted to an on-site location.~~
- ~~(c)~~(b) If greater than 6 feet in height, it shall not be located within 100 feet of a residential district.
- ~~(d)~~(c) Where 2 or more establishments at the same location receive approval of directional signs, the signs shall share the same support structure.

PART B.

Table 5.7.9.B: *Requirements For A Freestanding Sign Requiring A Sign Permit*, shall be amended as follows:

TABLE 5.7.9.B: REQUIREMENTS FOR A FREESTANDING SIGN REQUIRING A SIGN PERMIT							
ZONING DISTRICT OR SIGN TYPE		MAXIMUM NUMBER PER LOT FRONTAGE	AREA (SQ FT)		SETBACK FROM ROW (FEET)	MAX HEIGHT (FEET)	AREA COMPUTATION (SQUARE FEET PER EACH LINEAR FOOT OF LOT FRONTAGE)
			MAX	MIN [1]			
SIGN STANDARDS BY ZONING DISTRICT							
RC District	development identification sign	1/street frontage	300 200	200 n/a	10	30 [3]	n/a

Off-premise directional signs in the GB, LI, HI districts	1 total	8	n/a	n/a	6	n/a
---	--------------------	---	-----	-----	---	-----

The remainder of the table is unchanged.

PART C.

Section 5.7.9, *Freestanding Signs Requiring A Sign Permit*, subsection B.3. *Specific Standards By Sign Type* shall be amended by deleting paragraphs **(d) Instructional Sign (All Districts)** and **(e) Off-Site Directional Sign in the GB, LI and HI Districts** in their entirety, and re-lettering paragraphs (f) *Special Promotion Sign (All Districts)*, (g) *Electronic Changeable Copy Sign Requiring A Permit* and (h) *Video Signs – Freestanding* as **(d)**, **(e)** and **(f)** respectively.

PART D.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, subsection B.3. *Specific Standards By Sign Type* shall be amended as follows:

~~(g)~~(e) Electronic Changeable Copy Sign Requiring a Permit

(1) General Standards

(iii) Location and Type

Electronic changeable copy signs shall be located ~~on-site~~, as a portion of, and on the same support structure with a legal conforming accessory freestanding sign. Such signs shall not be added to a sign that is nonconforming, nor shall any part of an existing nonconforming sign be converted to an electronic changeable copy sign.

The remainder of this subsection is unchanged.

PART E.

Section 5.7.9 *Freestanding Signs Requiring A Sign Permit*, subsection B.3. *Specific Standards By Sign Type* shall be amended as follows:

~~{A}~~(f) Video Signs – Freestanding

(1) General Standards

(iii) Location

Video signs shall be allowed only on a lot with an existing principal use ~~shall be located on-site~~. No part of a freestanding video sign shall be closer than 25 feet from intersecting street rights-of-way. No encroachment by any part of the sign face, its base or support structure into the street right-of-way is permitted. Such signs shall not be incorporated with, or added to, any other freestanding sign, nor shall any other freestanding sign be converted to a video sign.

~~{3} — Only On-Site Advertising Permitted~~

~~Video signs shall only be used to advertise goods or services available on-site, or to provide information related to on-site businesses, promotions or events.~~

The remainder of this subsection is unchanged.

SECTION 6.

Section 5.7.11 *Outdoor Advertising Sign Requiring A Sign Permit*, of the City of High Point Development Ordinance shall be deleted in its entirety. Sections 5.7.12 *Sign For Historic Structures or Properties*, 5.7.13 *Common Signage Plan*, and 5.7.14 *Encroachment Agreement For Entrance Sign* shall be re-numbered as Sections 5.7.11., 5.7.12., and 5.7.13. respectively.

SECTION 7.

A new Section 5.7.14. entitled *Savings Clause* shall be added to the City of High Point Development Ordinance, which shall read as follows:

5.7.14. SAVINGS CLAUSE

Subject to the property owner's consent, a noncommercial message of any type may be substituted in whole or in part for the message displayed on any sign for which the sign structure or mounting device is legal, without consideration of message content. Any change to the structure or mounting device, or the refacing of a sign shall be subject to the requirements of Section 5.7. Signage, a common signage plan, and permitting, as may be applicable. The purpose of this provision is to prevent any inadvertent favoring of commercial speech over noncommercial speech, and to prevent favoring of any particular noncommercial message over any other noncommercial message.

SECTION 8.

Section 10.4 *Definitions*, of the City of High Point Development Ordinance shall be amended as follows:

SIGN, GOVERNMENTAL	A sign erected by or on behalf of a governmental body to post a legal notice, identify public property, convey public information <u>of significant importance</u> , and direct or regulate pedestrian or vehicular traffic.
SIGN, OFF-SITE	A sign which directs attention to a business, commodity, service, entertainment, or attraction sold, offered, or existing elsewhere than upon the lot where the sign is displayed.
SIGN, OFF-SITE DIRECTIONAL	A sign that indicates only the name and/or logo and direction to businesses, churches, hospitals, colleges, or similar campus uses.
SIGN, ON-SITE	A sign which directs attention to a business, commodity, service, entertainment, or attraction sold, offered, or existing on the same lot

	where the sign is displayed; provided, an on-site sign may also display a noncommercial message.
SIGN, OUTDOOR ADVERTISING (BILLBOARD)	A sign which directs attention to a business, commodity, service, entertainment, or attraction sold, offered, or existing elsewhere than the lot where the sign is displayed.
SIGN, TEMPORARY OFF-SITE	A sign that is displayed in a location different than the principal use it is advertising, is not permanently mounted, and in place for only a limited period of time.
SIGN, WARNING	An on-site sign with no commercial message that displays information pertinent to the safety or legal responsibilities of the public such as signs warning of high voltage, "no trespassing," and similar directives.

The remainder of this section is unchanged.

SECTION 9.

Should any section of provision of this ordinance be declared invalid, such decision shall not affect the validity of the remaining portions of this ordinance.

SECTION 10.

All ordinances or parts of ordinances in conflict with the provisions of this ordinance are hereby repealed.

SECTION 11.

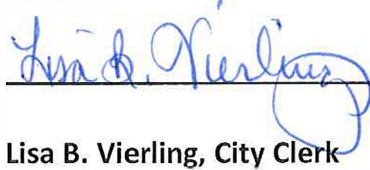
This ordinance shall become effective upon adoption.

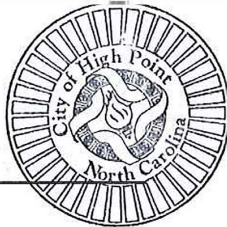
Adopted by the City Council
City of High Point, North Carolina
The 4th day of February 2019

By: 

Jay W. Wagner, Mayor

ATTEST:


Lisa B. Vierling, City Clerk



CITY OF HIGH POINT

AGENDA ITEM



Title: Introducing Bond Orders Authorizing Street and Sidewalk Bonds, Parks and Recreation Bonds, and Housing Bonds, and Calling a Public Hearing on the Bond Orders

From: Bobby D. Fitzjohn,
Financial Services Director

Meeting Date: July 15, 2019

Public Hearing: No

Advertising Date / N/A
Advertised By: -

Attachments: Introduction of Bond Orders
Resolution Setting Public Hearing

PURPOSE:

The City Council is required by the NC Local Government Commission to initiate certain actions in order to authorize the issuance of General Obligation Bonds pursuant to a voter referendum to be held on November 5, 2019, as follows:

June 17, 2019

The first step in the authorization process involves the adoption of a resolution by the City Council finding that 1) the bonds are necessary for the City, 2) the proposed principal amount of the bonds is adequate and not excessive, 3) the City's debt management procedures and fiscal policies are carried out in compliance with applicable law and 4) any increase in taxes to service the bonds will not be excessive. The resolution will also authorize the Finance Director to file an application for approval of the bonds with the Local Government Commission.

July 15, 2019

The second step will involve actions to be taken by City Council to introduce individual bond orders, by purpose (first reading), for the issuance of General Obligation Bonds and to call for a public hearing on the bond orders.

August 19, 2019

The third and final step requires the City Council to hold a public hearing on the bond orders, approve the bond orders (second reading) and to vote on the calling of a voter referendum on the bonds.

BACKGROUND:

This referendum will fund various projects within the adopted FY 2020-2024 Capital Improvement Plan. The proposed bond orders are summarized by purpose in the attached resolution.

BUDGET IMPACT:

The proposed referendum will authorize up to \$50 million in bonds. No increase in property taxes are anticipated to pay the debt service for the bonds authorized in this referendum.

RECOMMENDATION / ACTIONS REQUESTED:

It is recommended that the City Council approve the attached resolutions making certain findings related to the authorization and issuance of bonds of the City and filing of an application for said bonds with the Local Government Commission.

EXTRACTS FROM MINUTES OF CITY COUNCIL

* * *

A regular meeting of the City Council of the City of High Point, North Carolina (the “City Council”) was duly held in the Council Chambers of the Municipal Building located at 211 South Hamilton Street in High Point, North Carolina, the regular place of meeting, at 5:30 p.m. on July 15, 2019:

Members Present:

Members Absent:

* * * * *
* * *

Councilmember _____ introduced the following bond orders, summaries of which had been provided to each Councilmember, copies of which were available with the City Clerk and which were read by title:

BOND ORDER AUTHORIZING THE ISSUANCE OF \$22,000,000 GENERAL OBLIGATION STREETS AND SIDEWALK BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA

WHEREAS, the City Council of the City of High Point, North Carolina has ascertained and hereby determines that it is necessary to pay capital costs of providing streets and sidewalks, including without limitation bridges, viaducts, causeways, overpasses, underpasses, alleys and bicycle lanes; paving, grading, resurfacing, and widening streets; sidewalks, curbs and gutters, culverts, and drains; traffic controls, signals, and markers; lighting; and grade crossings and the elimination thereof and grade separations; streetscaping, landscaping and pedestrian improvements; transit stop improvements; and the acquisition of land therefor; and

WHEREAS, an application has been filed with the Secretary of the Local Government Commission of North Carolina requesting Commission approval of the General Obligation Streets and Sidewalk Bonds hereinafter described as required by the Local Government Bond Act, and the City Clerk has notified the City Council that the application has been accepted for submission to the Local Government Commission.

NOW, THEREFORE, BE IT ORDERED by the City Council of the City of High Point, North Carolina, as follows:

Section 1. In order to raise the money required for the purposes described above, in addition to any funds which may be made available for such purpose from any other source, General Obligation Streets and Sidewalk Bonds of the City are hereby authorized and shall be issued pursuant to the Local Government Finance Act of North Carolina. The maximum aggregate principal amount of such General Obligation Streets and Sidewalk Bonds authorized by this order shall be \$22,000,000.

Section 2. Taxes will be levied in an amount sufficient to pay the principal and interest on the General Obligation Streets and Sidewalk Bonds.

Section 3. A sworn statement of the City's debt has been filed with the City Clerk and is open to public inspection.

Section 4. This bond order will take effect when approved by the voters of the City at a referendum scheduled for November 5, 2019.

BOND ORDER AUTHORIZING THE ISSUANCE OF \$21,500,000 GENERAL OBLIGATION PARKS AND RECREATION BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA

WHEREAS, the City Council of the City of High Point, North Carolina has ascertained and hereby determines that it is necessary to pay capital costs of providing for the acquisition, construction, renovation, improvement, expansion, furnishing and equipping of parks and recreation facilities, including without limitation senior centers, athletic fields, parks, playgrounds, recreation centers, shelters and pool facilities and the acquisition of land therefor; and

WHEREAS, an application has been filed with the Secretary of the Local Government Commission of North Carolina requesting Commission approval of the General Obligation Parks and Recreation Bonds hereinafter described as required by the Local Government Bond Act, and the City Clerk has notified the City Council that the application has been accepted for submission to the Local Government Commission.

NOW, THEREFORE, BE IT ORDERED by the City Council of the City of High Point, North Carolina, as follows:

Section 1. In order to raise the money required for the purposes described above, in addition to any funds which may be made available for such purpose from any other source, General Obligation Parks and Recreation Bonds of the City are hereby authorized and shall be issued pursuant to the Local Government Finance Act of North Carolina. The maximum aggregate principal amount of such General Obligation Parks and Recreation Bonds authorized by this order shall be \$21,500,000.

Section 2. Taxes will be levied in an amount sufficient to pay the principal and interest on the General Obligation Parks and Recreation Bonds.

Section 3. A sworn statement of the City's debt has been filed with the City Clerk and is open to public inspection.

Section 4. This bond order will take effect when approved by the voters of the City at a referendum scheduled for November 5, 2019.

BOND ORDER AUTHORIZING THE ISSUANCE OF \$6,500,000 GENERAL OBLIGATION HOUSING BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA

WHEREAS, the City Council of the City of High Point, North Carolina (the "*City Council*") has ascertained and hereby determines that it is necessary to pay capital costs of providing housing projects

for the benefit of persons of low income, or moderate income, or low and moderate income, including without limitation construction or acquisition of projects to be owned by the City or a housing authority, and loans, grants, interest supplements and other programs of financial assistance to persons of low income, or moderate income, or low and moderate income, and developers of housing for persons of low income, or moderate income, or low and moderate income, and the acquisition of land therefor; and

WHEREAS, an application has been filed with the Secretary of the Local Government Commission of North Carolina requesting Commission approval of the General Obligation Housing Bonds hereinafter described as required by the Local Government Bond Act, and the City Clerk has notified the City Council that the application has been accepted for submission to the Local Government Commission.

NOW, THEREFORE, BE IT ORDERED by the City Council of the City of High Point, North Carolina, as follows:

Section 1. In order to raise the money required for the purposes described above, in addition to any funds which may be made available for such purpose from any other source, General Obligation Housing Bonds of the City are hereby authorized and shall be issued pursuant to the Local Government Finance Act of North Carolina. The maximum aggregate principal amount of such General Obligation Housing Bonds authorized by this order shall be \$6,500,000.

Section 2. Taxes will be levied in an amount sufficient to pay the principal and interest on the General Obligation Housing Bonds.

Section 3. A sworn statement of the City's debt has been filed with the City Clerk and is open to public inspection.

Section 4. This bond order will take effect when approved by the voters of the City at a referendum scheduled for November 5, 2019.

STATE OF NORTH CAROLINA)
) ss:
CITY OF HIGH POINT)

I, Lisa B. Vierling, City Clerk of the City of High Point, North Carolina, ***DO HEREBY CERTIFY*** that the foregoing is a true and exact copy of so much of the proceedings of the City Council as it relates to the introduction of the bond orders entitled “**BOND ORDER AUTHORIZING THE ISSUANCE OF \$22,000,000 GENERAL OBLIGATION STREETS AND SIDEWALK BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA,**” “**BOND ORDER AUTHORIZING THE ISSUANCE OF \$21,500,000 GENERAL OBLIGATION PARKS AND RECREATION BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA**” and “**BOND ORDER AUTHORIZING THE ISSUANCE OF \$6,500,000 GENERAL OBLIGATION HOUSING BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA**” by the City Council of the City of High Point, North Carolina, at a meeting held on the 15th day of July, 2019 and that such proceedings are to be recorded in the minute books of said City Council.

WITNESS my hand and the seal of the City of High Point, North Carolina, this the ____ day of _____, 2019.

City Clerk
City of High Point, North Carolina

(SEAL)

EXTRACTS FROM MINUTES OF CITY COUNCIL

* * *

A regular meeting of the City Council of the City of High Point, North Carolina (the “*City Council*”) was duly held in the Council Chambers of the Municipal Building located at 211 South Hamilton Street in High Point, North Carolina, the regular place of meeting, at 5:30 p.m. on July 15, 2019:

Members Present:

Members Absent:

* * * * *
* * *

Councilmember _____introduced the following resolution, a summary of which had been provided to each Councilmember, a copy of which was available with the City Clerk and which was read by title:

RESOLUTION OF THE CITY OF HIGH POINT, NORTH CAROLINA SETTING PUBLIC HEARINGS ON GENERAL OBLIGATION BOND ORDERS AND RELATED MATTERS

WHEREAS, bond orders entitled:

“BOND ORDER AUTHORIZING THE ISSUANCE OF \$22,000,000 GENERAL OBLIGATION STREETS AND SIDEWALK BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA;”

BOND ORDER AUTHORIZING THE ISSUANCE OF \$21,500,000 GENERAL OBLIGATION PARKS AND RECREATION BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA;” AND

“BOND ORDER AUTHORIZING THE ISSUANCE OF \$6,500,000 GENERAL OBLIGATION HOUSING BONDS OF THE CITY OF HIGH POINT, NORTH CAROLINA;”

have been introduced at a meeting of the City Council (the “*City Council*”) of the City of High Point, North Carolina this 15th day of July, 2019; and

WHEREAS, the City Council desires to provide for the holding of a public hearing thereon on August 19, 2019 and the submission of a statement of debt in connection therewith as required by The Local Government Bond Act.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF HIGH POINT, NORTH CAROLINA that the public hearing on said bond orders shall be held on the 19th day of August, 2019 at or about 5:30 p.m. in the Council Chambers of the Municipal Building located at 211 South Hamilton Street in High Point, North Carolina.

BE IT FURTHER RESOLVED that the City Clerk is hereby directed to cause a copy of said bond orders to be published with a notice of such hearing in the form prescribed by law in a newspaper of general circulation in the City on or before the 13th day of August, 2019.

BE IT FURTHER RESOLVED that the City's finance officer is hereby directed to file with the City Clerk, prior to publication of the bond orders, along with the notice of such public hearing, a statement setting forth the debt incurred or to be incurred, the net debt of the City, the assessed value of property subject to taxation by the City and the percentage that net debt of the City bears to the assessed value of property subject to taxation.

BE IT FURTHER RESOLVED that this Resolution shall become effective on the date of its adoption.

PASSED, ADOPTED AND APPROVED this 15th day of July, 2019.

STATE OF NORTH CAROLINA)
) ss:
CITY OF HIGH POINT)

I, Lisa B. Vierling, City Clerk of the City of High Point, North Carolina, ***DO HEREBY CERTIFY*** that the foregoing is a true and exact copy of so much of the proceedings of the City Council as it relates to a resolution entitled “**RESOLUTION OF THE CITY OF HIGH POINT, NORTH CAROLINA SETTING PUBLIC HEARINGS ON GENERAL OBLIGATION BOND ORDERS AND RELATED MATTERS**” duly adopted by the City Council of the City of High Point, North Carolina, at a meeting held on the 15th day of July, 2019 and that such proceedings are to be recorded in the minute books of said City Council.

WITNESS my hand and the seal of the City of High Point, North Carolina, this the ____ day of _____, 2019.

City Clerk
City of High Point, North Carolina

(SEAL)

CITY OF HIGH POINT

AGENDA ITEM



Title: NCDOT Municipal Agreement for Cost Participation
New Traffic Signal at N. University Parkway and Davis Avenue with
Upgrades to Decorative Poles and Mast Arms

From: Mark McDonald, Transportation Director

Meeting Date: Monday July 15, 2019

Public Hearing: No

Advertising Date: NA

Advertised By: NA

Attachments: Agreement, Location Map, Pictures

PURPOSE:

Consideration of a Municipal Agreement with the North Carolina Department of Transportation (NCDOT) for cost participation in the purchase of traffic signal pole and mast arm assemblies to be installed at the intersection of N. University Parkway and Davis Avenue.

BACKGROUND:

A traffic study conducted by NCDOT has found that the referenced intersection meets the required warrants for signalization, and funding for this traffic safety improvement was recently approved by the Board of Transportation. Plain, galvanized steel poles have been proposed by NCDOT as supports for a span wire configuration, however, the Transportation Department has requested that these poles be upgraded to match other signalized intersections that have been reconstructed in recent years. Similar locations are N. Main Street & Montlieu Avenue/Sunset Drive, N. Centennial Street & Montlieu Avenue, and University Parkway & E. Lexington Avenue. Other examples exist along the E. M.L. King, Jr. Drive corridor, and throughout the central business/Market district.

This upgrade from standard strain poles will make the signal less susceptible to wind damage and more aesthetically attractive. All service to the signal will be routed underground around the perimeter of the intersection.

BUDGET IMPACT:

The additional cost of black, powder-coated fluted pole and arm assemblies to fulfill the City's request is estimated at \$11,177. Upon completion of the project, NCDOT will invoice the City. Given the lead time necessary for fabrication, invoicing will not likely occur until FY 2021.

RECOMMENDATION / ACTION REQUESTED:

The Transportation Department requests City Council's approval of the Municipal Agreement with NCDOT for upgrade to the traffic signal pole and mast arm assemblies at the intersection of N. University Parkway and Davis Avenue.





City of High Point
City Council Meeting
February 4, 2019

Tab	Document
1.	Digital Billboards PSA Real Time Messaging
2A.	OAAA Digital Traffic Safety
2B.	OAAA What does the Traffic Accident Data Say?
2C.	Driving Performance and Digital Billboards - Final Report - March 22, 2007
2D.	The Effects of Commercial Electronic Variable Message Signs (CEVMS) on Driver Attention and Distraction: An Update - February 2009
2E.	Federal Highway Administration - Driver Visual Behavior In The Presence of Commercial Electronic Variable Message Signs (CEVMS) - September 2012
2F.	FHWA Final CEVMS Report Summary
3.	Letters
4.	Photos
5.	Letter from Asheville Tourist

Digital Messaging For Community Events, Activities, and Sporting Events

FAIRWAY

WIN **THIS CAR** WITH PINK CARES PIEDMONT



5\$ Tickets at



We partnered with Peters Auto Mall to help raise awareness of their raffle to win a car that raised money for breast cancer research.

Peters Auto Mall - Breast Cancer Awareness

FAIRWAY

HIGH POINT UNIVERSITY MEN'S LACROSSE

SEASON TICKETS

\$25^{+TAX}
ADULTS
\$15^{+TAX}
KIDS

=



FOR MORE INFO VISIT HIGHPOINTPANTHERS.COM/TICKETS OR CALL (336) 841-9276

VERT STADIUM

SATURDAY
12:00 P.M.

We use digitals to bring awareness to the community of upcoming games and ticket opportunities.

High Point University Lacrosse – Real Time Messaging

FAIRWAY

Here's To An

AMAZING SEASON

WF MENS SOCCER

CONGRATS

We use the digital to show our support to our local sports teams and universities.

Wake Forest University - Real Time Messaging

FAIRWAY



We use the digitals for real time countdowns for baseball games.

Community Sporting Venue – Real Time Countdown

FAIRWAY



MISS BABE RUTH'S
BARK IN THE PARK
gsohoppers.com JUNE 13 • 7PM



WE'RE HOME!
gsohoppers.com



\$1 HOT DOGS & DRINKS
MONEY OFF MONDAY
MAY 29 • 4PM



FANOMENAL FRIDAY
FIREWORKS!
gsohoppers.com MAY 26





TICKETS ON SALE NOW
NCWineFestival.com

PRESENTED BY **FOOD LION**



TICKETS ON SALE NOW
NCWineFestival.com

PRESENTED BY **FOOD LION**

We use the digitals to countdown the days to events happening in the community

NC Wine Festival – PSA Dynamic Content Countdown

FAIRWAY



VOTE TODAY

\$150,000 GRANT for **CAROLINA THEATRE**

VoteYourMainStreet.org

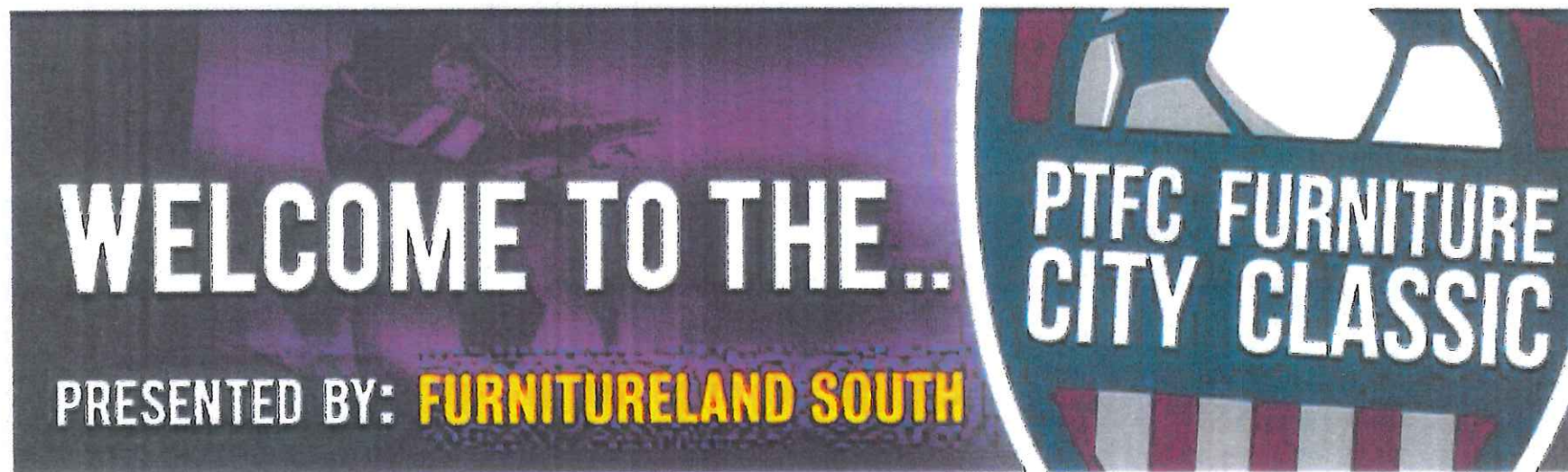


3 DAYS LEFT

Save A Seat

VoteYourMainStreet.org

We used the digitals to help bring awareness to the community about a \$150,000 grant that Carolina Theatre was trying to get. They wound up receiving the grant and sent us a letter stating that the digital billboards were a huge reason they got the grant.



PTFC Furniture City Classic– PSA Welcome Message For Community Event

FAIRWAY



CYCLING CLASSIC SAT. SEPT. 9TH



High Point Cycling Classic – PSA Community Event Advertising

FAIRWAY



We used our digitals to give students, parents and teachers an opportunity to shout their school, sports team, child, etc. using a twitter feed! Anyone could tweet from their phone to the @tomisGCshoutout twitter page for it to be shown all across the city.

Tomi's Shoutouts – Real Time Dynamic Twitter Feed

FAIRWAY



Congrats to

High Point's Tim Mabe

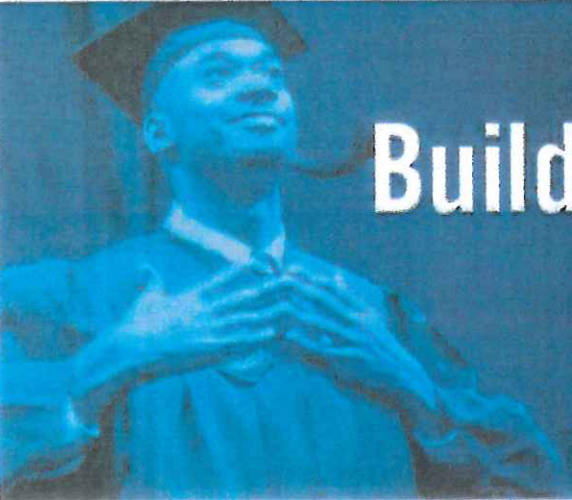
Awarded Governor's Long Leaf Pine Award

Congrats Tim Mabe – Real Time Community Interest Message

FAIRWAY

Local Economic Growth and Development Digital Advertising

FAIRWAY



Build your reputation on ours.



Conquer the world.

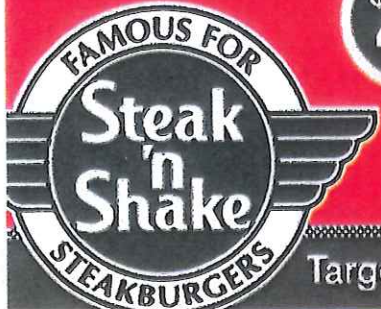


UNCG – Multi-Message For University Development

FAIRWAY




Target Shopping Center, Lawndale Dr.



\$4 MEALS

OPEN 24 HOURS



Target Shopping Center, Lawndale Dr.

OPEN 24 HRS



KIDS EAT FREE SAT & SUN

*One Drink In Kids Plate with every \$9 spent



Target Shopping Center - Lawndale Dr

Steak N Shake – Multi-Messaging For Economic Growth

FAIRWAY

FREE Breakfast Wednesdays!

Thruway Shopping Center



FREE Breakfast Wednesdays!

Yes, that's
tomorrow!

Thruway Shopping Center



FREE Breakfast Wednesdays!

Yes, that's
TODAY!

Thruway Shopping Center



Chick-Fil-A – Economic Development Week/Day Parting

FAIRWAY

© 2017 Cone Health - Outcomes Inc.™



Top 1% in the Nation.

This is today's Cone Health.



Nationally Recognized for Excellence in Behavioral Health.



conehealth.com/bhs

This is Today's Cone Health.

© 2017 Cone Health - Outcomes Inc.™



Top 1% in the Nation.

This is today's Cone Health.



Cone Health – Multi-Message For Community Health and Development

FAIRWAY

Digital Real Time Messaging For PSA-FBI, Amber Alerts, and Local Crimestoppers

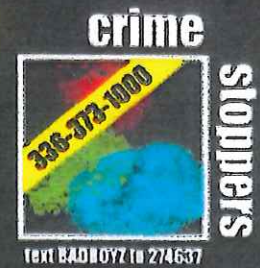
FAIRWAY



WANTED

Kelvin Whiteside

Indecent Liberties with a Child



Crime Stoppers • 336-373-1000



WANTED

Nicholas Garneau

Habitual Misdemeanor Assault



Crime Stoppers • 336-373-1000

We use digitals to help the local police departments find wanted people and get them off the street.

GPD Crimestoppers – Wanted People – PSA Real Time Messaging

FAIRWAY



MISSING PERSON

Gloria Smith 5'7" | 130 Lbs

Last Seen 10/7/16 **(336)373-2222**

We use digitals for scenarios like Gloria Smith who was missing for over a month. We put this image up on 10 digitals across Greensboro and within 2 hours of posting, her nurse saw the digital. She had been in the hospital as a Jane Doe. She couldn't remember who she was. The digital helped identify her and bring her back to her family.

Missing Person – Greensboro Local Crimestopper Real Time Messaging

FAIRWAY

**SEEKING
INFORMATION:**

Murder Victims

LAST SEEN: 2/13/2017, Delphi, Indiana
ABIGAIL WILLIAMS / LIBERTY GERMAN

844-459-5786



FBI



SUSPECT



VICTIM



VICTIM

We work directly with the FBI to help with widespread awareness of current cases whether it be seeking information or helping find criminals.

FBI – Seeking Information – Real Time Messaging

FAIRWAY

AMBER ALERT

ANY INFO CALL: 925-462-1212

Justin Knottingham

Male | Age 5YO | Blond Hair

2004 Blue Honda - Lic. # 5TIC261



Amber Alert - Real Time Dynamic Content

FAIRWAY

Digital Billboards PSA Real Time Messaging

FAIRWAY

LET'S SAVE THEM
BEFORE THEY'RE GONE

wildlifeday.org #iProtectBigCats

World Wildlife Day March 3

A taxidermied lion and its cub are shown in a close embrace. To their left is a circular WWF logo featuring a red panda on a globe.

LET'S SAVE THEM
BEFORE THEY'RE GONE

wildlifeday.org #iProtectBigCats

World Wildlife Day March 3

A taxidermied leopard is shown in profile, looking to the left. To its left is a circular WWF logo featuring a red panda on a globe.

LET'S SAVE THEM
BEFORE THEY'RE GONE

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World Wildlife Day March 3

A taxidermied tiger and its cub are shown in a close embrace. To their left is a circular WWF logo featuring a red panda on a globe.

World Wildlife Day – National PSA Advertising Message

FAIRWAY



Help people affected by
Hurricane Harvey.

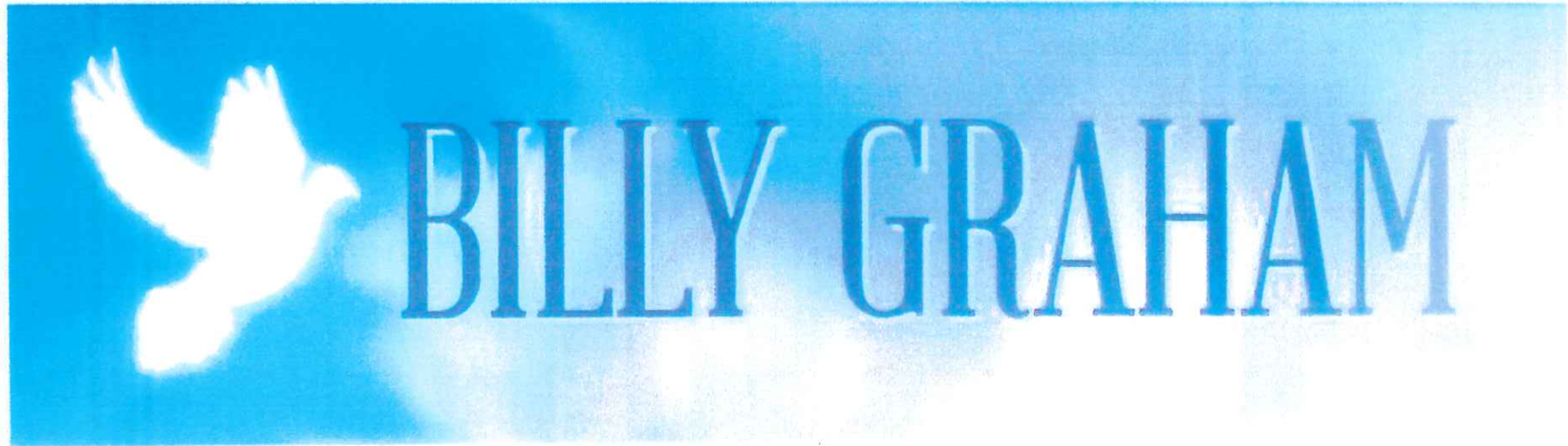
DONATE NOW

redcross.org



American Red Cross – PSA Digital Message

FAIRWAY



We can use our digitals to quickly put up tributes for people that had large impacts on the community.

Billy Graham - PSA Tribute

FAIRWAY



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DIGITAL TRAFFIC SAFETY

Research shows that billboards -- even the most attention-getting billboards -- are not related to accidents. The presence of billboards does not affect motorists' behavior, such as changing lanes or change speed.

New technology enables billboard copy to change electronically. Known as digital billboards, these signs display static messages, typically for six or eight seconds. State and local governments have reviewed accident records for roadways near digital billboards; they do not cite traffic safety problems associated with digital billboards. Likewise, an engineering analysis of three years of accident data in the Cleveland, OH, area showed no statistical relationship between digital billboards and accidents. A separate study of drivers in the same area said digital billboards are safety neutral.

Accident Research

Analysis of accident data -- by the industry and state and local governments -- shows that digital billboards are not related to accidents.



Albuquerque, NM 2010

Cleveland, OH 2009

Cleveland, OH 2007



Reading, PA 2010

Richmond, VA 2010

Rochester, MN 2009



Zoning



Jerry Wachtel's Review of
Cleveland 2007



Summary of Accident
Research

State and local jurisdictions have reviewed accident data to determine if the rate of accidents increased in proximity to digital billboards; these officials answered that question in the negative.



South Carolina Memorandum

Virginia DOT

"Our study has turned up no accidents reported to local police in the vicinity of the digital signs we've been monitoring."

James R. Barrett, C.P.E.S.C.
Regulatory and Compliance Manager
Asset Management Division
Virginia Department of Transportation
September 24, 2007



El Paso Memorandum

New York Department of Transportation

"There is no empirical evidence at this time to indicate a CEVMS message changing every six seconds results in an increased risk of accidents."

From the NY DOT guidelines (October 28, 2008)



Rochester, MN Letters

City of Albuquerque
Chamber of Commerce
Letter

El Paso County, TX
Sheriff's letter

Driver Behavior Research

Typical eye glances in the direction of digital billboards are less than one second, which is well under the risk threshold identified in a major federal study (The NHTSA 100-car study performed by VTTI).

In 2007, the outdoor advertising industry's foundation (FOARE), commissioned Virginia Tech Transportation Institute (VTTI) to study driver behavior in relation to digital billboards in Cleveland, OH. The study found:

- Drivers did not glance more frequently in the direction of digital billboards than in the direction of other event types
- Drivers did take longer glances in the direction of digital billboards and comparison sites than in the direction of static billboards and baseline sites
- The mean glance at the digital billboards lasted less than 1.6 seconds



VTTI Cleveland 2007

Cunitz Review of Swedish
Report

Summary of Cunitz Review

FHWA Traffic Safety Research Documents

In early 2008, FHWA initiated driver behavior research similar to the industry's VTTI research to determine whether or not digital billboards ("Commercial Electronic Variable Message Signs") are a potential driving hazard. In-car driving tests were conducted in Reading, PA, and Richmond, VA. On December 30, 2013, FHWA released the final report. The 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.
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. In short, the FHWA study determined that digital billboard glances are well within federal safety standards concerning driver distraction.

In short, the FHWA study determined that digital billboard glances are well within federal safety standards concerning driver distraction.



FHWA – The Effects of CEVMS on Driver Distraction



FHWA-Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)-Final Report

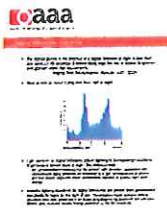


FHWA Final CEVMS Report Summary

Research Summaries



Industry Traffic Safety Research



Nighttime Research White Paper



Summary of Past Traffic Research Studies



Importance of Government Crash Data

Opposition Research

3000 Analysis of the Emergency Room
Report Publishing for the
Transportation Safety

2010-2011

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AASHTO - Wachtel Final
Report April 2009



OAAA White Paper on
AASHTO-Wachtel Report

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Outdoor Advertising Association of America

What does the Traffic Accident Data Say?

Traffic accident data is a valued, standard tool for policy makers. The National Highway Traffic Safety Administration (NHTSA) sums up this point:

"Traffic records are the basis for defining, managing, and evaluating traffic safety and performance."

Did you know that crash-data studies show no increase in accidents near digital billboards? Industry in these markets reviewed:

- **Cuyahoga County, OH (2007)**
 - Accident reports **3 years** before and after installation of digital billboards
 - **7 digital billboards** located along Interstates
 - **33,000 accident records** from the Ohio Department of Transportation.
- **Rochester, MN (2009)**
 - Accident reports spanning more than **4 years** before and after installation
 - **5 digital billboards** located along local roads
 - **18,000 accident records** from the local police department.
- **Cuyahoga County, OH (2009)**

This study updated the 2007 report, evaluating more time and data:

 - Accident reports **4 years** before and after installation
 - **7 digital billboards** along Interstates (same structures as 2007 study)
 - **60,000+ accident records** from the Ohio DOT
- **Albuquerque, NM (2010)**
 - Accident reports spanning **3½ years** before and after the installation
 - **17 digital billboards** located along local roads
 - **7,000+ accident records** from the local police department
- **Reading, PA (2010)**
 - Accident reports spanning **4 years** before and after installation
 - **26 digital billboard faces** on 20 structures along expressways and local roads
 - **35,000 accident records** from Pennsylvania DOT and local police

Key Findings

- There is no statistically significant relationship between accidents and digital billboards; digital billboards are “safety neutral”
- More than 120,000 accident records in proximity to 55 digital billboard faces were analyzed
- *Circumstances different . . . conclusion the same*
 - Size of digital billboards were different:
 - Standardized bulletins in Cuyahoga County (14'x48')
 - Standardized bulletins in Rochester (10'6"x36')
 - Standardized posters in Albuquerque (12'x24')
 - Variety of bulletins, posters, and miscellaneous sizes in Reading
 - Digital billboard locations were different:
 - Along **Interstates** in the Cuyahoga County
 - Along **local roads** in Rochester and Albuquerque
 - Along **local roads and expressways** in Reading
 - Combined traffic counts exceed one-half billion cars per year
- *The age of driver is a neutral factor*
 - Younger drivers (under 21) show no increases in accident rates
 - Older drivers (over 65) show no increases in accident rates

The researchers said: “For comparisons of younger, older or nighttime drivers, there are no increases in accident rates near these digital billboards”
- *Time of day is a neutral factor*
 - Daytime and nighttime comparisons show no increases in rates in the area surrounding the digital billboards

The consistent outcome from these studies:

Digital Billboards are NOT Linked to Accidents



Outdoor Advertising Association of America

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 (VTII).
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/

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 HILL

January 07, 2014 02:57 PM

DOT study finds digital billboards don't distract drivers

By NER LARJ

f 16 10 10 10 10

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 (FHWA), found that drivers are not any more likely to be distracted by digital billboards than stationary signs.

Driving Performance and Digital Billboards

FINAL REPORT

Prepared for:

Foundation for Outdoor Advertising Research and Education

By:

Suzanne E. Lee

Melinda J. McElheny

and

Ronald Gibbons



**TRANSPORTATION
INSTITUTE**

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 open-ended description of the main distracting factor in the accident, and over 1,400 responses were recorded. One response (out of 2,800 crashes) included a billboard being repaired as a causal factor for driver distraction leading to a crash. No mention of outdoor advertising was made in any other place in the study, despite the fact that 35% of distracters were outside of the vehicle in question (62% were in-vehicle and 3% were unknown). Typical in-vehicle distracters included passenger/children distraction (8.7%), adjusting radio/changing CD or tape (6.5%), eating or drinking (4.2%), and cell phone (3.9%). Typical out of vehicle distracters included looking at crash, other roadside incident, or traffic (13.1%), looking at scenery or landmarks (9.8%), and weather conditions (1.9%). There were also 25 cases of drivers being distracted by traffic signs or signals (<1%).

Tantala and Tantala (2005) have been the most recent researchers to attempt a rigorous examination of the relationship between advertising signs and traffic accidents. They used methods intended to control for the analytical issues noted with early studies of this type. They conducted two analyses for this research. In the first situation, a highway (New Jersey Turnpike) with advertising signs was selected and studied, including analysis of sign location, road conditions, and traffic-accident locations, to determine whether traffic accidents were more

prevalent at or near existing signs. More than four years of data and 23,000 accidents were used in this analysis. Statistical correlation coefficients showed that the correlation was statistically low for all analyses conducted, including accident density and sign density (with and without interchanges included), accident distance and viewer reaction distance (again with and without interchanges included), and accident density and proximity to the sign. They also found that these correlation values were consistent from year to year. This section of the analysis led them to conclude that there are no statistical or causal relationships between advertising signs and accidents.

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

Researchers are beginning to conduct more studies of driver performance in the presence of various types of advertising signs. For example, Beijer, Smiley, and Eizenman (2004) studied video advertising signs (those with full motion displays) in Toronto using eyegance 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 eyegance location were used as primary measures of driver visual performance. Additional measures were included to provide further insight into driving performance; these included speed variation and lane

deviation. The overall conclusion from this study was that there is no measurable evidence that billboards cause changes in driver behavior in terms of visual behavior, speed maintenance, and lane keeping. A rigorous examination of individual billboards that could be considered to be the most visually attention-getting demonstrated no measurable relationship between glance location and billboard location. Driving performance measures in the presence of these specific billboards generally showed less speed variation and lane deviation.

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

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

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

The only currently available research report related to electronic billboards is a literature review sponsored by the FHWA (Farbry, Wochinger, Shafer, Owens, and Nedzesky, 2001). The motivation for this report was to fill the knowledge gap in this area since the last attempt by Wachtel and Netherton in 1980. However, the material does not appear to address the instantaneously changing digital billboards of the type discussed in the current report. Examples shown pictorially in Farbry et al. (2001) are signs with changeable elements (such as time and temperature signs), tri-vision signs, and video digital billboards of the type studied by Beijer et al. (2004). Farbry et al. (2001) raised questions about safety implications with regard to driver distraction, summarized current knowledge in this research field, assessed areas needing

exploration, and developed a research plan to address them. While some electronic billboards (EBBs) display motion and color with fine detail, others just show a short sequence of words in which each letter is composed of a matrix of LEDs (Farbry et al., 2001). This type of display is also used by governmental agencies to present information to drivers and is known by several different acronyms: variable message sign (VMS); dynamic message sign (DMS); and changeable message sign (CMS). A tri-panel sign, also known as a tri-vision sign, is composed of triangular cylinders that rotate periodically, showing a different composite image in between each rotation. The only movement is that of the images in transition.

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

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

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

Other than age, a variable that may influence the degree to which a sign distracts a driver is route familiarity (Farbry et al., 2001). A driver who is new to a road may be looking for navigational or service cues, and this task may 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 Tantalala and Tantalala (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 $2 \times 2 \times 2 \times 2 \times 4$ 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.

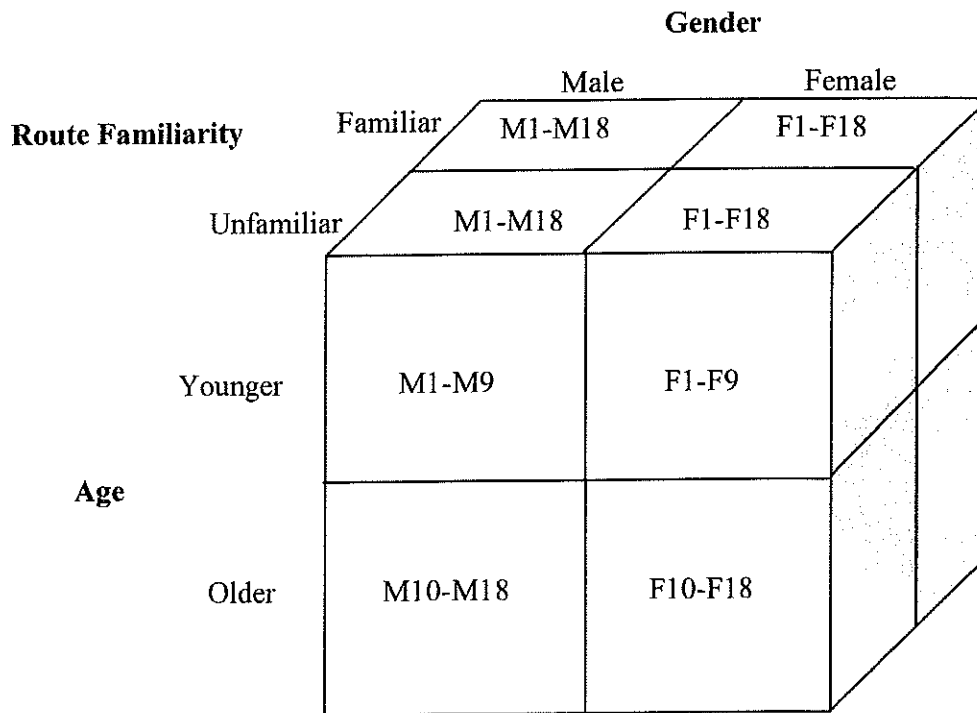


Figure 1. Assignment of Participants to Experimental Conditions.

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.

Digital Billboards. 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 print, 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.

Baseline events. The baseline event type referred to areas with no billboards or other large signs visible (except for perhaps speed limit and other small traffic control signs). These 12 areas

served as locations with which to compare velocity, lane position, and glance patterns and are indicated by blue dots (●) in Figure 2.

Table 2. Event Types Indicating Description, Side of the Road, Latitude, Longitude, and Specific Site Location Information.

	Event Type	Description	Side	Latitude	Longitude	Site	Road Type
1	4	Baseline	Both	41.41208267	-81.6701355	480 W, W/O Lancaster Dr.	I
2	2	Static Billboard	Left	41.42123795	-81.69820404	480 W, W/O Broadview Rd.	I
3	3	On Prem/Logo	Right	41.42151642	-81.70906067	480 W, E/O State Rd.	I
4	2	Static Billboard	Left	41.42173767	-81.71897125	480 W, E/O Pearl Rd.	I
5	4	Baseline	Both	41.42321014	-81.74341583	480 W, W/O Ridge Rd.	I
6	2	Static Billboard	Left	41.42559433	-81.76654053	480 W, W/O Tiedeman Rd.	I
7	2	Static Billboard	Right	41.42352295	-81.77274323	480 W, E/O W. 130th St.	I
8	1	LED Billboard	Left	41.42056274	-81.78245544	480 W, W/O W. 130th St.	I
9	3	On Prem/Logo	Left	41.42053986	-81.7904892	480 W, @ W. 139th St.	I
10	2	Static Billboard	Left	41.42324829	-81.80148315	4866 West 150th	S
11	4	Baseline	Both	41.4307785	-81.80125427	4545 West 150th	S
12	2	Static Billboard	Left	41.43348694	-81.79000854	13986 Puritas Ave	S
13	4	Baseline	Both	41.43657303	-81.78400421	13456 Bellaire Rd	S
14	3	On Prem/Logo	Left	41.43969727	-81.77674103	12686 Bellaire Rd	S
15	3	Tri-Vision Billboard	Right	41.44282913	-81.77227783	12071 Bellaire Rd	S
16	4	Baseline	Both	41.45092773	-81.76893616	3757 West 117th	S
17	2	Static Billboard	Left	41.46089554	-81.76893616	3370 West 117th	S
18	4	Baseline	Both	41.46966553	-81.75019836	90 E, @ W. 97th St.	I
19	1	LED Billboard	Right	41.47394943	-81.72478485	90 E, @ W. 55th St.	I
20	2	Static Billboard	Left	41.47385406	-81.70856476	90 E, W/O Fulton Rd.	I
21	3	On Prem/Logo	Left	41.48424911	-81.69098663	90 E, S/O Abbey Ave.	I
22	1	LED Billboard	Right	41.4903717	-81.68776703	90 E, @ W. 3rd St.	I
23	3	On Prem LED Billboard	Left	41.49866867	-81.67558289	2071 Carnegie Ave.	S
24	3	On Prem/Logo	Left	41.49928284	-81.67251587	2351 Carnegie Ave.	S
25	3	On Prem LED Billboard	Left	41.52510452	-81.66101074	90 E, E/O E. 49th St.	I
26	3	Building	Right	41.53549194	-81.64455414	90 E, W/O E. 72nd St.	I
27	2	Static Billboard	Right	41.54089737	-81.62488556	90 E, W/O E. 99th St.	I
28	2	Static Billboard	Right	41.54464722	-81.61724854	90 E, W/O E. 105th St.	I
29	4	Baseline	Both	41.5479126	-81.60997009	90 E, @ E. 109th St.	I
30	3	On Prem/Logo	Right	41.55478668	-81.59642029	90 E, @ Coit Rd.	I
31	4	Baseline	Both	41.56173325	-81.59170532	90 E, W/O E. 140th St.	I
32	4	Baseline	Both	41.56638718	-81.57984161	90 E, W/O E. 152nd St.	I
33	2	Static Billboard	Right	41.57143021	-81.56455994	90 E, @ E. 167th St.	I
34	3	On Prem/Logo	Right	41.57068634	-81.56790924	90 W, @ E. 161st St.	I
35	4	Baseline	Both	41.56744385	-81.57712555	90 W, W/O E. 152nd St.	I
36	4	Baseline	Both	41.55927277	-81.59375763	90 W, W/O E. 140th St.	I
37	1	LED Billboard	Left	41.54701233	-81.61243439	90 W, W/O E. 105th St.	I
38	2	Static Billboard	Left	41.54128647	-81.62450409	90 W, W/O E. 99th St.	I
39	3	On Prem LED Billboard	Right	41.52567673	-81.66069031	90 W, W/O E. 55th St.	I
40	2	Static Billboard	Left	41.49006653	-81.66697693	77S, S/O Woodland Ave.	I
41	2	Static Billboard	Right	41.48295593	-81.66287231	77 S, @ I-490 Exit	I
42	1	LED Billboard	Right	41.46414566	-81.65770721	77 S, S/O Pershing Ave.	I
43	4	Baseline	Both	41.45179367	-81.65712738	77 S, N/O Harvard Ave. Exit	I
44	2	Static Billboard	Left	41.4439621	-81.65229797	77 S, N/O Grant Ave. Exit	I

Event Type: 1=LED Billboard, 2=Static Billboard, 3=Comparison, 4=Baseline

Road Type: I=Interstate, S=Surface Street

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.

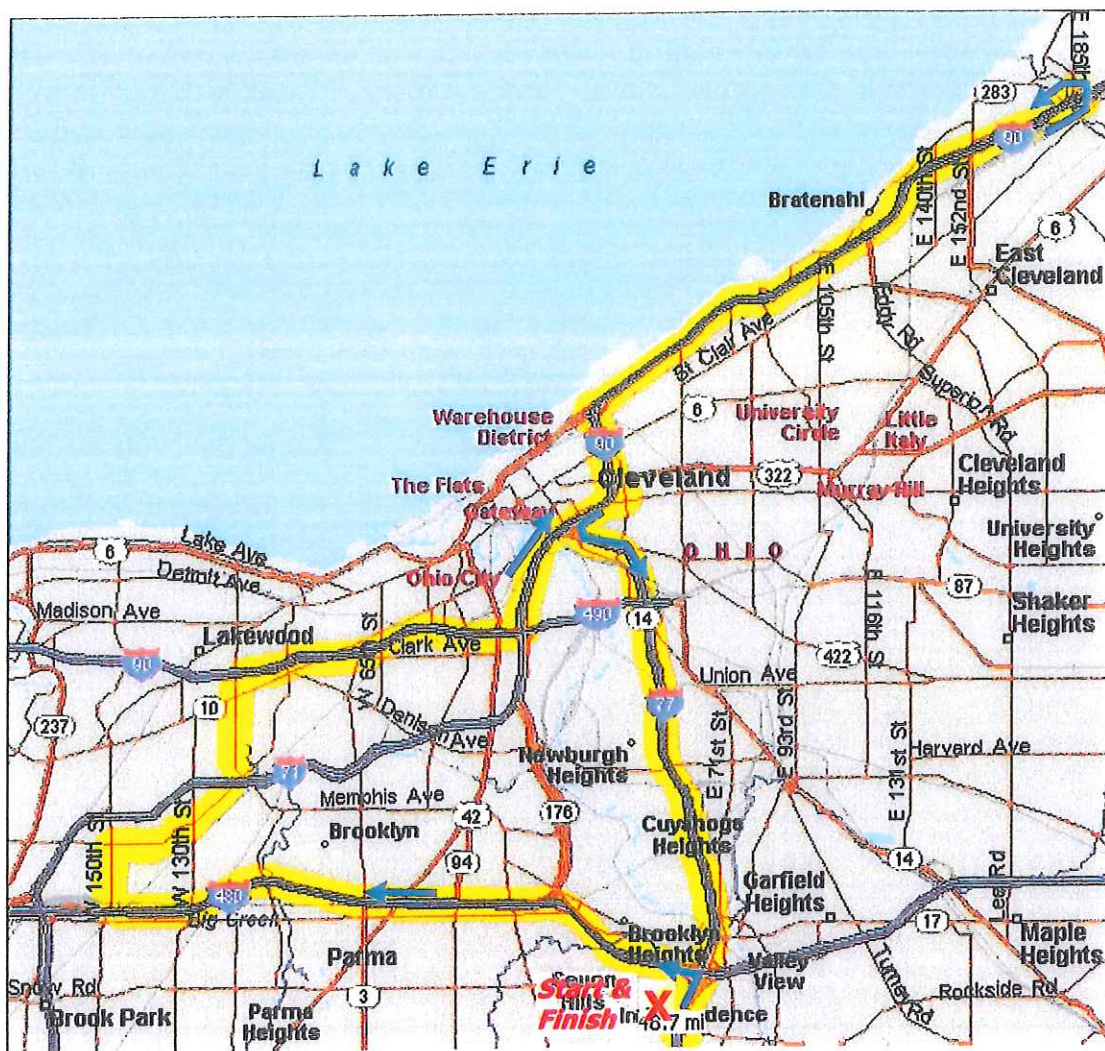


Figure 5. Map of 50-mile Daytime Loop Route in Cleveland, Ohio.

Table 3. Directions for 50-mile daytime route in Cleveland, OH.

<u>Directions</u>	<u>Trip Distance</u>	<u>Notes</u>
← Left out of Residence Inn onto W. Creek Rd.	0.0	
← Left onto Rockside Rd.	0.3	
⇒ Right toward I-77 North	0.5	Go under overpass to I-77 N entrance
Left lane onto I-480 West / Toledo	1.1	
EXIT 12A Right Exit 12A, turn Right onto W. 150th St.	9.9	
⇒ Right onto Puritas	10.9	Curves to Left, becomes Bellaire
← Left onto W. 117th	13.1	Just past entrance to I-71
⇒ Right onto I-90 East / Cleveland	14.4	
EXIT 172A Right Exit 172-A, East 9th St.	20.1	Stay to Right
⇒ Right onto Carnegie	20.4	
← Left onto East 30th St.	21.3	DODD Camera on far left corner
← Go 1 block, Left onto Prospect	21.4	
← Go 500 ft., Left onto I-90 East	21.5	
EXIT 182A Right Exit 182A, Right onto E. 185th St.	30.9	
Stay in Right Lane and get onto I-90 West to Downtown	31.2	Stay on 90 W when splits to left
EXIT 172A Take Right Exit 172A to I-77 South	41.2	
Follow I-77 South to Rockside Road exit	48.2	
EXIT 155 Take Exit 155 Rockside Road and Independence, turn Right onto Rockside Rd.	48.8	
⇒ Turn Right onto W. Creek Rd.	48.9	
⇒ Turn Right into Residence Inn parking lot	49.2	

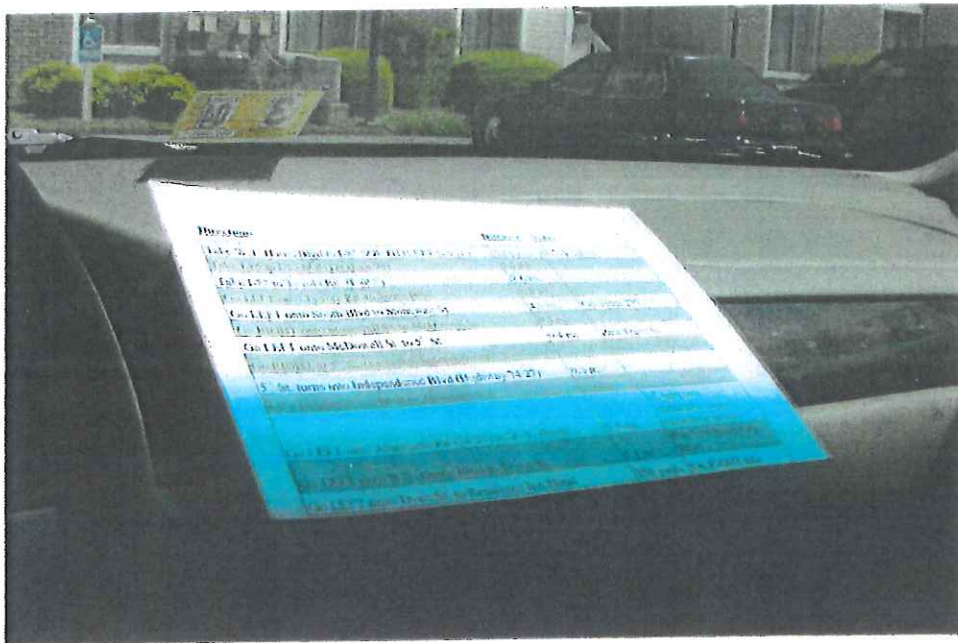


Figure 6. Directions mounted on dashboard of vehicle (this picture is from a previous experiment which used the same protocol and vehicle type).

Practice Route. A short, 1.5-mile practice route was also included. This route was driven prior to data collection on the 50-mile loop route. During the practice route, the experimenter rode as a passenger with the participant to make sure that the participant was familiar with the directions and the vehicle's displays and controls. Table 4 lists the directions for the practice route, which was conducted on local streets near the hotel where the study began and ended.

Table 4. Directions for 1.5-mile Practice Route in Independence, Ohio.

<u>Directions</u>	<u>Trip Distance</u>	<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.

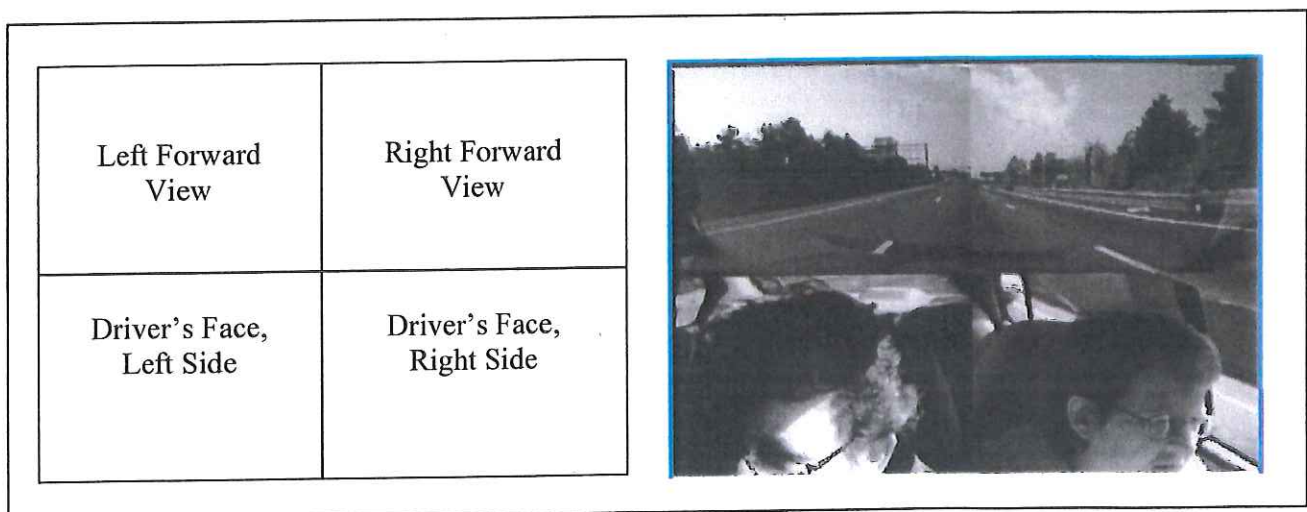


Figure 11. Diagram of Simultaneous Presentation of Four Camera Views.



Figure 12. Data Acquisition System Located in Trunk of Vehicle.

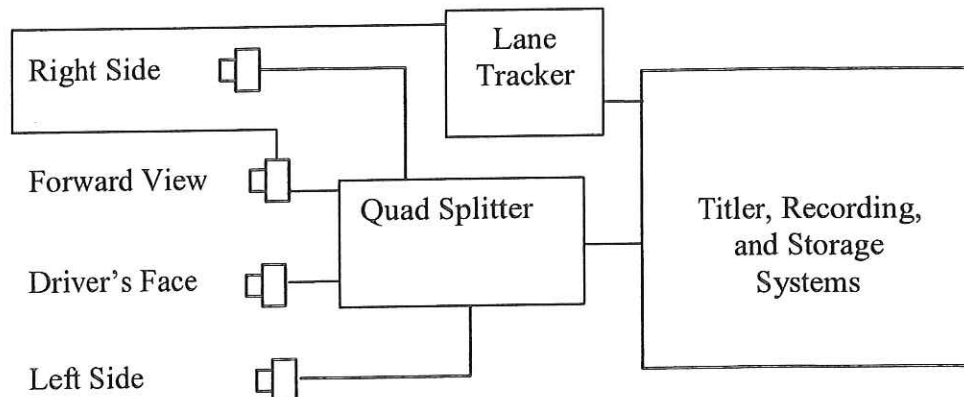


Figure 13. Components of the Data Collection System.

All video data were recorded at 30 Hz (30 frames per s), using MPEG 4 compression algorithms at a rate of 4 MB per minute. Driving performance data, including lane position and velocity, were collected at 10 Hz (10 times per s). The lane tracking system used fuzzy logic and statistical probabilities to detect lane edges in the forward camera view. Lane position was collected with a resolution of ± 2 inches from the center of the lane. Raw performance data, including lane position, velocity, and video data, were saved on the hard drive of a laptop computer and then backed up onto individual DVDs for each participant. After each trial, the experimenter reviewed the data to assure that the data collection system performed to specification.

Procedure

Participant Recruitment and Screening

Straight-text newspaper advertisements were placed in the *Cleveland Plain Dealer* (Figure 3) and flyers were posted in strategic locations in Cleveland, OH to solicit volunteer participants for the study. Respondents were instructed to contact the experimenter via email or by telephone. A telephone/email screening form (Appendix A) was used to collect general information on age, gender, medical, and driving history, familiarity with the route(s), and use of corrective lenses or sunglasses. A list of potential participants was compiled as screenings were completed, and participants who met all of the required criteria were then contacted to set up an appointment for participation. The participant met the experimenter on the appropriate date and time in the hotel lobby of the Residence Inn on West Creek Road, in Independence, OH (just south of Cleveland).

Experimental Protocol

Upon arrival, each participant presented a valid driver's license for the experimenter's inspection. Each participant then completed an informed consent form (Appendix B) and a health screening questionnaire (Appendix C). Participants also completed a vision test using a Snellen eye chart. Only participants with vision of 20/40 or better were eligible to participate.

Participants received an orientation (including the practice route), drove the 50-mile experimental route, completed a post-drive questionnaire (Appendix D), and received \$20/hr for their time. Most participants completed the experiment in less than two hours. All procedures for recruitment and data collection were approved by the Virginia Tech IRB, as required by federal and state law.

In all, 36 drivers were recruited for the full experiment. Another participant completed the experiment, but the data were not used because it rained during most of the session. Of the 36 drivers who completed the experiment, 3 repeated the experiment on a later date due to rain. That is, their initial data were not used and were replaced with the second driving session. The order in which participants were run in the experiment is shown in Table 5.

Table 5. Order of Participation (shown by Age and Gender).

Number	AgeGrp	Gender
1	O	M
2	O	M
3	Y	M
4	O	M
5	Y	F
6	Y	F
7	O	F
8	Y	F
9	O	F
10	Y	M
11	O	F
12	Y	M
13	O	M
14	O	M
15	Y	M
16	O	F
17	O	F
18	O	F
19	O	M
20	Y	F
21	Y	M
22	Y	F
23	Y	F
24	O	M
25	Y	F
26	O	F
27	O	M
28	Y	M
29	O	F
30	Y	F
31	Y	F
32	O	F
33	Y	M
34	Y	M
35	Y	M
36	Y	F

The informed consent form explained the general purpose of the experiment to the driver and obtained his/her permission to participate in the study. After the required paperwork was completed, the following script describing the experiment was read aloud to the participant:

Today we will have you drive a pre-determined loop route along major freeways and highways. The vehicle that you will be operating is specially equipped with instruments that collect information about your driving habits. The purpose of this

study is to collect information about the way people drive under normal circumstances, in order to improve driver safety. We want you to drive as you would if you were in your own vehicle and were driving, for example, to visit a friend, do an errand, or go to work. With this in mind, we will also want you to obey all typical traffic regulations as you normally would, including, but not limited to, posted speed limits, lane markings, and traffic control devices (such as stoplights).

I will be riding in the passenger seat during a 5-minute orientation drive. You are welcome to ask questions if necessary, as this orientation will help you become familiar with the vehicle and its controls. As always, our first priority is your safety. If at any time you feel uncomfortable please inform me and we can make any necessary adjustments or end the study early.

After the 5-minute orientation, I will exit the vehicle and have you drive the pre-determined route, which will bring you back to this location. This route will take about 1.5 hours. A map and written instructions will be provided for your reference, and I will also review the route with you before you depart. After the route is completed, I will debrief you and the session will be complete.

Do you have any questions I can answer at this time?

The experimenter then reviewed the map (Figure 5) and directions (Table 4) in detail. A laminated copy of the map was stored in the glove compartment for easy reference. A laminated copy of the directions was prominently displayed on the dashboard (Figure 6). A cellular telephone was also stored in the glove compartment for emergency use only.

The experimenter then oriented the participant to the vehicle, including adjustment of the seat, seat belt, mirrors, and steering wheel. Displays and controls were also reviewed, including a review of the map, directions, and cell phone operation instructions. The participant then drove the 5-minute orientation route, with verbal reminders provided by the experimenter when required. After the orientation route was completed, the experimenter checked the data, reminded the participant to drive as he/she normally would, and then returned to the hotel. The participant drove the 50-mile loop route, which eventually brought him/her back to the hotel.

After the experiment, in-vehicle eyeglance calibration was completed in the hotel parking lot. With the vehicle parked, the experimenter sat in the passenger seat and provided verbal instructions. The protocol included having the participant sit as if driving, while alternating 3-second glances to various locations with a default forward glance location. The glances included left blind spot, left window, left mirror, left forward, forward, right forward, right mirror, right window, right blind spot, rear view mirror, instrument panel (speedometer), and climate and radio controls.

After the eyeglance calibration, the participant and the experimenter returned to the hotel lobby, where the post-drive questionnaire was completed (Appendix D). The experimenter then reviewed the questionnaire to make sure that all of the answers were legible. Item #3, "Please check the top five items that most caught your attention during your drive," included a "Billboards" option (among a list of 18 possible items). If the experimenter noticed that

"Billboards" had been marked, she asked about every checked item in an attempt to discover the details as to what caught their attention. For the billboard item specifically, the experimenter noted what aspect of the billboard caught the participant's attention, without conveying the importance of that particular topic. Payment was then issued to the driver at a rate of \$20 per hour, (2 hours in most cases, for a total of \$40) and a payment log was signed to verify that funds were received. At no time was the participant made aware that this experiment was related to driving behavior regarding billboards or other roadside items.

Data for each participant were briefly reviewed to verify that all the cameras were operating correctly and that data had been recorded. Data and video files were then transferred from the data collection system's computer to a portable laptop computer. Each participant's data were copied onto a separate DVD as a second back-up measure. The results from the post-drive questionnaire were then entered into an Excel spreadsheet for later processing.

Data Reduction

Analyst Training

Two data analysts worked on this project under the supervision of the principal investigator. All analysts were experienced in video data reduction prior to this project. Training began with a 2-hour session in which the user manual was reviewed and the analysis software was demonstrated by the experimenter. Relevant functions were shown, and the process of how to load the map and associated GPS coordinates was explained. Prior to actual data analysis, each analyst spent an additional eight hours mastering eyeglance direction determination and spreadsheet use. This period included time with an experienced analyst present. A large part of that time was dedicated to establishing inter-analyst reliability by comparing judgments and modifying techniques until all analysts' independent determinations matched. Throughout the entire analysis effort, at least one experienced analyst was available at all times to answer any questions or review particular cases as needed. "Spot checks" were performed throughout the data reduction process, with input provided as needed to maintain a high level of consistency. Robust reliability was further assured by ascertaining that each analyst recorded a portion of the data from each participant (i.e., a portion of the data for each of the 36 participants was analyzed by each analyst). As events were completed, a written record was created with the analyst's initials and date of completion.

Software

This section outlines the data reduction software program developed to analyze digital billboard, conventional billboard, comparison, and baseline events. The software, currently called DART (Data Analysis and Reduction Tools), was originally developed by software engineers at VTTI for a large-scale naturalistic driving study known as the 100 Car Study (Dingus, Klauer, Neale, Petersen, Lee, et al., 2006). This program integrates Microsoft MapPoint 2003 using GPS data for billboard, comparison, and baseline site locations with the data obtained from the multiple sensors in the test vehicle via a graphical interface. A total of 36 files (representing the route driven for each participant) were analyzed. After a file was opened, the software presented the analyst with the relevant windows required for data identification and reduction. The MapPoint

application allowed the analyst to view a map of the Cleveland, OH area, showing the relationship between the site and the roads, so that video could be compared with GPS data during site identification and eyeglance analysis. The map illustrated the route and the location of the vehicle, which was represented by a green vehicle icon that moved as the event was played. This map served solely as a visual display and could not be manipulated.

Procedure

Data reduction was performed by the two analysts for each of the 36 data files. This occurred in three steps: software preparation, event identification, and eyeglance analysis. Analysts were blind as to which event type was being analyzed (in other words, they knew the event only by its number, and did not know what type of event was contained in that segment of data). This was done to insure impartiality in this aspect of the data reduction (event identification and eyeglance reduction were the only two aspects of data analysis which had a subjective component; this was compensated for by re-doing 10% of the events and calculating inter-rater reliability).

Event Identification

Analysts first used the DART software to identify the locations of interest. The GPS coordinates for each location were entered into a master map. Each file was then opened and the DART software suggested the correct point for each location of interest based on the master GPS list. The analyst compared the forward view shown in the video with a master file of forward views and adjusted the event timing slightly if necessary to make sure the forward views were the same for every participant (thus providing a common geographic point of reference for each event analyzed). The end of an event was defined as the sync number (time reference) at which the test vehicle passed the site, and the event's beginning was calculated to be eight seconds before the end point. Identification of the end point thus combined two methods: the GPS data was used to align the vehicle directly in conjunction with the site, and then the video was used to visually confirm accurate GPS positioning using comparison to a master file of forward views.

Eyeglance Analysis

Once all of the events were correctly identified and stored in the database, the analysts conducted the eyeglance analysis for each event. The first step in eyeglance analysis was familiarization with the participant's individual glance patterns by means of a glance location calibration video, during which participants looked at specific places according to a set script. Analysts referred often to the calibration file collected for each participant to make sure that the glance locations were being coded correctly.

As described in the procedures section, eye calibration was conducted *after* data collection was complete, in order to serve as a record of how a particular driver's glance to particular location is shown in video. Analysts reviewed these records in order to become familiar with the

participant's glance style. The analyst was thus able to conduct the glance analysis according to each participant's glance style. Glances were coded according to the following abbreviations:

- F - Forward
- RF - Right Forward
- LF - Left Forward
- RVM - Rear View Mirror
- OX - Outer eXterior, including side mirrors, side windows, blind spot, etc.
- DIR – glances toward the experimental route DIREctions
- OINT - Other INTerior, including speedometer, sun visor, cell phone, etc.

Analysts reviewed events from beginning to end, one tenth of a second at a time, determining the direction of glance for every tenth of a second for the eight-second duration of the event. New glances were recorded as the sync number at which the participant's glance *rested* in a new location. Transition time to the new location was included in the glance location the driver was moving *away* from. The DART program automatically calculated the duration of each glance. Summary information for each event included the number of glances, average glance duration, number of glances in each direction, and the average duration of glances in each direction. The final inter-rater reliability for the eyeglance reduction process was 96.5%, which is considered quite good. Approximately 5% of the daytime events were analyzed by both raters independently, resulting in 8,084 individual glance locations, each lasting 0.1 s. The agreement between raters for each location was compared; the 96.5% reliability means that the raters were in agreement for 7,804 glance locations.

Final Reduced Data Set

With 36 participants and 44 sites, there were 1,584 events available for analysis from approximately 63 hours of data collection. A small amount of data was lost due to cell phone use, sensor outages, sun angle, and vehicle stoppages, leaving 1,540 events for eyeglance analyses. Altogether, 124,740 video frames were analyzed (1,540 events x 81 frames/event) and 8,678 individual glances were identified. The speed data was filtered to remove events as described above, and then further filtered to remove events in which the maximum speed failed to read 20 mph or the minimum speed failed to reach 15 mph, leaving 1,494 events in this dataset, with 121,014 data points for speed. The lane position dataset was further filtered to remove events indicating a possible lane change or lane position sensor failure (often due to poor lane markings). After filtering, there were 1,188 events remaining in the lane position dataset, with 96,228 data points.

Statistical Analysis

Descriptive statistics were calculated using Excel. All other statistical analyses were conducted using SAS statistical software. The analysis of variance (ANOVA) statistical technique was used; in SAS this was accomplished by means of the general linear model (GLM) procedure. Where significant differences were found, and there were more than two levels of the independent variable, a post-hoc analysis was run using the Least Squares Difference procedure

in SAS to determine which levels were significantly different from which other levels. (For independent variables with just two levels that differ significantly, a simple examination of the means will demonstrate which level is significantly greater than the other.)

Nighttime Study

A smaller exploratory study was also conducted at nighttime using an abbreviated route that avoided some of the downtown streets. Given that the digital signs being studied were intrinsically illuminated, this was felt to be an important first step in determining whether there are driver performance differences in the presence of these signs under different levels of ambient illumination. All of the nighttime drivers had previously driven the route during the daytime and were thus somewhat familiar with the route (so were unlikely to get lost or go off route). The nighttime route directions are shown in Table 6, while the order of participation is shown in Table 7 (12 of the 36 drivers returned for the nighttime experiment). The nighttime route map is shown in Figure 14.

Table 6. Nighttime Driving Directions.

<u>Directions</u>	<u>Trip Distance</u>	<u>Notes</u>
← Left out of Residence Inn onto W. Creek Rd.	0.0	
← Left onto Rockside Rd.	0.3	
➡ Right toward I-77 North	0.5	Go under overpass to I-77 N entrance
Left lane onto I-480 West / Toledo	1.1	
 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	
 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
 Take Right Exit 172A to I-77 South	40.3	
Follow I-77 South to Rockside Road exit	47.3	
 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	

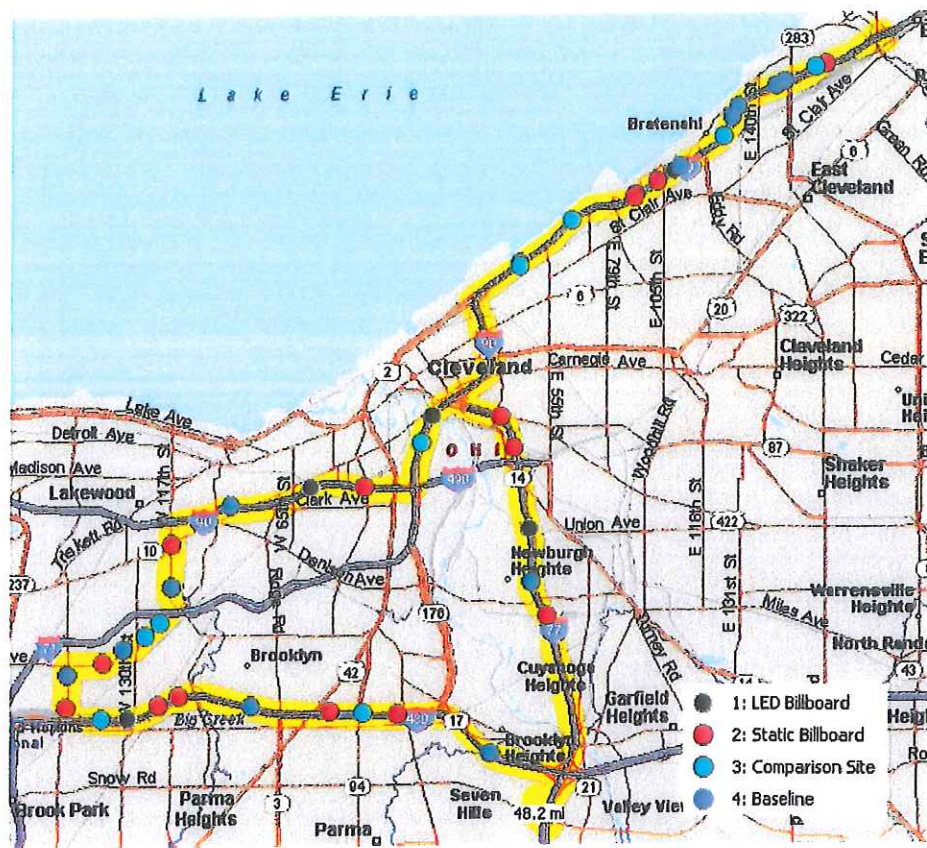


Figure 14. Map Illustrating Nighttime Route with Digital Billboards (black), Conventional Billboards (red), Comparison Sites (aqua blue), and Baseline Sites (blue).

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 eyegance analyses. Altogether, 38,070 video frames were analyzed (470 events x 81 frames/event) and 2,335 individual glances were identified. The speed data was filtered to remove events as described above, and then further filtered to remove events in which the maximum speed failed to read 20 mph or the minimum speed failed to reach 15 mph, leaving 456 events in this dataset, with 36,936 data points for speed. The lane position dataset was further filtered to remove events indicating a possible lane change or lane position sensor failure (often due to poor lane markings). After filtering, there were 411 events remaining in the lane position dataset, with 33,291 data points. Because the nighttime study was exploratory in nature with fewer data points, these data are shown descriptively, but were not analyzed statistically (due to lack of statistical power).

RESULTS

Post-Drive Questionnaire – Daytime Results

Participants completed the post-drive questionnaire (Appendix D) after they returned from driving the daytime driving route as well as the nighttime route. The questionnaire gathered information such as route familiarity and items noticed while driving; it also collected demographic and personal information, including education level, marital status, ethnicity, and income. The questionnaire was the same one used by Lee et al. (2004) in the previous study using similar methods. The following sections summarize all questionnaire results for the daytime drivers, followed by a section describing the results for the nighttime drivers.

Demographics Overview

In terms of demographics, the average age was 28 years for younger drivers and 59 years for older drivers. The sample of drivers was quite diverse in terms of education level, marital status, and income. All drivers lived and worked in the Cleveland, OH area and were familiar with some or most of the route. The following sections provide details for relevant information about the sample of drivers. Table 8 presents these findings as well.

Age. The sample of 36 drivers ranged in age from 18 to 71 years old. The mean age of all participants was 43.3 years ($SD = 16.7$). The younger drivers ranged in age from 18 to 35 years old, with a mean of 27.9 years ($SD = 6.0$). The older drivers ranged in age from 50 to 71 years old, with a mean of 58.7 years ($SD = 6.1$).

Education Level. Participants were surveyed regarding the highest education level they had completed. The number of responses and equivalent number of years were used to calculate the product. This was used to calculate the mean education level for the sample by dividing the total number of years completed by the number of participants ($482/36$). The average was 13.4 years of education completed (equivalent to high school plus a year and a half of college). Most of the participants had finished high school, but few had attended college.

Marital Status. Half of the participants were married, while 28% reported that they were single and 17% were divorced. Two individuals (5.6%) indicated that they were separated.

Ethnicity. Most participants were European (Caucasian/White) with only one participant identifying herself as African American.

Income. The income level with the most participants was the group earning between \$25,000 and \$49,000 per year (16 participants or 44%).

Table 8. Summary of Demographic Results for All Daytime Participants.

CATEGORY	LEVELS			
Age (mean)	Younger Drivers	Older Drivers	All Drivers	
	27.9 years	58.7 years	43.3 years	
Education Level	High Sch.	2-Yr Deg.	B.A./B.S.	
	52.8%	25.0%	22.2%	
Marital Status	Single	Married	Divorced	Separated
	27.8%	50.0%	16.7%	5.6%
Ethnicity	African American	European		
	2.8%	97.2%		
Income Level	\$0-24K	\$25-49K	\$50-74K	>\$100K
	33.3%	44.4%	19.4%	2.8%

Route Familiarity

Route familiarity was assessed by three items in the questionnaire. Specific topics addressed were: location of work, location of home, and frequency of driving on roads in the experimental route (defined as familiarity). Table 9 presents the route familiarity findings.

Living and Working Location. All drivers reported that they were familiar with the Cleveland, OH area and had driven on the interstates and surface roads included in the route. All of the participants lived in the Cleveland area, and those who were employed also worked in the area. Cleveland proper, Parma, and Independence were the most common locations where participants lived and worked, with 39% of participants reporting that they both lived and worked in one of these three areas (Independence and Parma are adjacent suburbs of Cleveland).

Familiarity. Route familiarity was also evaluated in terms of five route segments that represented various types of driving (i.e., various segments of interstate and downtown Cleveland). Drivers were asked to indicate if they were either "familiar" (driven at least once a week) or "not familiar" (driven less than one time a week) with each segment. In some cases, participants inquired about this question item, indicating (verbally) that, although they were quite familiar with certain areas, they may not drive on them every week. Nonetheless, the results indicated that overall, drivers were familiar with the route, particularly I-480 W between I-77 and W150th (83% were familiar with this segment as shown in Table 9).

Table 9. Route Segment Familiarity for All Daytime Participants.

	Route Segment				
%	I-480W between I- 77 and W150th	W.130th - Bellaire - W.117th	I-90 between 9th and 185th	Carnegie Ave.	I-77 between I- 90 and Rockside
Familiar	83%	42%	64%	67%	72%

Overview of What Drivers Noticed

Drivers primarily noticed items such as traffic and other drivers, road or highway signs, and road construction. Fifteen of 36 drivers (42%) marked “billboards” as one of the top 5 items (out of 18 items) that caught their attention during the drive. Participants engaged in a variety of activities while driving; listening to the radio or CD player and using the cell phone were the most prevalent. At no point was it apparent that any participant knew the specific purpose of the study; all responses indicated that drivers believed the study was related to observing drivers in a natural driving situation, which was also true. The following sub-sections describe findings in more detail, with tables illustrating drivers’ responses.

Attention Getters. Participants were asked to indicate “the top five items that most caught your attention during your drive.” Over 50% of drivers indicated that they paid attention to traffic, road signs, exit signs, and other drivers. The top 9 items (out of 18 listed) are shown in Figure 15. For those drivers who indicated “billboard” as one of the items that caught their attention, the experimenter asked them to verbally expand upon all items; however, none of these drivers made any additional comments about billboards except that they caught their attention. Three drivers (8%) mentioned billboard under a separate question regarding the single most memorable part of the drive. Their comments were “The lighted billboards,” “Ridiculous billboards,” and “The light up billboards.” A fourth driver mentioned “Markers and signs” but did not elaborate further. Even in the daytime, the digital billboards appeared to have been noticeably different from conventional billboards and appeared to attract a certain amount of attention.

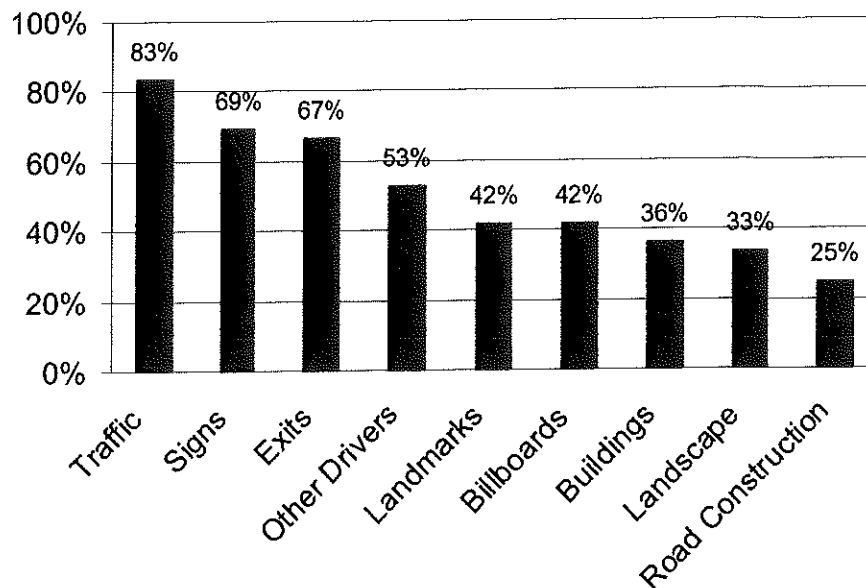


Figure 15. Top Daytime Attention Getters (top nine of eighteen possible).

Most Memorable. Participants were asked “What was most memorable about the drive?” This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. There were 35 comments. Over 68% of the comments were related to construction, weather/view, the experimental vehicle, or traffic, as presented in Table 10.

Table 10. Number and Percent of Comments for Daytime Participants for the Question: “What was most memorable about the drive? For example, were there any objects that stood out?”

Comment Categories	Number of Comments	Percent of Comments
Other Vehicles/Traffic	7	17.5%
New Route/feature about route	6	15.0%
Lake	5	12.5%
Weather/View	4	10.0%
Test Vehicle	3	7.5%
Digital Billboards/Billboards/signs	3	7.5%
Neighborhoods	3	7.5%
Rough Road	3	7.5%
Relaxing/Positive trip	2	5.0%
Construction	1	2.5%
Near accident/Accident	1	2.5%
Sports Arena	1	2.5%

What Bothers You? Participants were asked, “What bothers you about other drivers?” This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. A total of 30 comments were made. The large majority of the comments were related to aggressive maneuvers or questionable driving behavior such as tailgating, being cut off, not using turn signals, or driving slowly in the fast lane (Table 11).

Table 11. Number and Percent of Comments for Daytime Participants in Response to the Question: “Does anything about other drivers bother you? If so, please briefly describe.”

Comment Category	Number of Comments	Percent of Comments
Tailgating	7	23.3%
Cut off	6	20.0%
No signal	5	16.7%
Speeding	3	10.0%
Aggressive	3	10.0%
Slow in fast lane	3	10.0%
Cell phone talking	1	3.3%
Drivers who don't pay attention	1	3.3%
Inability to adjust to conditions	1	3.3%

Other Activities. Participants were asked, “What other activities do you engage in while driving?” Again, this was open-ended and the comments varied, but similar comments were grouped where possible. There were 72 comments in all. Listening to the radio or CDs was the largest single activity, making up over 26% of the comments. Using the cell phone was also common (15%). Other activities included singing or talking, drinking, smoking cigarettes, and eating, as presented in Table 12.

Table 12. Number and Percent of Comments for Daytime Participants in Response to the Question: “What other activities do you typically engage in while driving?”

Comment Categories	Number of Comments	Percent of Comments
Listen to radio/CDs	21	38.9%
Cell phone	11	20.4%
Smoking	4	7.4%
Eating	4	7.4%
Drinking	3	5.6%
Talk w/others	3	5.6%
Adjust radio/CDs	2	3.7%
Driving/steering	2	3.7%
Adjust AC/windows	1	1.9%
Look for something	1	1.9%
Homework	1	1.9%
Read directions/map	1	1.9%

Other questions asked participants for additional input about the written directions and the purpose of the study. Substantively relevant participant responses included three separate suggestions relating to conducting a driving study with passengers or children, the effect of video cameras on driving behavior, and the statement that “driving in my own car would be more ‘normal.’ ” While no one reported problems with the directions, three drivers did get off-route at one point during their trip; however, very few data points were missed. Drivers were also queried as to their recollection of the purpose of the study; all responses were within the scope of what they had been told verbally and in the informed consent form.

Post-Drive Questionnaire – Nighttime Results

Age

The sample of 12 nighttime drivers ranged in age from 25 to 62 years old and consisted of drivers who had recently performed the daytime portion of the experiment. As for the main experiment, the participant pool was balanced for age and gender. The mean age of the nighttime participants was 44.5 years ($SD = 14.0$). The younger drivers ranged in age from 25 to 35 years old, with a mean of 31.5 years ($SD = 4.1$). The older drivers ranged in age from 54 to 62 years old, with a mean of 57.5 years ($SD = 3.3$). The demographics for these 12 drivers are summarized in Table 13.

Table 13. Summary of Demographic Results for All Nighttime Participants.

CATEGORY	LEVELS		
Age (mean)	Younger Drivers	Older Drivers	All Drivers
	31.5 years	57.5 years	44.5 years
Education Level	High Sch.	2-Yr Deg.	B.A./B.S.
	58.3%	25.0%	16.7%
Marital Status	Single	Married	Divorced
	8.3%	66.7%	25.0%
Ethnicity	European		
	100.0%		
Income Level	\$0-24K	\$25-49K	\$50-74K
	16.7%	41.7%	41.7%

Route Familiarity

Route familiarity was assessed by three items in the questionnaire. Specific topics addressed were: location of work, location of home, and frequency of driving on roads in the experimental route (defined as familiarity). As before, all nighttime drivers lived and worked in the Cleveland, OH area. Route familiarity was also evaluated in terms of five route segments that represented various types of driving (i.e., various segments of interstate). Drivers were asked to indicate if they were either “familiar” (driven at least once a week) or “not familiar” (driven less than one time a week) with each segment. Table 14 presents the route familiarity findings.

Table 14. Route Segment Familiarity for All Nighttime Participants.

	Route Segment				
	I-480W between I- 77 and W150th	W.130th - Bellaire - W.117th	I-90 between 9th and 185th	Carnegie Ave.	I-77 between I- 90 and Rockside
% Familiar	75%	42%	58%	58%	50%

Attention Getters

Participants were asked to indicate “the top five items that most caught your attention during your drive.” Over 50% of drivers indicated that they paid attention to traffic, road signs, billboards, and exits. Figure 16 shows the top nine nighttime attention getters. For those drivers who indicated “billboard” as one of the items that caught their attention, the experimenter asked them to verbally expand upon all items, but no one made any remarks relevant to billboards. However, 3 of the 12 nighttime drivers (25%) noted billboards as being the single most memorable thing about the drive. One person just said “Billboards,” another said “I saw a billboard that changed and I wished it hadn’t because I wanted to read the previous message,” and a third said “One billboard.” This is much higher than the 8% who mentioned billboards as

being most memorable during the daytime, and may be a reflection of the nature of the digital billboards.

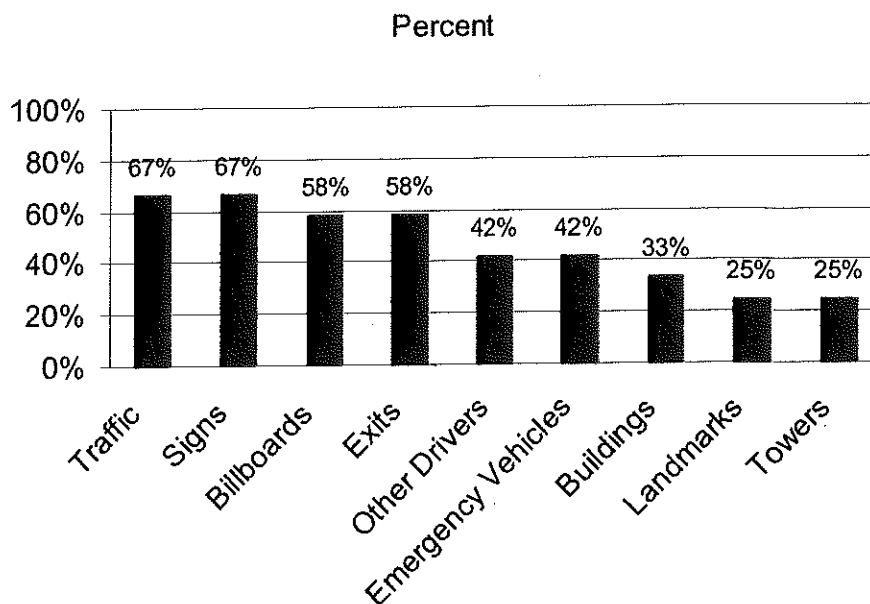


Figure 16. Top Nighttime Attention Getters (top nine of eighteen possible).

Most Memorable

Participants were asked “What was most memorable about the drive?” This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. There were nine comments from the 12 nighttime drivers. As mentioned, three comments concerned billboards, while other common answers included the views and other vehicles and traffic, as presented in Table 15. The drivers had previously answered the general questions regarding “What bothers you about other drivers?” and “What other activities do you engage in while driving?” during their daytime session, so these were not asked again here. Likewise, the responses to “What is the purpose of this study?” were similar to what the same participants had said during the daytime session; all responses were within the scope of what they had been told verbally and in the informed consent form.

Table 15. Number and Percent of Comments for Nighttime Participants in Response to the Question: “What was most memorable about the drive? For example, were there any objects that stood out?”

Comment Categories	Frequency
Digital Billboards/Billboards	3
View	2
Other Vehicles/Traffic	2
Positive trip	1
Personal condition while driving	1

Driving Performance Results – Daytime

Event Type

Eyeglance Results. With regard to eyeglance behavior, there were six questions of interest, each of which will be discussed in turn:

1. Does eyes-on-road percent (looking straight forward) vary in the presence of different event types?
2. Is there a more active glance pattern in the presence of certain event types (as measured by the number of individual glances to any location during the eight seconds of the event)?
3. For events on the left side of the road, are there more glances in the left forward direction for certain event types?
4. For events on the right side of the road, are there more glances in the right forward direction for certain event types?
5. For events on the left side of the road, does the mean single glance time in the left forward direction vary according to event type?
6. For events on the right side of the road, does the mean single glance time in the right forward direction vary according to event type?
7. Are longer glances (longer than 1.6 s) associated more with any of the event types?

Question 1 (Does eyes-on-road percent (looking straight forward) vary in the presence of different event types?) was answered by examining the amount of time spend looking straight forward in the course of an event, and dividing it by 8 s to obtain the percentage of time the driver was looking forward. As shown in Figure 17, this ranged between 70% and 75% for the various event types, with baseline, digital billboard, and conventional billboard being close to equal. Statistical analysis showed that this measure did vary across event types ($F_{3,96} = 11.62, p < 0.0001$, using an α of 0.05 as a criterion, as is standard for studies of this type). The comparison events had significantly less eyes-on-road percent than did the other event types, which did not vary from one another.

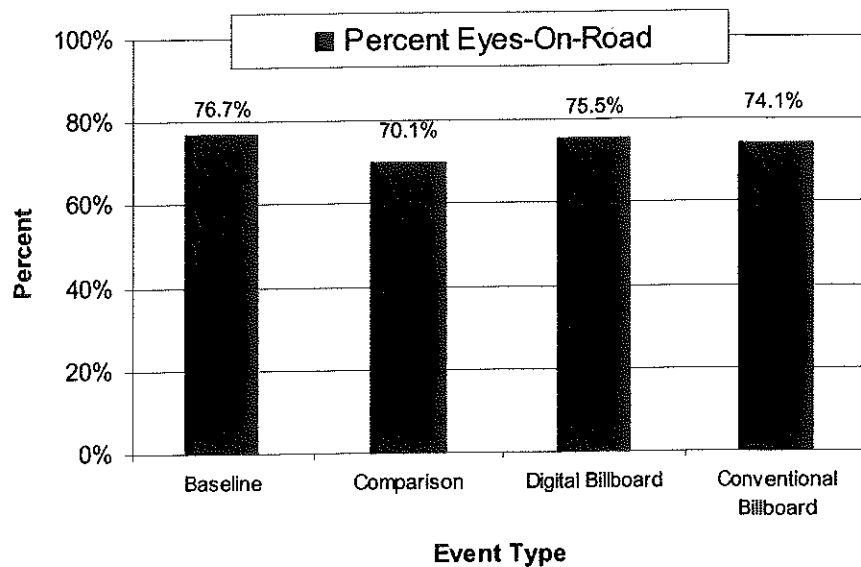


Figure 17. Percent Eyes-on-Road Time for the Four Event Types. (Comparison events were significantly lower than the other three event types, which did not differ from one another).

Question 2 (Is there a more active glance pattern in the presence of certain event types?) was measured by examining the number of individual glances to any location during the eight seconds of the event. A higher mean number of glances during the eight seconds indicated a more active scanning pattern. As shown in Figure 18, there were very few differences in the overall glance activity. The statistical analysis verified this observation, showing no significant differences between event types ($F_{3,96} = 1.78, p = 0.1564$).

Questions 1 and 2 were aimed at the larger question of whether overall driver eyeglance behavior changed in the presence of certain event types. In other words, did driver total time looking forward change in the presence of certain event types, and did drivers exhibit a more active glance pattern for certain event types? Except for lower eyes-on-road time for comparison events, there were no observed differences in overall eyeglance patterns. The next four questions are concerned with the specific eyeglance patterns that might be expected to occur if drivers were allocating more visual attention to specific objects located on the side of the road.

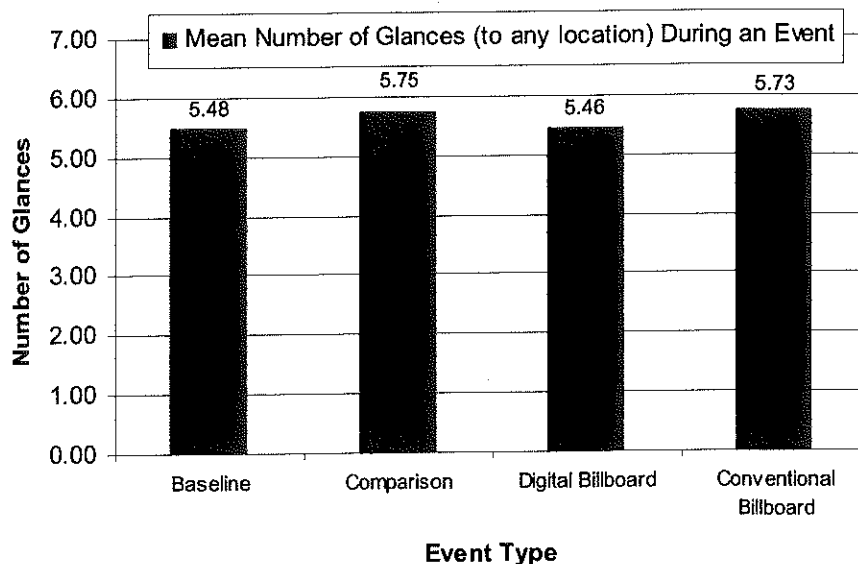


Figure 18. Mean Number of Glances to Any Location During an Event. (There were no significant differences between event types.)

Question 3 (For events on the left side of the road, are there more glances in the left forward direction for certain event types?) was aimed at the question of whether the presence of a site of interest on the side of the road was related to a greater number of glances in that direction. All baseline events were included in this analysis since these events were considered to have been located on both sides of the road. As can be seen in Figure 19, digital billboards to the left side of the road did garner a larger number of left forward glances during the eight seconds than did any of the other event types. However, statistical analysis showed that these differences were not significant ($F_{3,73} = 1.49, p = 0.2244$).

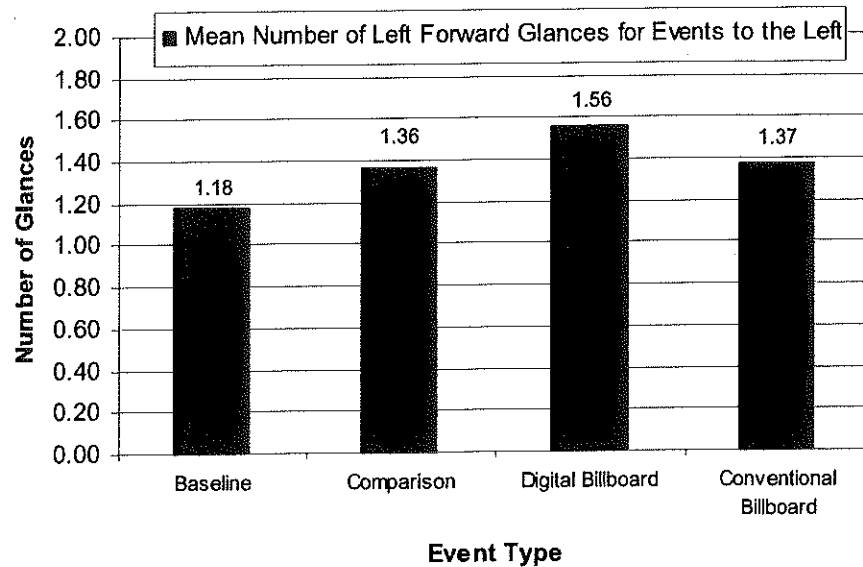


Figure 19. Mean Number of Left Forward Glances for Events on the Left Side of the Road.
(There were no significant differences between event types.)

Question 4 (For events on the right side of the road, are there more glances in the right forward direction for certain event types?) was similar in intent, but used events on the right side of the road and right forward glances. Again, all baseline events were included in this analysis since these events were considered to have been located on both sides of the road. As can be seen in Figure 20, there appeared to be little difference in the number of right forward glances across event types. Statistical analysis showed that the observed differences were not significant ($F_{3,77} = 0.29, p = 0.8353$).

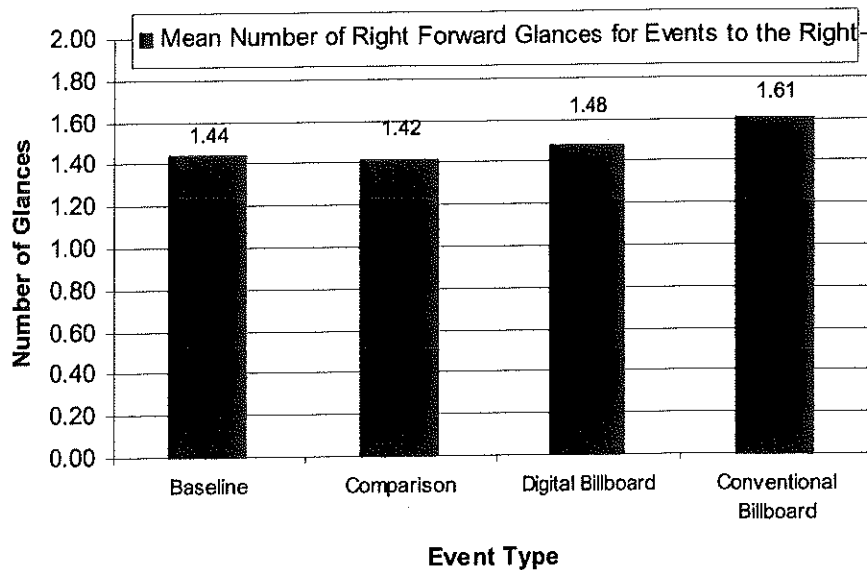


Figure 20. Mean Number of Right Forward Glances for Events on the Right Side of the Road. (None of the observed differences were significant.)

Question 5 (For events on the left side of the road, does the mean single glance time in the left forward direction vary according to event type?) was measured by examining the mean single glance time for left forward glances. Longer glances in the left forward direction for events to the left could indicate that the driver is paying greater visual attention to the event. Figure 21 shows that the digital billboard and comparison event types had longer mean single glance times than did baseline or conventional billboard events. Statistical analysis showed that these differences were significant ($F_{3,73} = 3.59, p = 0.0176$). Post hoc analysis showed that the digital billboards to the left had significantly longer left forward glances than did conventional billboards or baseline sites, but that they did not differ from comparison sites. Comparison sites differed from baseline sites, but not from conventional billboard sites, and conventional billboards and baseline sites did not differ from one another.

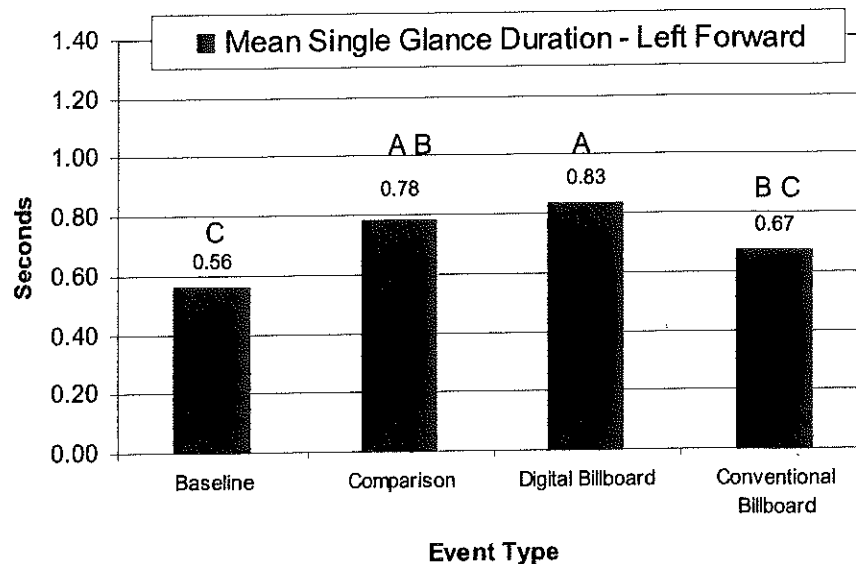


Figure 21. Mean Single Glance Time for Left Forward Glances for Events on the Left Side of the Road. (Data points with a shared letter do not differ significantly from one another.)

Question 6 (For events on the right side of the road, does the mean single glance time in the right forward direction vary according to event type?) was similar to Question 5 in approach, except that it examined right forward glances and events to the right. Statistical analysis showed that the observed differences were significant ($F_{3,77} = 3.73, p = 0.0147$). Post-hoc tests showed that digital billboards located on the right had significantly longer glance times to the right than did either baseline events or conventional billboards, but did not differ significantly from comparison events. Comparison events had longer glance times than did baseline events, but did not differ significantly from conventional billboards. Conventional billboards also had significantly longer glances than did baseline events.

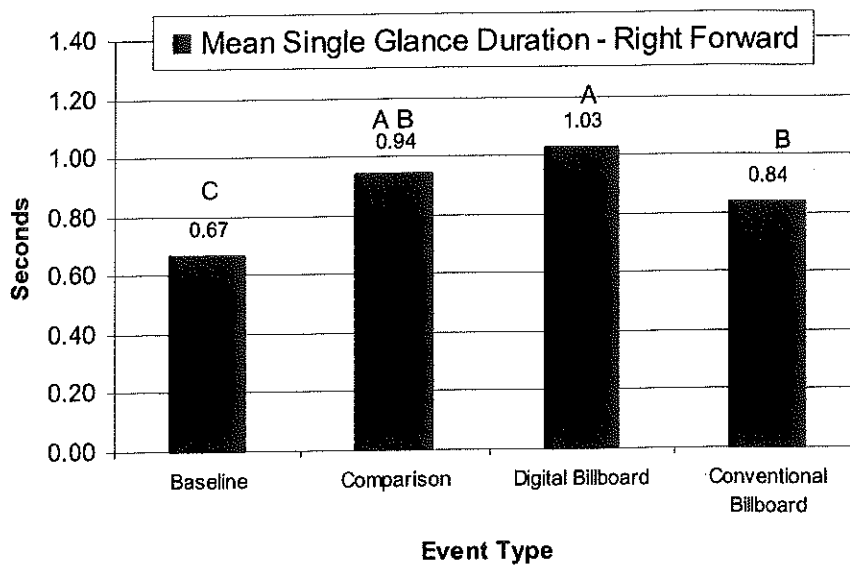


Figure 22. Mean Single Glance Time for Right Forward Glances for Events on the Right Side of the Road. (Data points with a shared letter do not differ significantly from one another.)

Question 7 (Are longer glances (longer than 1.6 s) associated more with any of the event types?) follows an approach provided by Horrey and Wickens (2007), who suggest analyzing the tails of the distributions whenever eyeglance analysis is performed. Various researchers have suggested that longer glances may be associated with poorer driving performance. For example, Wierwille (1993) suggests a 1.6 s criterion as representing a long glance away from the forward roadway. As shown in Figure 23, the distributions of glance duration were similar across all event types, and there was no obvious pattern of longer glances being associated with any of the event types.

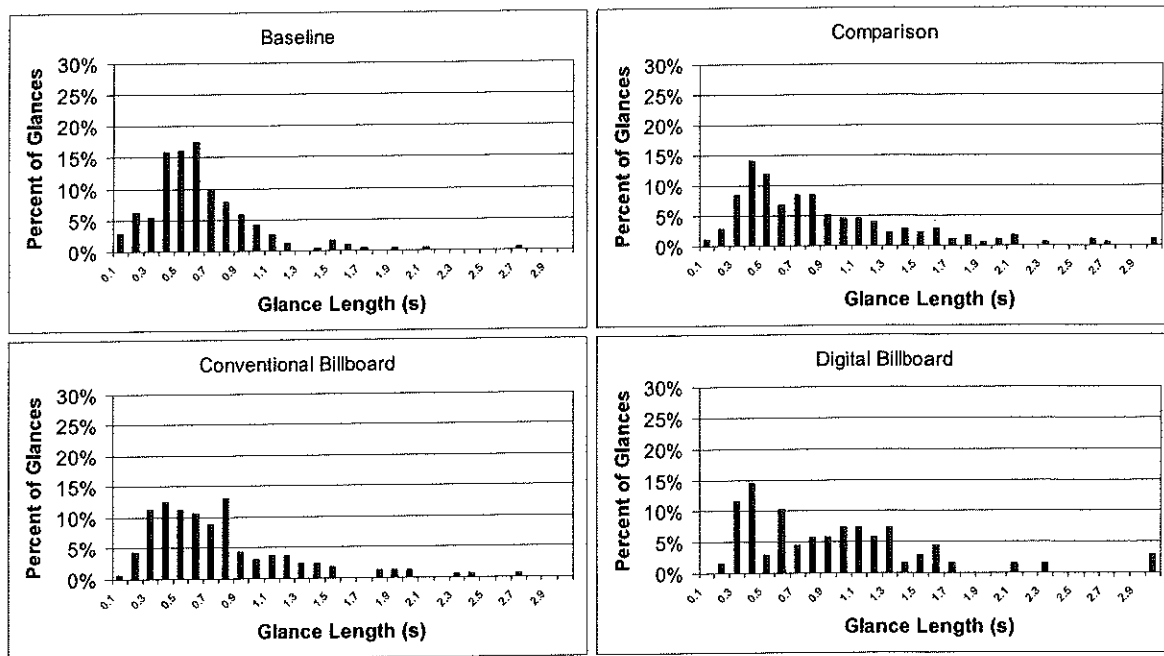


Figure 23. Tails analysis for the distribution of glance duration, (method described in Horrey and Wickens, 2007).

Discussion of Daytime Eyeglance Results. Results showed that digital billboards were not associated with changes in overall glance patterns (overall number of glances or percent eyes-on-road time). Likewise, digital billboards were not associated with more frequent glances towards the direction where the billboard was located. However, digital billboards in both the left and right directions were associated with longer glances in that direction.

There were only five digital billboards along the route (these were all that were available). This led to low statistical power for the digital comparisons, especially when the digital billboards were separated into left and right (two in one direction and three in the other). To increase power and verify the above findings, the data were next aggregated so that all glances in the direction where an event was located were included. For glance frequency, there were still no significant differences in the number of glances depending on event type ($F_{3, 91} = 1.22, p = 0.3065$). For glance duration, the findings from above were also confirmed with this combined analysis ($F_{3, 91} = 4.98, p = 0.0030$). Digital billboards and comparison sites did not differ from one another, but each differed from conventional billboards and baseline events. Conventional billboards and baseline events did not differ from one another; these results are shown in Figure 24.

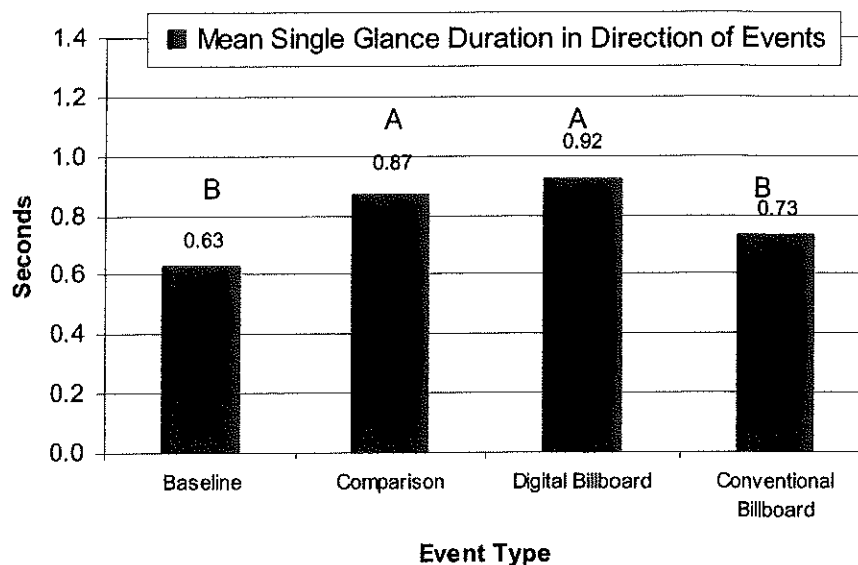


Figure 24. Mean Single Glance Time for Glances in the Direction of Events. (Data points with a shared letter do not differ significantly from one another.)

It should also be noted that digital billboards did not differ in glance duration from comparison events for left side, right side, or the combined comparison. Several of the comparison events had a digital component, but in the form of on-premises signing rather than as billboards. One comparison event used full motion video at times. Thus, it is not surprising that these event types revealed similar glance duration patterns. Finally, it should be noted that the results for conventional billboards were similar to those found in the Charlotte study, with very few differences between conventional billboards and either comparison events or baseline events.

Speed maintenance. As shown in Figure 25, there were differences in the standard deviation of speed for the different event types. These differences were statistically significant ($F_{3, 96} = 5.33$, $p = 0.0019$), with conventional billboards showing a higher speed deviation than baseline and digital billboards, but not different from comparison sites. Baseline events, comparison events, and digital billboards did not differ from one another. Much of this difference may be because there is typically greater speed deviation on surface streets than on interstates, and all of the digital billboards were on interstates. To account for this in the research design, the same analysis was conducted, but using only events occurring on interstates. In this analysis, there were no significant differences in standard deviation of speed ($F_{3, 96} = 1.66$, $p = 0.1819$), as shown in Figure 26.

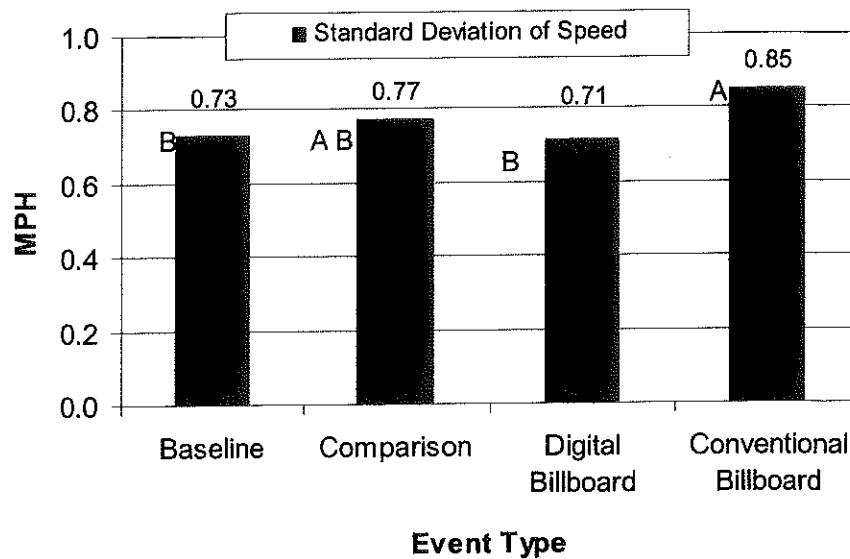


Figure 25. Standard Deviation of Speed by Event, in miles per hour. (Data points with a shared letter do not differ significantly from one another.)

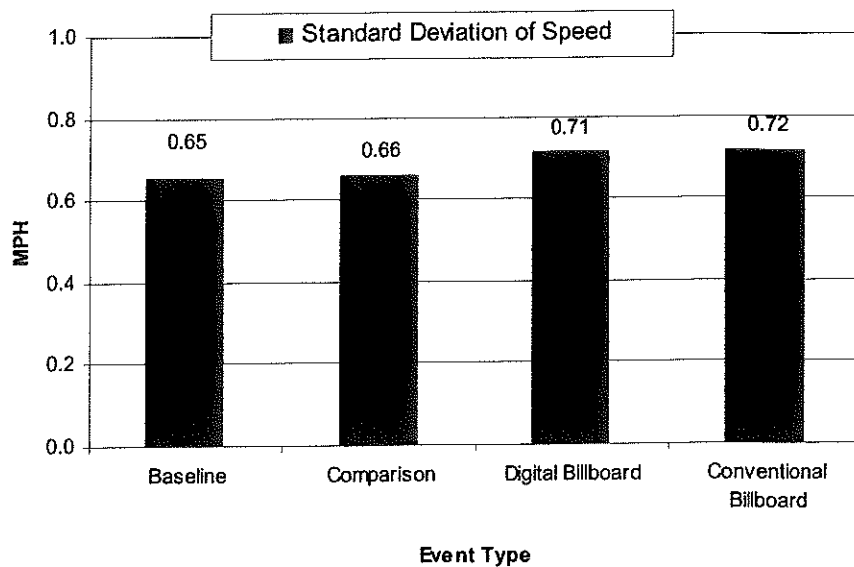


Figure 26. Standard Deviation of Speed by Event for Events Occurring on Interstates, in miles per hour. (None of the observed differences was significant.)

Lane keeping. The standard deviation of lane position was calculated for each event. Standard deviation was used instead of average lane position, because average lane position can be to the right or left, and thus an average would tend to wash out true differences, while standard deviation takes overall deviation into account, regardless of left or right. While there appeared to be differences in lane keeping for the different event types as shown in Figure 27, these differences did not quite reach significance ($F_{3,91} = 2.46, p = 0.0673$). Nevertheless, the trend is that digital billboards and conventional billboards seem to be related to poorer lane keeping, and it is likely that a larger sample would have shown significance for this measure.

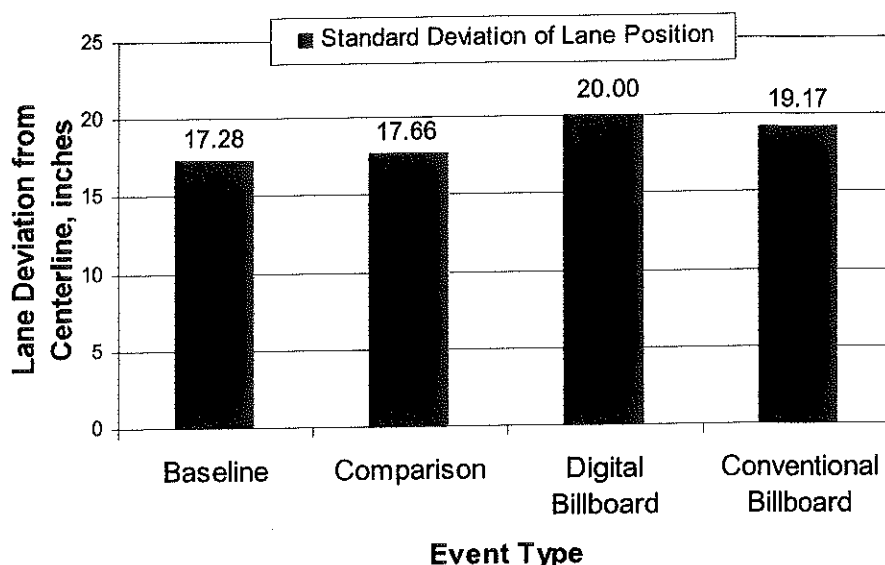


Figure 27. Standard Deviation of Lane Position by Event, in inches. (None of the observed differences was significant.)

Other findings

Road Type. There were significant differences in the two overall eyeglance measures, both of which indicated a more active glance pattern on surface streets. The eyes-on-road percentage was higher for interstate events than for surface street events (71% for interstate vs. 64% for surface streets; $F_{1,32} = 30.29, p < 0.0001$). There were also more total glances during an event on surface streets as opposed to on the interstates (6.3 glances for interstate vs. 7.2 glances for surface streets; $F_{1,32} = 10.51, p < 0.0028$). There were no significant differences for the eyeglance measures associated with the left or right side of the road. These findings are consistent with the findings of the Charlotte study, in that eyeglance patterns tend to be more active while driving on surface streets due to driver monitoring of driveways, intersections, and on-coming traffic.

Familiarity. Drivers spent significantly more time with their eyes on the road while driving on unfamiliar roads (73% for familiar roads and 75% for unfamiliar roads; $F_{1,22} = 4.81, p = 0.0392$). However, this small significant difference likely has no practical implications, especially given that the overall glance frequency was not significant ($F_{1,22} = 1.38, p = 0.2530$).

There were no significant differences for speed maintenance or lane keeping depending on familiarity with the route segment. These results are likely confounded by the fact that most of the road segments that drivers classified as familiar were the interstate portions of the route, while the unfamiliar roads tended to be the surface street sections.

Age. There were two age findings in the eyeglance measures. Older drivers had higher eyes-on-road percentage than did younger drivers (73% for older and 67% for younger; $F_{1,32} = 4.46$, $p = 0.0426$). Younger drivers also had more frequent right forward glances for events to the right than did older drivers (younger = 1.55 right forward glances per event; older = 1.34 right forward glances per event; $F_{1,32} = 4.42$, $p = 0.0436$). Younger drivers thus seemed to have a slightly more active glance pattern than older drivers, but this did not show up in very many of the eyeglance measures examined. There were no age differences for speed keeping or lane maintenance.

Gender. There were no significant findings for gender for eyeglance, speed maintenance, or lane keeping measures.

Driving Performance Results – Nighttime

Event Type

Eyeglance results. As mentioned previously, there were about one-third fewer data points for the nighttime portion of the study, which was considered an exploratory study. Thus, the results in this section are presented descriptively, without statistical analysis. Where the differences shown are strong, it is likely that a larger study would show statistical significance, while weak differences may or may not hold up with a larger study. Four eyeglance measures were examined for the nighttime data: eyes-on-road percent, overall glance frequency, mean glance duration in the direction of an event, and mean number of glances in the direction of an event. Eyes-on-road percent is presented in Figure 28, which shows that digital billboards and comparison events tended to have less eyes-on-road time at nighttime than either baseline events or conventional billboards. The overall glance frequency was also higher in the presence of digital billboards and comparison events at nighttime, as shown in Figure 29. These two findings taken together show a more active glance pattern at nighttime in the presence of these two event types, which mirrors some of the daytime findings.

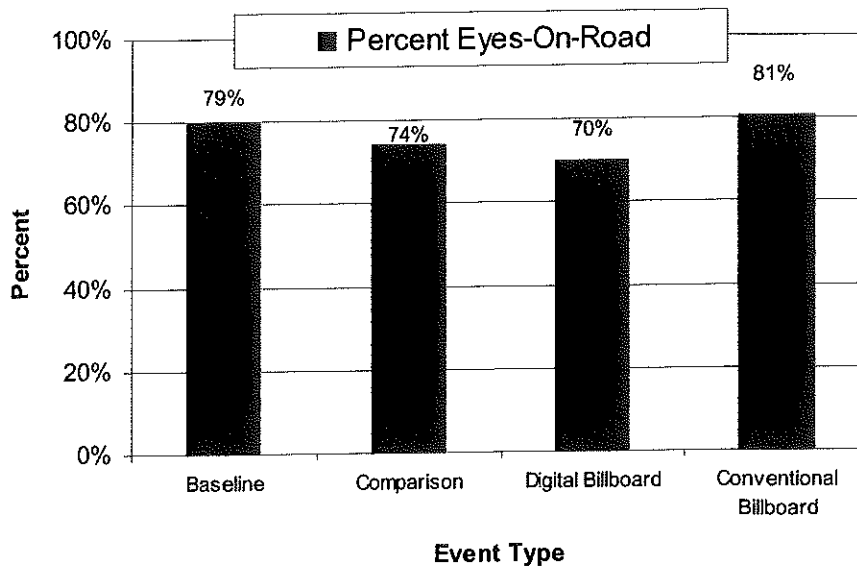


Figure 28. Eyes-on-Road Percent by Event Type for the Nighttime Exploratory Study.

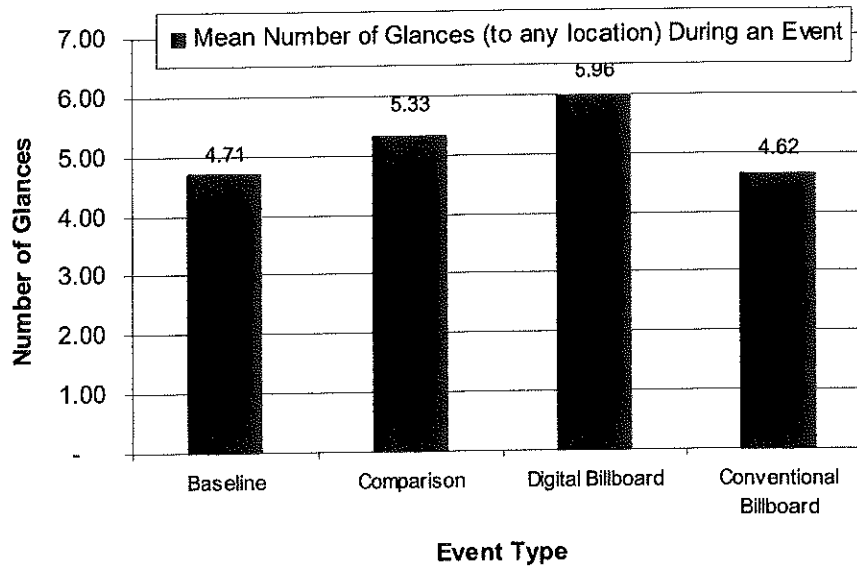


Figure 29. Overall Glance Frequency by Event Type for the Nighttime Exploratory Study.

The mean glance duration for glances in the direction of an event also showed higher values for digital billboards and comparison events; however, in this case, the comparison sites appeared to have longer glance times than did the digital billboards (Figure 30). The mean number of glances in the direction of an event again showed digital billboards and comparison events as having higher values than either baseline events or conventional billboards, as shown in Figure 31. Taken together, these four findings indicate that digital billboards and comparison events

may result in more active glance patterns overall, as well as more frequent and longer glances towards the digital billboards and comparison events.

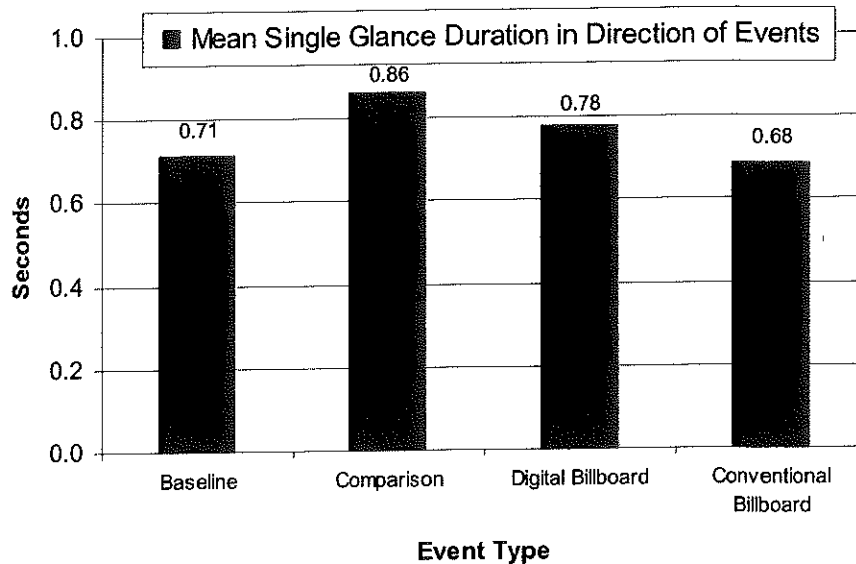


Figure 30. Mean Glance Time for Glances in the Direction of an Event for the Nighttime Exploratory Study.

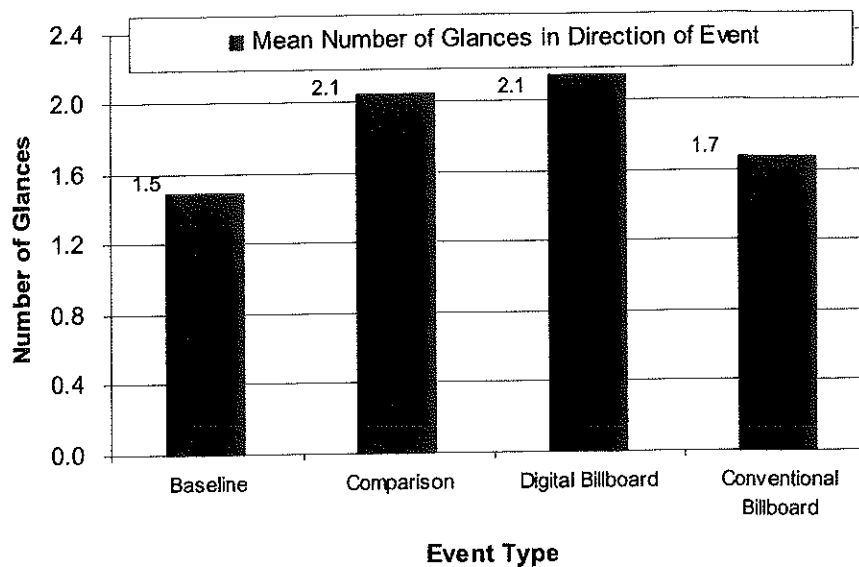


Figure 31. Mean Number of Glances in the Direction of an Event for the Nighttime Exploratory Study.

Speed maintenance. Figure 32 shows that the standard deviation of speed appeared to be higher in the presence of both conventional and digital billboards than for baseline and comparison events. If this effect is related to the event type, it may be due to the attempt to read the copy of these signs at night while driving. If this is true, the higher value shown for conventional billboards may indicate that these signs are more difficult to read at night than are the digital billboards.

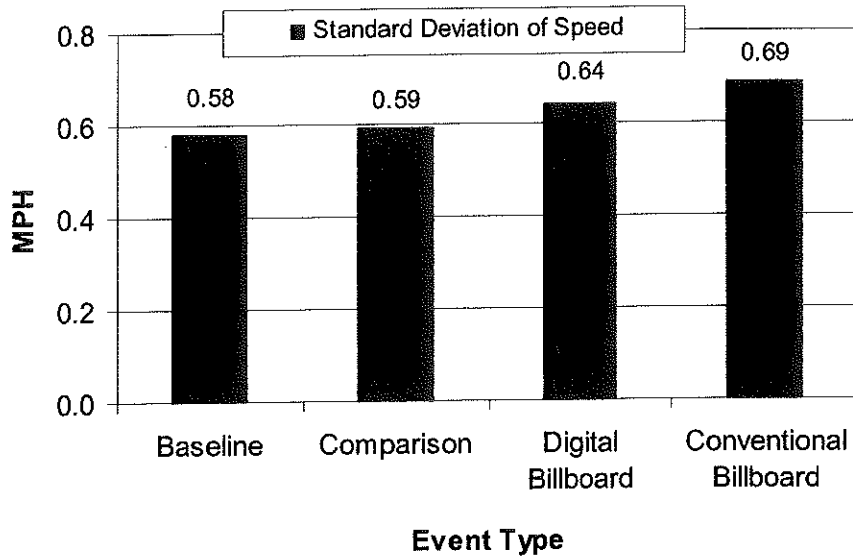


Figure 32. Speed Maintenance as Measured by the Standard Deviation of Speed by Event for the Nighttime Exploratory Study.

Lane keeping. Lane keeping also showed a trend towards greater lane deviations in the presence of both digital billboards and conventional billboards as shown in Figure 33. As was true for speed maintenance, conventional billboards showed higher values than did digital billboards. Again, this may be an indication of the difficulty of reading these signs at night.

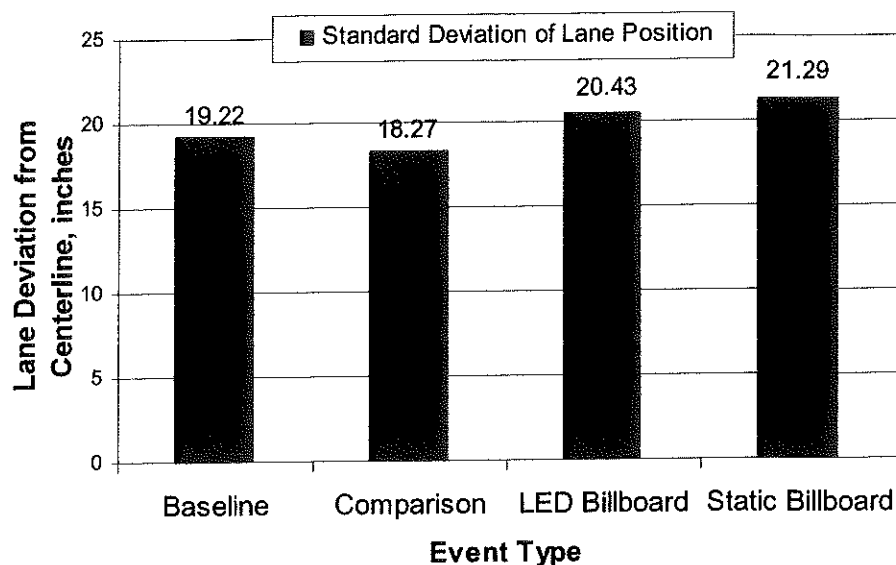


Figure 33. Lane Keeping as Measured by the Standard Deviation of Lane Position by Event for the Nighttime Exploratory Study.

Nighttime Luminance Measures

The luminance was measured with a Radiant Imaging Charge-Coupled Device (CCD) photometer with a 300 mm lens. The CCD photometer provided a method of capturing the luminance of an entire scene at one time. Luminance represents the amount of light that is projected off a surface in a given direction. For this investigation, the direction of interest was towards the driver. Luminance is measured in candelas per meter squared.

The photometer was located in the experimental vehicle as close to the driver's position as possible (Figures 34 and 35). The experimental vehicle was then driven to the sign location and stopped on the side of the road. Images of the sign were then acquired. For multiple face signs such as the digital and the tri-visions signs, each of the presented messages was imaged. Using the software provided with the system, the average luminance of the sign and each message was measured. The photometer was connected to a laptop computer in the back seat that stored the data as the images were acquired. All measurements were taken at night. Figure 36 shows the average luminance measures for each of the four event types measured in candelas per meter squared. Note that the digital billboards had noticeably higher luminance values than any of the other event types, even though their luminance was automatically reduced at night. This probably explains some of the driver performance findings in the presence of the digital billboards. The overall ranking of luminance by event (digital billboards were the highest, followed in order by comparison events, conventional billboards, and baseline events) closely mirrors the rankings of many of the performance measures for both daytime and nighttime, including eyeglance, speed maintenance, and lane keeping. Altogether, there were 74 measurements (17 for comparison events, 36 for digital billboards, 6 for conventional billboards, and 15 for baseline events). More readings were taken for the digital billboards because each message was measured individually.



Figure 34. Bracket for Radiant Imaging CCD Photometer.



Figure 35. Radiant Imaging CCD Photometer in Position for Measurements, with Experimenter Making Final Adjustments.

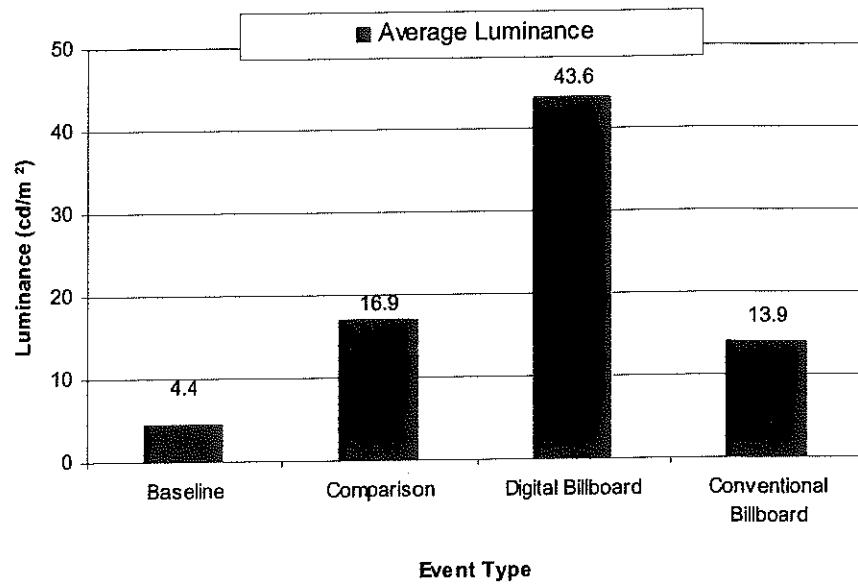


Figure 36. Average Luminance of the Four Event Types, in Candelas per Meter Squared.

COMPARISONS TO THE CHARLOTTE STUDY

There were several similarities and several differences between this study and the study conducted in Charlotte, NC. The original intent was to make the studies as similar as possible, and this was achieved to the degree possible, as demonstrated by the following items:

- Both were conducted in mid-sized cities (Charlotte population: 540,828; Cleveland population: 478,403; both figures taken from US Census 2000).
- Both were conducted in areas with similar terrain (fairly flat, with a few rolling hills; Charlotte elevation: 650 feet; Cleveland elevation: 581 feet).
- Both studies included conventional billboards, comparison events, and baseline events.
- Both studies showed similar results when conventional billboards were compared to baseline and comparison sites (very few differences in eyeglance measures, speed maintenance, or lane keeping for conventional billboards as compared to baseline events and comparison events).
- Both studies used 36 participants who performed the experiment in the daytime, equally divided into four age by gender cells (nine older males, nine older females, nine younger males, and nine younger females).
- Both included participants who lived and worked in the area and were familiar with at least some parts of the route.
- Both studies were conducted during similar times of day (between rush hours, from about 9 a.m. to 4 p.m.).
- Both studies included surface streets and interstates.
- Both studies used the same make and model of vehicle, and similar instrumentation.
- Both studies used the same basic protocols and questionnaires.
- The data were reduced and analyzed in a similar fashion using the same software tools.
- Both studies were sponsored by a foundation with strong ties to the outdoor advertising industry. Thus, in each study every effort was made to remove sources of potential bias. These efforts included:
 - Final selection of route and events were made by VTTI project staff;
 - Data collection and reduction was as automated as possible (speed and lane keeping data were totally automated, and involved no human intervention or interpretation); and
 - In the case of eyeglance data reduction, where human intervention and interpretation were necessary, data reductionists knew very little about the project, its focus, or its sponsor. They evaluated each event according to a number code, with no knowledge about whether the number represented a digital billboard, conventional billboard, comparison event, or baseline event.
 - In addition, the participants themselves did not know the true purpose of the study.

Differences between the two studies included the following items; these were motivated primarily by the difference in focus between the two studies:

- The focus of the Charlotte study was driver performance in relation to conventional billboards, while the focus of the Cleveland study was driver performance in relation to digital billboards.
- The comparison events in each study were chosen to be comparable to the events of interest. In the Charlotte study, the comparison events were chosen prior to data collection and were considered by the experimenters to be visually similar to conventional billboards. In the Cleveland study, the comparison events were again chosen prior to data collection and were considered by the experimenters to be visually similar to digital billboards.
- The Cleveland route was longer (50 miles, versus 35 miles for the Charlotte study; this was due to the need to include as many digital billboards as possible).
- The Cleveland subject pool was not as representative of the demographics of Cleveland as was the Charlotte subject pool (in terms of race and ethnicity). For example, Cleveland is approximately 41% Caucasian, while 97% of the participants were Caucasian. Charlotte is 58% Caucasian and 61% of the participants in that study were Caucasian.
- The Charlotte study examined the 7 seconds preceding each event, while the Cleveland study used 8 seconds (to increase the chances of capturing data for a message change for the digital billboards).
- The Cleveland study included digital billboards, which were not present in the Charlotte study.
- The Cleveland study included an exploratory nighttime study using 12 of the daytime participants.
- Luminance measures were obtained for the Cleveland study as part of the nighttime exploratory study.
- The Charlotte study included some US highway type roads that were not available in the Cleveland study.
- Because the digital billboards were all located on the interstate segments of the route, the road type and event type were confounded, unlike in the Charlotte study. To get around this, some of the analyses examined only events occurring on interstates.
- Because most of the drivers were more familiar with the interstate segments than with the surface streets, road type and familiarity were also confounded to a greater degree than in the Charlotte study. However, this interaction was not a primary focus of the current study.
- The Cleveland study was conducted in late fall and early winter, while the Charlotte study was conducted in late spring.

CONCLUSIONS

As with all studies, especially those conducted in real-world environments, the research design demonstrated both limitations and strengths. The study was designed to be as similar as possible to the study previously conducted in Charlotte, NC, with the major exception of the focus of the study (conventional billboards for Charlotte and digital billboards for Cleveland). The studies were similar in many important aspects with the exception of the location of the digital billboards. In the Charlotte study, billboards were present on all road types, while in Cleveland, all of the digital billboards were located along interstate highways. Thus, no conclusions can be made regarding the potential impact of digital billboards located on surface streets on driver behavior or performance. Despite this one flaw, necessitated by the real-world constraints of the digital billboard locations, the overall findings of this study were consistent and compelling.

The overall conclusion, supported by both the eyeglance results and the questionnaire results, is that the digital billboards seem to attract more attention than the conventional billboards and baseline sites (as shown by a greater number of spontaneous comments regarding the digital billboards and by longer glances in the direction of the billboards). The comparison events, 25% of which included signs with digital components, showed very similar results to the digital billboards. Thus, there appears to be some aspect of the digital billboards and on-premises signs that holds the driver's attention once the driver has glanced in that direction. This is most likely the result of the intrinsic lighting of these signs, which is noticeable even during the daytime. Drivers may also have maintained longer glances towards the digital billboards in the hopes of catching the next message (knowing that the message changed periodically), although an analysis of longer glances did not bear this out.

Although exploratory in nature, the nighttime results were very similar to the daytime results, with degraded eyeglance performance for digital billboards and comparison events. The digital billboards were also found to have much higher luminance at nighttime than any of the other event types.

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

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APPENDICES

Appendix A: Initial Participant Telephone Screening Form

FOARE Cleveland Participant Screening Script

Note to Researcher:

Initial contact between participants and researchers may take place over the phone. If this is the case, read the following Introductory Statement, followed by the questionnaire. Regardless of how contact is made, this questionnaire must be administered verbally before a decision is made regarding suitability for this study.

Introductory Statement:

After prospective participant calls or you call him/her, use the following script as a guideline in the screening interview.

Hello. My name is Melinda McElheny and I'm a researcher with the Virginia Tech Transportation Institute in Blacksburg, Virginia. The project involves participation in a driving study to help researchers understand how people drive.

This study involves coming to a meeting room at the Residence Inn by Marriott in Independence, OH, just south of Cleveland on I-77 one time for approximately 2 hours. During this session you would help us by driving one of our vehicles along a pre-selected route for about 50 miles. The vehicle will be equipped with data collection equipment. Does this sound interesting to you?

Next, I would like to ask you several questions to see if you are eligible to participate.

Questions

1. Do you have a valid driver's license?

Yes _____ No _____

2. How often do you drive each week?

Every day _____ At least 2 times a week _____ Less than 2 times a week _____

3. How old are you? _____ (stop if not 18-35 years old or 50-75 years old.)

4. What type of vehicle do you usually drive? _____

5. Have you previously participated in any experiments at the Virginia Tech Transportation Institute? If so, can you briefly describe the study?

Yes _____
No _____

6. How long have you held your drivers' license? _____
7. Are you able to drive an automatic transmission without assistive devices or special equipment? Yes _____ No _____
8. Do you have a history of any of the following? If yes, please explain.

Stroke	No _____	Yes _____
Brain tumor	No _____	Yes _____
Head injury	No _____	Yes _____
Epileptic seizures	No _____	Yes _____
Respiratory disorders	No _____	Yes _____
Motion sickness	No _____	Yes _____
Inner ear problems	No _____	Yes _____
Dizziness, vertigo, or other balance problems	No _____	Yes _____
Diabetes	No _____	Yes _____
Migraine, tension headaches	No _____	Yes _____

9. (Females only, of course) Are you currently pregnant?

Yes _____ No _____ (If "yes" then read the following statement to the participant: *"It is not recommended that pregnant women participate in this study. However, female participants who are pregnant and wish to participate must first consult with their personal physician for advice and guidance regarding participation in a study where risks, although minimal, include the possibility of collision and airbag deployment."*)

10. Are you currently taking any medications on a regular basis? If yes, please list them.

Yes _____
No _____

11. Do you have normal or corrected to normal hearing and vision? If no, please explain.

Yes _____
No _____

12. Have you ever had radial keratotomy, LASIK, or other eye surgeries? If yes, please specify.

Yes _____
No _____

I would like to take your name, phone number or phone numbers, and/or email where you can be reached and hours/days when it's best to reach you.

Name _____ Male/Female

Phone Numbers _____ Age: _____

Best Time to Call _____

Email _____

When contacting participants for scheduling purposes, the following statement must be included in the conversation. *"We ask that all participants refrain from drinking alcohol and taking any substances that will impair their ability to drive prior to participating in our study."*

Criteria for Participation:

1. ***Must hold a valid driver's license.***
2. ***Must be 18-35 or 50-75 years of age.***
3. ***Must drive at least 2 times a week.***
4. ***Must have normal (or corrected to normal) hearing and vision.***
5. ***Must be able to drive an automatic transmission without special equipment.***
6. ***Cannot have lingering effects of brain damage from stroke, tumor, head injury, recent concussion, or infection. Cannot have had epileptic seizures within 12 months, respiratory disorders, motion sickness, inner ear problems, dizziness, vertigo, balance problems, diabetes for which insulin is required, chronic migraine or tension headaches.***
7. ***Cannot currently be taking any substances that may interfere with driving ability (cause drowsiness or impair motor abilities).***
8. ***No history of radial keratotomy, LASIK eye surgery, or any other ophthalmic surgery.***
9. ***Must be willing to drive without sunglasses or tinted lenses.***
10. ***Must live or work in the Cleveland area.***

A total of 2 hours of time will be needed. What days and times would you be able to participate?

Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
9:30	9:30	9:30	9:30	9:30	9:30	9:30
11:45	11:45	11:45	11:45	11:45	11:45	11:45
2:00	2:00	2:00	2:00	2:00	2:00	2:00

Thank you for your time. I will contact you to schedule a session if you are selected as a participant.

Appendix B: Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

Title of Project: Influence of driver characteristics on driving performance

Investigators: Dr. Suzanne E. Lee, Research Scientist, Virginia Tech Transportation Institute.

Dr. Ronald B. Gibbons, Research Scientist, Virginia Tech Transportation Institute.

Melinda J. McElheny, Senior Research Specialist, Virginia Tech Transportation Institute.

I. The Purpose of this Research Project

This study will collect driver performance data to help understand the way people drive in a natural environment (with no experimenter present). The goal of this study is improve the understanding of how people drive.

II. Procedures

For this study you will be asked to drive on a loop-route on freeways and highways in Cleveland, Ohio. We want you to drive as you normally would on any roadway, following the typical laws and regulations of the road. The session is expected to last about two hours, including this orientation. You will then be paid for your participation.

This vehicle contains sensors and data processing equipment that will capture aspects of your driving behavior. Small video cameras are also mounted in the vehicle. One of these cameras will be directed toward your face while you are driving. The equipment has been installed in such a way that you will hardly be able to notice its presence. It will not interfere with your driving, and there is nothing special that you will need to do in regard to the equipment.

This experiment will consist of five experimental stages:

1. Introductory stage

This stage consists of preliminaries. You will be asked to read the informed consent form. Once you have signed this form, we will also ask to see your driver's license, and an eye exam will be administered. Finally, we will have you complete a medical questionnaire. Once you have completed this stage we will go on to stage 2.

2. Familiarization with the test vehicle

While the instrumented vehicle is parked you will be shown how to operate the vehicle (for example, lights, mirror adjustments, windshield wipers, etc.) as this may be different from your

personal vehicle. You will then be asked to set each control to the best level for your comfort and driving performance. You will then take a short drive with the experimenter riding along in the passenger's seat to become familiar with the vehicle. This stage should take approximately 15 minutes.

3. Preparation for loop route

The experimenter will then review the loop-route with you. You will be given a map and written directions that the experimenter will review with you.

4. Driving the loop route

You will then drive the instrumented vehicle for approximately 1.5 hours over the pre-planned loop route of approximately 50 miles. You are expected to follow the posted speed limit and to wear your seatbelt. Also, please stay in the right-hand lane to the extent possible during the drive. The loop route is to be completed in one session if possible.

5. Debriefing and Payment

After completing the experiment, you will return here for a short debriefing session. You will then be paid for your participation. It is expected that the complete session will last approximately 2 hours, including orientation, loop-route, and debriefing.

III. Risks

The experiment is believed to be minimal risk. There are risks or discomforts to which you are exposed in volunteering for this research. The risks in this study are the same as the risks normally associated with driving on public roadways. The risks involved include the following:

- 1) The risks normally associated with driving on commonly encountered roadway segments at freeway speeds, and if you are participating in the nighttime driving study, the risks include those normally associated with driving on similar roadway segments at night.
- 2) Possible fatigue due to the length of the experiment. However, the route will be selected to minimize the amount of driving required. You will be instructed to exit the roadway to take a break if you feel the need to do so at any time during the experimental session.
- 3) Cameras will videotape you as you drive the vehicle; therefore, we will ask you not to wear sunglasses. However, you should feel free to put on your sunglasses if this request at any time impairs your ability to drive the vehicle safely.

The following precautions will be taken to ensure minimal risk to you:

- 1) The experimenter will monitor you during the orientation drive and help you become familiar with the experimental vehicle. However, as long as the you are driving the research vehicle, it remains your responsibility to drive in a safe, legal manner.
- 2) You will be required to wear the lap and shoulder belt restraint system while in the car. The vehicle is also equipped with a driver's side airbag supplemental restraint system.
- 3) If an accident does occur, you will be instructed to call appropriate emergency services via a cell phone in the glove compartment, and then to call the experimenter. If a visit to a medical facility is required, you would be required to undergo examination by medical personnel.

- 4) A cell phone (stored in the glove compartment) will be made available for you to call the experimenter for any reason. You will be instructed to call only while the vehicle is in a safe location, and while the vehicle is not in motion.
- 5) All data collection equipment will be mounted such that, to the greatest extent possible, it does not pose a hazard to you in any foreseeable case.
- 6) None of the data collection equipment or the display technology interferes with any part of your normal field of view present in the automobile.

IV. Benefits of this Research Project

The information collected from this project will provide new information on how people tend to drive in a natural setting. This information will be used to improve roadway and vehicle design, so that roadside and in-vehicle devices can be better designed to fit in with what people expect. While there are no direct benefits of participating in this study, you may find the experiment interesting. No guarantee of benefits has been made to encourage you to participate. However, to avoid biasing other potential participants, you are requested not to discuss this study with anyone for at least 8 months after participation.

V. Extent of Anonymity and Confidentiality

The results obtained from this study will be kept completely anonymous. Your name will not appear on data derived from your session. Only a number will differentiate your data from others who take part in the study. This number, and not your name, will also be used in subsequent data analyses and reports.

As indicated, video will be recorded while you are driving. The video includes an image of your face, so that we can determine where you are normally looking. The video will be treated with confidentiality and kept secure. It will be shared only with other qualified researchers, and not published except as noted in the following paragraph.

If at a later time we wish to use the video information for other than research purposes, say, for public education, or if we wish to publish (for research or for other purposes) your likeness or other information from the study that identifies you either directly or indirectly, we will only do so after we have contacted you again and obtained your explicit permission.

VI. Compensation

You will be paid \$20 per hour for the time you actually spend in the experiment. It is estimated that the entire session, including orientation, driving, and debriefing will be 2 hours. Payment will be made in cash immediately after you have finished your participation.

VII. Freedom to Withdraw

You are free to withdraw at any time without penalty. If you choose to withdraw from this study you will be compensated for your time up until that point.

VIII. Medical Treatment and Insurance

If you should become injured in an accident, the medical treatment available to you would be that provided to any driver or passenger by emergency medical services in the vicinity where the accident occurs. The vehicle you will be driving is insured for automobile liability and

collision/comprehensive through Virginia Tech and the Commonwealth of Virginia. There is medical coverage for you under this policy. The total policy amount per occurrence is \$2,000,000. This coverage would apply in case of an accident, except as noted below.

Under certain circumstances, you may be deemed to be driving in the course of your employment, and your employer's worker's compensation provisions may apply in lieu of the Virginia Tech and Commonwealth of Virginia insurance provisions, in case of an accident. The particular circumstances under which worker's compensation would apply are specified in Virginia law. If worker's compensation provisions do not apply in a particular situation, the Virginia Tech and Commonwealth of Virginia insurance provisions will provide coverage.

Briefly, worker's compensation would apply if your driving for this research can be considered as part of the duties you perform in your regular job. If it is not considered as part of your regular job, then the insurance policy would apply.

IX. Approval of Research

You should know that this research project has been approved, as required by the Institutional Review Board for Research Involving Human Participants at Virginia Polytechnic Institute and State University, and the Virginia Tech Transportation Institution.

X. Participant's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

- 1) I should not participate in this study if I do not have a valid driver's license or if I am not in good health.
- 2) I should notify the experimenter if at any time I do not want to continue my participation.
- 3) I should operate the instrumented vehicle in a safe and responsible manner.
- 4) I should answer all questions truthfully.

XI. Participant's Permission

Check one of the following:

- ☐ I have **not** had an eye injury/eye surgery (including, but not limited to, LASIK, Radial Keratotomy, and cataract surgery.)
- ☐ I **have** had an eye injury/eye surgery and I've have been informed of the possible risks to participants who have had eye surgery. I choose to accept this possible risk to participate in this study.

Participant # _____

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

Signature

Date

Should I have any questions about this research project or its conduct, I may contact:

Dr. Suzanne E. Lee, Principal Investigator

(540) 231-1511

Melinda J. McElheny, Senior Research Specialist

(540) 231-1557

David Moore, Chair of the Virginia Tech Institutional Review Board

(540) 231-4991

Participants must be given a complete copy (or duplicate original) of the signed Informed Consent.

Appendix C: Health Screening Questionnaire***Health Screening Questionnaire***

1. Are you in good general health? Yes No

If no, list any health-related conditions you are experiencing or have experienced in the recent past.

2. Have you, in the last 24 hours, experienced any of the following conditions?

Inadequate sleep	Yes	No
Hangover	Yes	No
Headache	Yes	No
Cold symptoms	Yes	No
Depression	Yes	No
Allergies	Yes	No
Emotional upset	Yes	No

3. Do you have a history of any of the following?

Visual Impairment	Yes	No
-------------------	-----	----

(If yes, please describe.)

Seizures or other lapses of consciousness	Yes	No
---	-----	----

(If yes, please describe.)

Any disorders similar to the above or that would impair your driving ability	Yes	No
--	-----	----

(If yes, please describe.)

Participant # _____

4. List any prescription or non-prescription drugs you are currently taking or have taken in the last 24 hours.

5. List the approximate amount of alcohol (beer, wine, fortified wine, or liquor) you have consumed in the last 24 hours.

6. Are you taking any drugs of any kind other than those listed in 4 or 5 above?

Yes No

Signature

Date

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-480 between I-77 and 150 th	_____ Familiar	_____ Not Familiar
W. 130 th - Bellaire - W. 117 th	_____ Familiar	_____ Not Familiar
I-90 between 9 th and 185 th	_____ Familiar	_____ Not Familiar
Carnegie St.	_____ Familiar	_____ Not Familiar
I-77 between I-90 and Rockside	_____ Familiar	_____ Not Familiar

2. For the following systems, please check what you liked or disliked:

Seating	_____ like	_____ neutral	_____ dislike
Air conditioning	_____ like	_____ neutral	_____ dislike
Engine power	_____ like	_____ neutral	_____ dislike
Visibility	_____ like	_____ neutral	_____ dislike
Steering	_____ like	_____ neutral	_____ dislike

3. Please check the top five items that most caught your attention during your drive:

_____ Surrounding traffic
 _____ Other drivers
 _____ Construction areas
 _____ Road/street signs
 _____ Emergency vehicles
 _____ Buildings
 _____ Landmarks
 _____ Walls
 _____ Landscaping/scenery
 _____ Gas Stations
 _____ Restaurants
 _____ Motels/Hotels
 _____ Billboards
 _____ Towers
 _____ Highway/Exit Signs
 _____ Smoke Stacks
 _____ Apartments/housing
 _____ Other _____

4. Did you experience any problems while following the written directions? ___Yes ___No
If yes, please describe:

5. What was most memorable about the drive? For example, were there any objects that stood out?

6. What other activities do you typically engage in while driving?

7. Does anything about other drivers bother you? If so, please briefly describe:

8. Please provide any other input about this study:

9. In what city do you live?

10. In what city do you work?

11. What level of education have you completed?

- ___Elementary/Secondary
- ___Junior High School
- ___High School degree
- ___2-yr Associate degree
- ___Bachelor's degree
- ___Master's degree
- ___Doctoral/Professional degree

12. Please indicate your marital status:

___single ___married ___widowed ___divorced ___separated

13. Which of the following groups best represent your ethnicity?

- ___African American
- ___Hispanic (Latino)
- ___Asian

Participant # _____

- _____ Native American (American Indian)
- _____ European (Caucasian, White)
- _____ Multi-racial

14. Which of the following best represents your annual household income?

- _____ \$0-\$24,999
- _____ \$25,000-\$49,999
- _____ \$50,000-\$74,999
- _____ \$75,000-\$99,999
- _____ > \$100,000

15. What was the purpose of this study?

The Effects of Commercial Electronic Variable Message Signs (CEVMS) on Driver Attention and Distraction: An Update

PUBLICATION NO. FHWA-HRT-09-018

FEBRUARY 2009



U.S. Department of Transportation
Federal Highway Administration

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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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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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²
*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)				

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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.⁽¹⁾ 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.^(1,2) 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. The present report does not provide guidance to States on the control of CEVMS.

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, tri-vision, 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.⁽¹⁾ 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.⁽⁵⁾ 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.⁽⁶⁾ 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.⁽⁵⁾ 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.⁽⁸⁾ 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.⁽¹⁴⁾ 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).⁽¹⁴⁾ 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.^(7,15) 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.⁽¹⁵⁾ 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.⁽⁷⁾

Smiley et al. also employed safety surrogate measures of conditions which might be precursors of a possible crash.⁽⁷⁾ 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).⁽⁷⁾ 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.⁽¹⁶⁾ 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.⁽¹⁷⁾ 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.⁽¹⁷⁾ 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.⁽¹⁸⁾ 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 in-vehicle versus external-to-vehicle distractors on performance of inexperienced versus experienced drivers.⁽¹⁹⁾ 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.⁽¹⁶⁾ 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.⁽²¹⁾ 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.⁽²²⁾ They cited two prior reviews by Wachtel and Netherton in the United States and by Andreassen in Australia as the basis of their review.^(2,23) 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.⁽²⁶⁾ 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.^(17,26) 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).⁽²⁶⁾

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.⁽²⁸⁾ 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.⁽²⁹⁾ 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.⁽³⁰⁾ 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.^(31,32) 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.⁽³⁰⁾ 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].

The Effects of Commercial Electronic Variable Message Signs (CEVMS) on Driver Attention and Distraction: An Update

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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.

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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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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²
*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)				

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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.⁽¹⁾ 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.^(1,2) 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. The present report does not provide guidance to States on the control of CEVMS.

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, tri-vision, 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.⁽¹⁾ 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.⁽⁵⁾ 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.⁽⁶⁾ 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.⁽⁵⁾ 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.⁽⁸⁾ 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.⁽¹⁴⁾ 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).⁽¹⁴⁾ 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.^(7,15) 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.⁽¹⁵⁾ 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.⁽⁷⁾

Smiley et al. also employed safety surrogate measures of conditions which might be precursors of a possible crash.⁽⁷⁾ 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).⁽⁷⁾ 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.⁽¹⁶⁾ 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.⁽¹⁷⁾ 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.⁽¹⁷⁾ 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.⁽¹⁸⁾ 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 in-vehicle versus external-to-vehicle distractors on performance of inexperienced versus experienced drivers.⁽¹⁹⁾ 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.⁽¹⁶⁾ 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.⁽²¹⁾ 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.⁽²²⁾ They cited two prior reviews by Wachtel and Netherton in the United States and by Andreassen in Australia as the basis of their review.^(2,23) 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.⁽²⁶⁾ 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.^(17,26) 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).⁽²⁶⁾

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.⁽²⁸⁾ 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.⁽²⁹⁾ 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.⁽³⁰⁾ 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.^(31,32) 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.⁽³⁰⁾ 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 their 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 eye-tracking 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 vehicle-mounted 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); retro-reflective		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, 4	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 head-mounted 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. Vehicle-mounted 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 to 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), in-vehicle 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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**DRIVER VISUAL BEHAVIOR IN THE PRESENCE OF COMMERCIAL
ELECTRONIC VARIABLE MESSAGE SIGNS (CEVMS)**

SEPTEMBER 2012

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.

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Research and Development

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

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

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

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
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LIST OF ACRONYMS AND SYMBOLS

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

EXECUTIVE SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

- The average fixation duration to CEVMS was 379 ms and to standard billboards it was 335 ms across the two cities. The average fixation durations to CEVMS and standard billboards were similar to the average fixation duration to the road ahead.
- The longest fixation to a CEVMS was 1,335 ms and to a standard billboard it was 1,284 ms. The current widely accepted threshold for durations of glances away from the road ahead that result in higher crash risk is 2,000 ms. This value comes from a NHTSA

naturalistic driving study that showed a significant increase in crash odds when glances away from the road ahead were 2,000 ms or longer.

- Four dwell times (aggregate of consecutive fixations to the same object) greater than 2,000 ms were observed across the two studies. Three were to standard billboards and one was to a CEVMS. The long dwell time to the CEVMS occurred in the daytime to a billboard viewable from a freeway. Review of the video data for these four long dwell times showed that the signs were not far from the forward view while participant's gaze dwelled on them. Therefore, the drivers still had access to information about what was in front of them through peripheral vision.
- The results did not provide evidence indicating that CEVMS, as deployed and tested in the two selected cities, were associated with unacceptably long glances away from the road. When dwell times longer than the currently accepted threshold of 2,000 ms occurred, the road ahead was still in the driver's field of view. This was the case for both CEVMS and standard billboards.

Do drivers look at CEVMS more than at standard billboards?

- When comparing the probability of a gaze at a CEVMS versus a standard billboard, the drivers in this study were generally more likely to gaze at CEVMS than at standard billboards. However, some variability occurred between the two locations and between the types of roadway (arterial or freeway).
- In Reading, when considering the proportion of time spent looking at billboards, the participants looked more often at CEVMS than at standard billboards when on arterials (63 percent to CEVMS and 37 percent to a standard billboard), whereas they looked more often at standard billboards when on freeways (33 percent to CEVMS and 67 percent to a standard billboard). In Richmond, the drivers looked at CEVMS more than standard billboards no matter the type of road they were on, but as in Reading, the preference for gazing at CEVMS was greater on arterials (68 percent to CEVMS and 32 percent to standard billboards) than on freeways (55 percent to CEVMS and 45 percent to standard billboards). When a gaze was to an off-premise advertising sign, the drivers were generally more likely to gaze at a CEVMS than at a standard billboard.
- In Richmond, the drivers showed a preference for gazing at CEVMS versus standard billboards at night, but in Reading the time of day did not affect gaze behavior. In Richmond, drivers gazed at CEVMS 71 percent and at standard billboards 29 percent at night. On the other hand, in the day the drivers gazed at CEVMS 52 percent and at standard billboards 48 percent.
- In Reading, the average gaze dwell time for CEVMS was 981 ms and for standard billboards it was 1,386 ms. The difference in these average dwell times was not statistically significant. In contrast, the average dwell times to CEVMS and standard billboards were significantly different in Richmond (1,096 ms and 674 ms, respectively).

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

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

INTRODUCTION

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

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

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

BACKGROUND

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

Post-Hoc Crash Studies

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

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

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

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

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

Field Investigations

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

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

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

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

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

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

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

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

Laboratory Studies

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

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

Summary

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

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

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

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

STUDY APPROACH

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

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

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

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

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

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

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

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

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

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

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

In sum, most of the literature concerning eye gaze behavior in dynamic environments suggests that task demands tend to override visual salience in determining attention allocation. When extended to driving, it would be expected that visual attention will be directed toward task-relevant areas and objects (e.g., the roadway, other vehicles, speed limit signs, etc.) and other

salient objects, such as billboards, will not necessarily capture attention. However, driving is a somewhat automatic process and conditions generally do not require constant undivided attention. As a result, salient stimuli, such as CEVMS, might capture driver attention and provide an unwarranted increase in driver distraction. The present study addresses this concern.

Research Questions

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

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

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

EXPERIMENTAL APPROACH

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



Figure 1. Eye tracking system camera placement.

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

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



Figure 2. FHWA's field research vehicle.

EXPERIMENTAL DESIGN OVERVIEW

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

Site Selection

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

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

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

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

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

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

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

- **The type of advertising.** This included CEVMS, standard billboards, and no off-premise advertising. (It should be noted that in areas with no off-premise advertising, it was still possible to encounter on-premise advertising; e.g., for gas stations, restaurants, and other miscellaneous stores and shops.)
- **Time of day.** This included driving in the daytime and at night.
- **The functional class of roadways in which off-premise advertising signs were located.** Roads were classified as either freeway or arterial. It was observed that the different road classes were correlated with the presence of other visual information that could affect the driver's glance behavior. For example, the visual environment on arterials may be more complex or cluttered than on freeways because of the close proximity of buildings, driveways, and on-premise advertising, etc.

READING

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

METHOD

Selection of Data Collection Zone Limits

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

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

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

Advertising Conditions

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

- **CEVMS.** These were DCZs that contained one target CEVMS. Two CEVMS DCZs were located on freeways and two were located on arterials. Figure 3 and figure 4 show examples of CEVMS DCZs with the CEVMS highlighted in the pictures.
- **Standard billboard.** These were DCZs that contained one target standard billboard. Two standard billboard DCZs were located on freeways and two were located on arterials. Figure 5 and figure 6 show examples of standard billboard DCZs; the standard billboards are highlighted in the pictures.

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

Table 2. Inventory of target billboards with relevant parameters.

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

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



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



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



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



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



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



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

Photometric Measurement of Signs

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

Photometric Equipment

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

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

Measurement Methodology

Images of the billboards were acquired using the photometer manufacturer's software. The software provided the mean luminance of each billboard message. To prevent overexposure of

images in daylight, neutral density filters were manually affixed to the photometer lens and the luminance values were scaled appropriately. Standard billboards were typically measured only once; however, for CEVMS multiple measures were taken to account for changing content.

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

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

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

Visual Complexity

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

The method proposed by Rozenholtz, Li, and Nakano provides quantitative and perhaps reliable measures of visual clutter.⁽³⁴⁾ Their approach measures the feature congestion in a visual image. The implementation of the feature congestion measure involves four stages: (1) compute local feature covariance at multiple scales and compute the volume of the local covariance ellipsoid, (2) combine clutter across scale, (3) combine clutter across feature types, and (4) pool over space to get a single measure of clutter for each input image. The implementation that was used employed color, orientation and luminance contrast as features. Presumably, less cluttered

images can be visually coded more efficiently than cluttered images. For example, visual clutter can cause decreased recognition performance and greater difficulty in performing visual search.⁽³⁵⁾

Participants

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

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

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

Procedures

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

Pre-Data Collection Activities

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

Next, the participant and both researchers moved to the eye tracking calibration location and the test vehicle. The calibration procedure took approximately 20 minutes. Calibration of the eye tracking system entailed development of a profile for each participant. This was accomplished by taking multiple photographs of the participant's face as they slowly rotate their head from side to side. The saved photographs include points on the face for subsequent real-time head and eye tracking. Marked coordinates on the face photographs were edited by the experimenter as needed to improve the real-time face tracking. The procedure also included gaze calibration in which participants gazed at nine points on a wall. These points had been carefully plotted on the wall and correspond to the points in the eye tracking system's world model. Gaze calibration relates the individual participant's gaze vectors to known points in the real world. The eye tracking system uses two pulsating infrared sources mounted on the dashboard to create two corneal glints that are used to calculate gaze direction vectors. The glints were captured at 60 Hz. A second set

of cameras (scene cameras), fixed on top of the car close to the driver's viewpoint, were used to produce a video scene of the area ahead. The scene cameras recorded at 25 Hz. A parallax correction algorithm compensated for the distance between the driver's viewpoint and the scene cameras so that later processing could use the gaze vectors to show where in the forward scene the driver was gazing.

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

Practice

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

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

Data Collection

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

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

Debriefing

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

DATA REDUCTION

Eye Tracking Measures

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

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

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

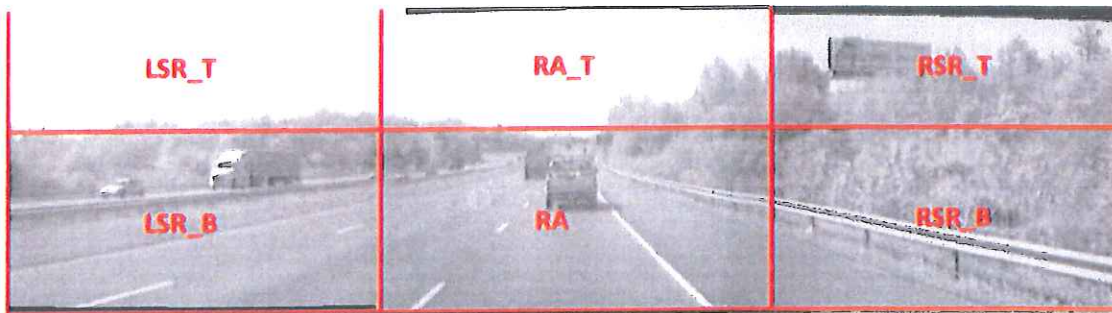


Figure 9. Screen capture showing static ROIs on a scene video output.

The following ROIs were defined with the analysis software:

Static ROIs

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

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

- Road ahead top: top portion (approximately 1/3) of the area of the forward roadway (center camera).
- Right side of road bottom: bottom portion (approximately 2/3) of the area to the right of the forward roadway (right camera).
- Right side of road top: top portion (approximately 1/3) of the area to the right of the forward roadway (right camera).
- Left side of road bottom (LSR_B): bottom portion (approximately 2/3) of the area to the left of the forward roadway (left camera).
- Left side of road bottom (LSR_T): top portion (approximately 1/3) of the area to the left of the forward roadway (left camera).
- Inside vehicle: below the panoramic video scene (outside of the view of the cameras, but eye tracking is still possible).
- Top: above the panoramic video scene (outside of the view of the cameras, but eye tracking is still possible).

Dynamic ROIs

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

- Driving-related safety risk: vehicle which posed a potential safety risk to the driver, defined as a car that is/may turn into the driver's direction of travel at a non-signalized or non-stop-controlled intersection (e.g., a car making a U-turn, a car waiting to turn right, or a car waiting to turn left). These vehicles were actively turning or entering the roadway or appeared to be in a position to enter the roadway.
- Target standard billboard: target standard billboard that defines the start and end of the DCZ.
- Other standard billboard: standard billboard(s) located in the DCZ, other than the target standard billboard or the target digital billboard.
- CEVMS: target digital billboard that defines the start and end of the DCZ.

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

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

Other Measures

Driving Behavior Measures

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

- **Driver Error:** signified any error on behalf of the driver in which the researcher felt slightly uncomfortable, but not to a significant degree (e.g., driving on an exit ramp too quickly, turning too quickly).
- **Near Miss:** signified any event in which the researcher felt uncomfortable due to driver response to external sources (e.g., slamming on brakes, swerving). A near miss is the extreme case of a driver error.
- **Incident:** signified any event in the roadway which may have had a potential impact on the attention of the driver and/or the flow of traffic (e.g., crash, emergency vehicle, animal, construction, train).

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

Level of Service Estimates

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

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

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

$$\text{Vehicle Density} = [(\text{Number of Vehicles in Analysis Zone})/(\text{Distance of Analysis Zone in ft}/5280)]/\text{Number of Lanes.}$$

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

Vehicle Speed

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

RESULTS

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

Photometric Measurements

Luminance

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

Contrast

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

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

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

Visual Complexity

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

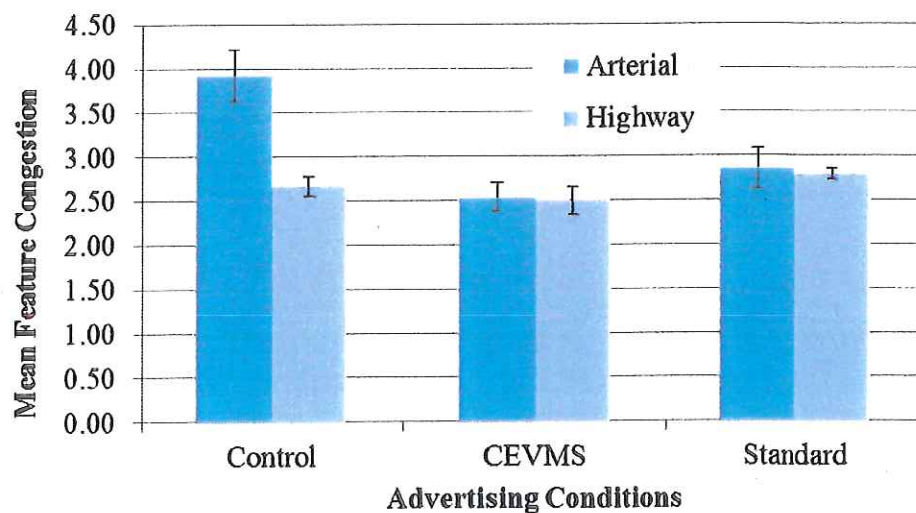


Figure 10. Mean feature congestion as a function of advertising condition and road type (standard errors for the mean are included in the graph).

Effects of Billboards on Gazes to the Road Ahead

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

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

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

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

<i>Advertising Condition</i>	<i>Arterial</i>	<i>Freeway</i>
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.

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

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

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

Fixations to CEVMS and Standard Billboards

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

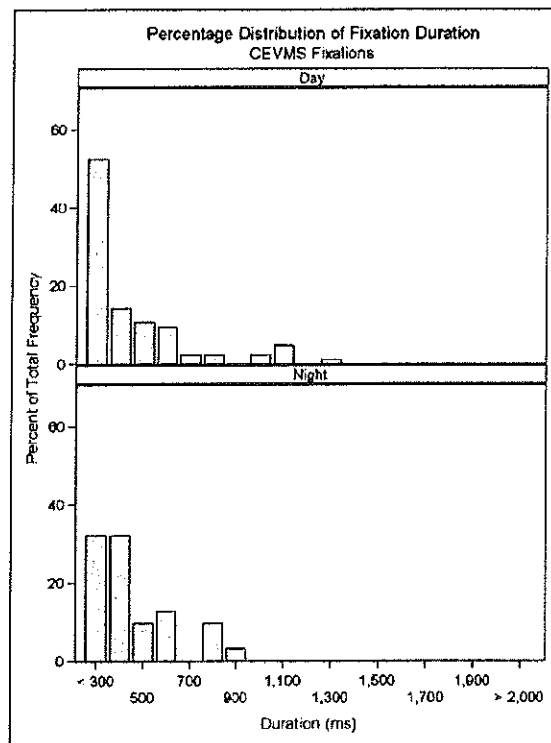


Figure 11. Distribution of fixation duration for CEVMS in the daytime and nighttime.

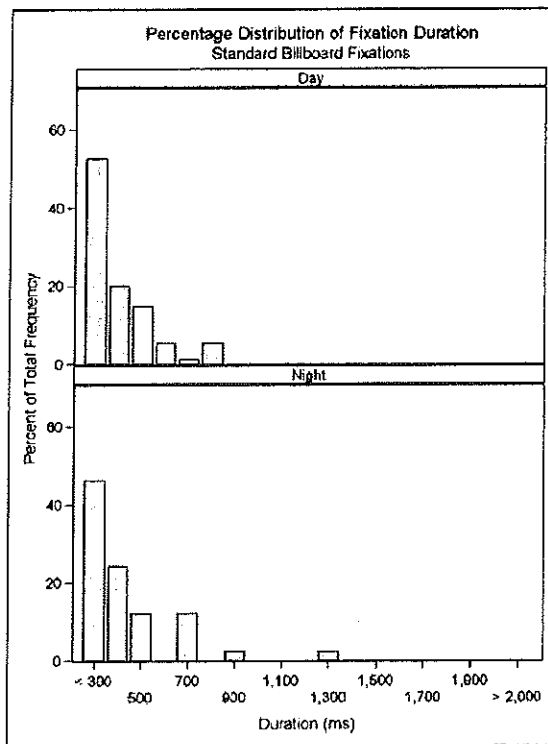


Figure 12. Distribution of fixation duration for standard billboards in the daytime and nighttime.

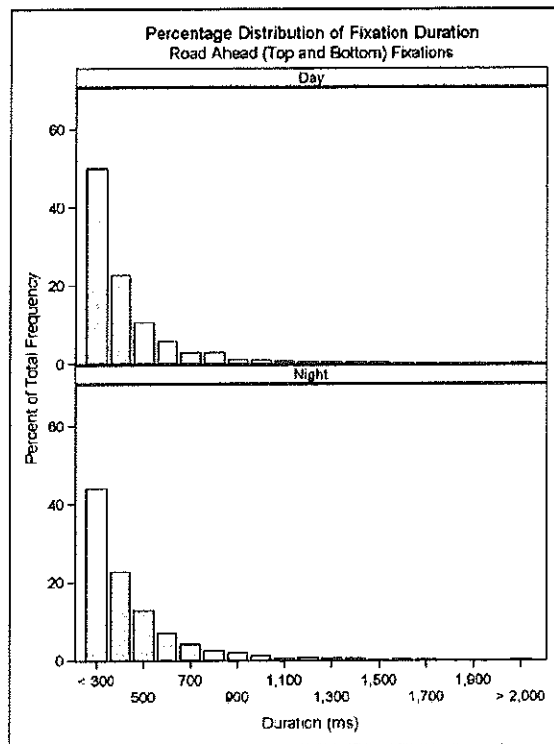


Figure 13. Distribution of fixation duration for road ahead (i.e., top and bottom road ahead ROIs) in the daytime and nighttime.

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

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

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

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

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

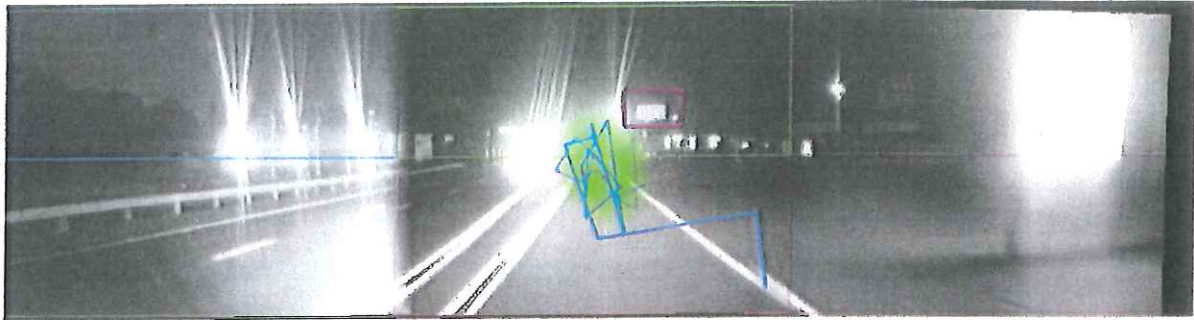


Figure 14. Heat map for the start of a DCZ for a standard billboard at night on an arterial.

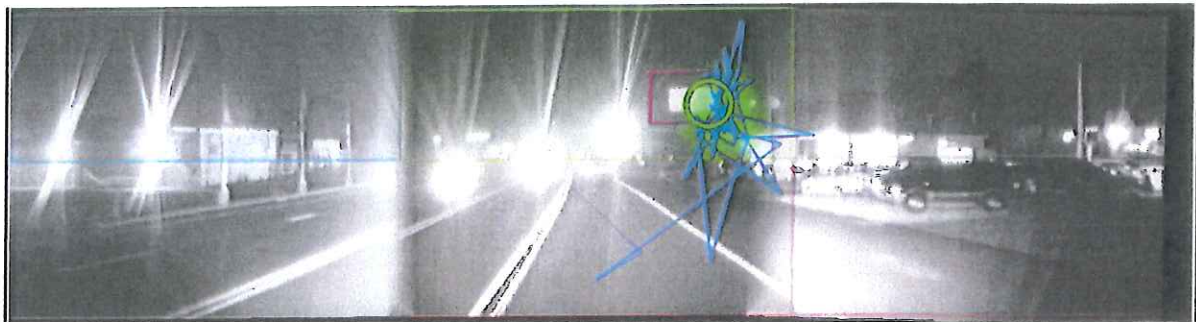


Figure 15. Heat map for the middle of a DCZ for a standard billboard at night on an arterial.

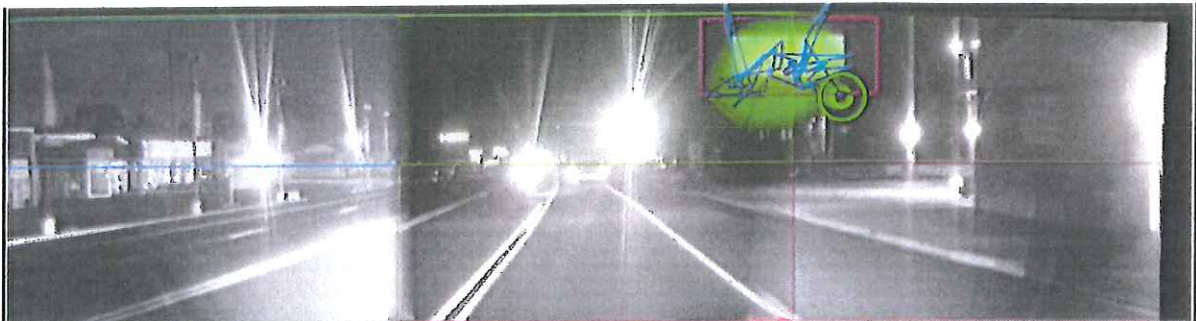


Figure 16. Heat map near the end of a DCZ for a standard billboard at night on an arterial.

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



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

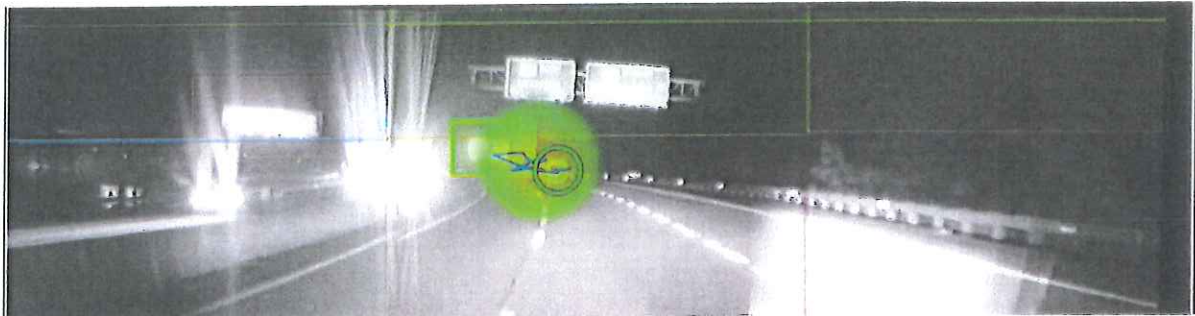


Figure 18. Heat map for middle of a DCZ for a standard billboard at night on a freeway.

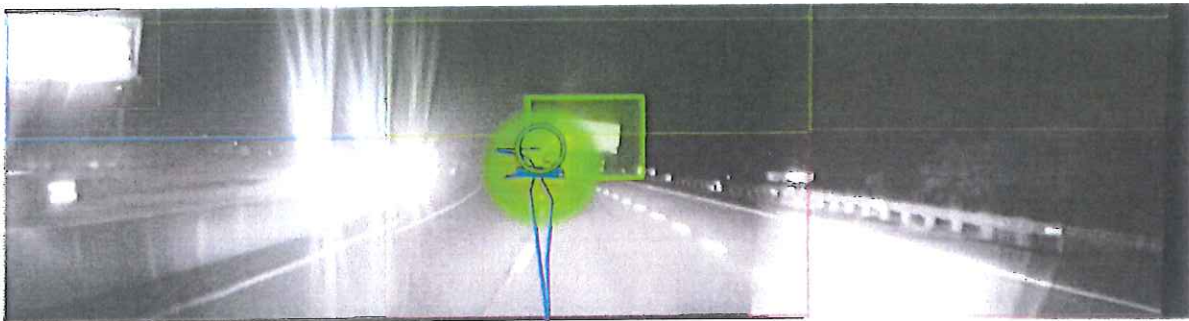


Figure 19. Heat map near the end of a DCZ for a standard billboard at night on a freeway.

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

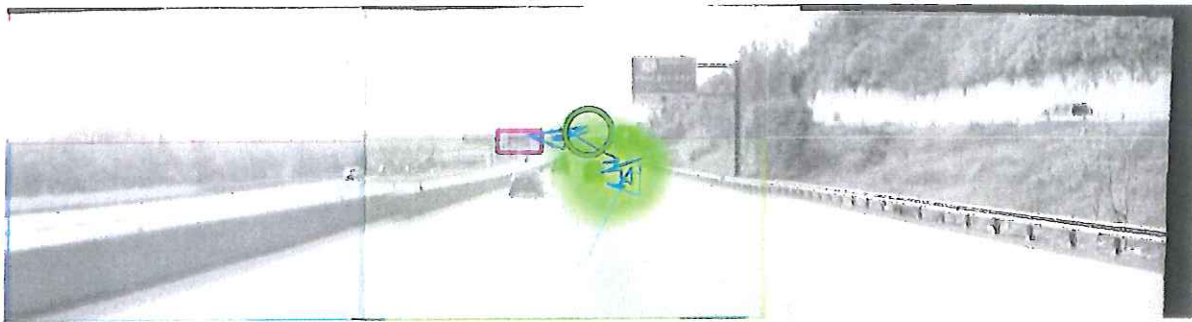


Figure 20. Heat map for the start of a DCZ for a standard billboard in the daytime on a freeway.

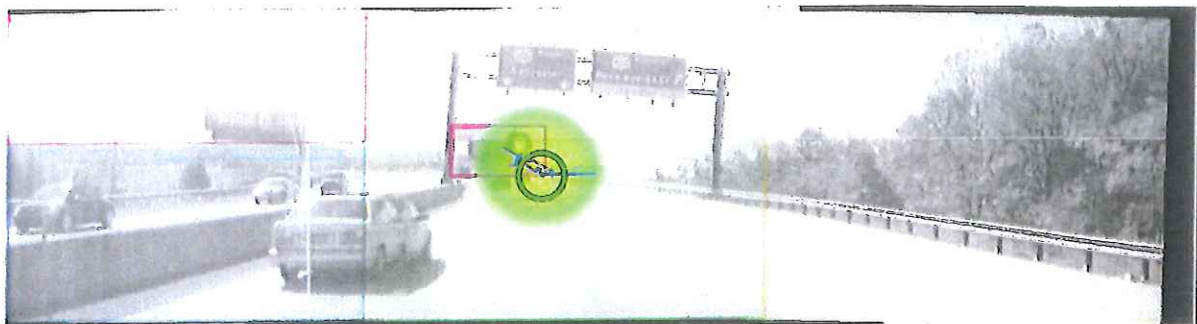


Figure 21. Heat map near the middle of a DCZ for a standard billboard in the daytime on a freeway.

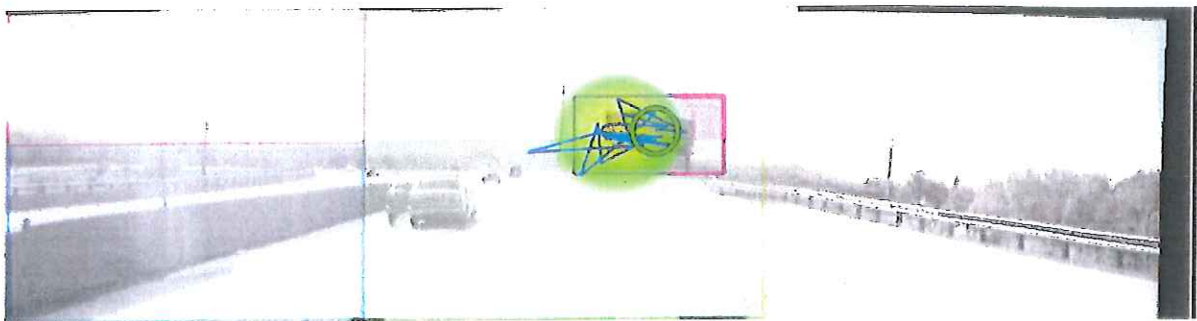


Figure 22. Heat map near the end of DCZ for standard billboard in the daytime on a freeway.

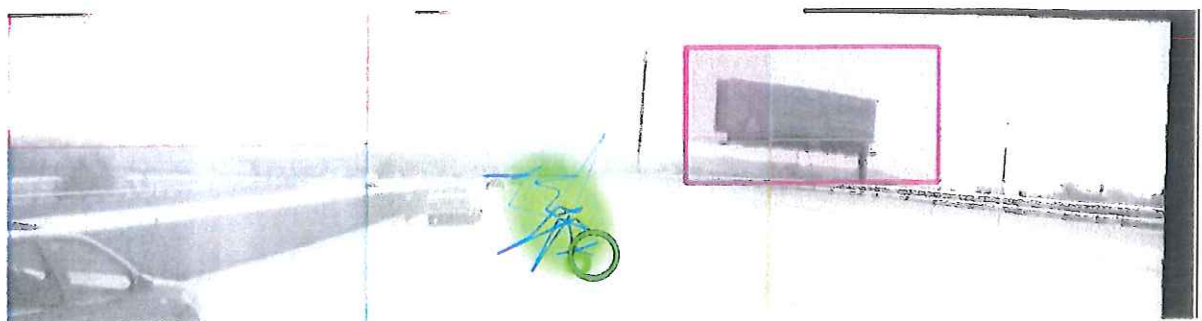


Figure 23. Heat map at the end of DCZ for standard billboard in the daytime on a freeway.

Comparison of Gazes to CEVMS and Standard Billboards

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

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

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

Observation of Driver Behavior

No near misses or driver errors were observed in Reading.

Level of Service

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

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.

	<i>Arterial</i>		<i>Freeway</i>	
	Day	Night	Day	Night
Control	B	A	C	B
CEVMS	C	A	B	A
Standard	A	A	B	A

DISCUSSION OF READING RESULTS

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

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

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

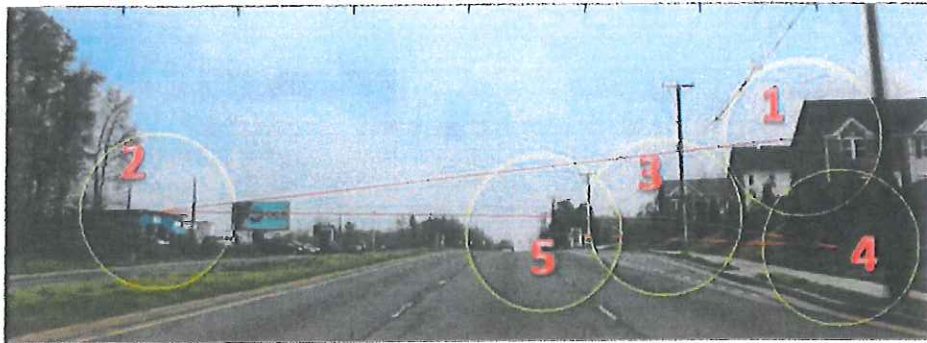


Figure 24. Example of identified salient areas in a road scene based on bottom-up analysis.

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

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

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

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

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

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

RICHMOND

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

METHOD

Selection of DCZ Limits

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

Advertising Type

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

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

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

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

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

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

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

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



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



Figure 26. Example of CEVMS DCZ an arterial.

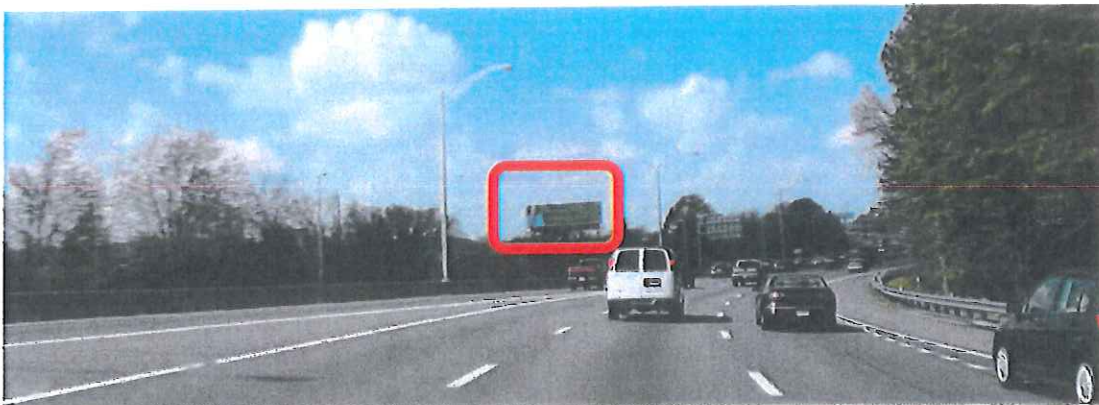


Figure 27. Example of a standard billboard DCZ on a freeway.



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



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



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

Photometric Measurement of Signs

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

Visual Complexity

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

Participants

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

Procedures

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

Participant Testing

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

Pre-Data Collection Activities

This was the same as in Reading.

Practice Drive

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

Data Collection

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

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

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

Debriefing

This was the same as in Reading.

DATA REDUCTION

Eye Tracking Measures

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

Other Measures

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

RESULTS

Photometric Measurement of Signs

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

Luminance

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

Contrast

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

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

	Luminance (cd/m^2)		Contrast	
	Mean	St. Dev.	Mean	St. Dev.
Day				
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.

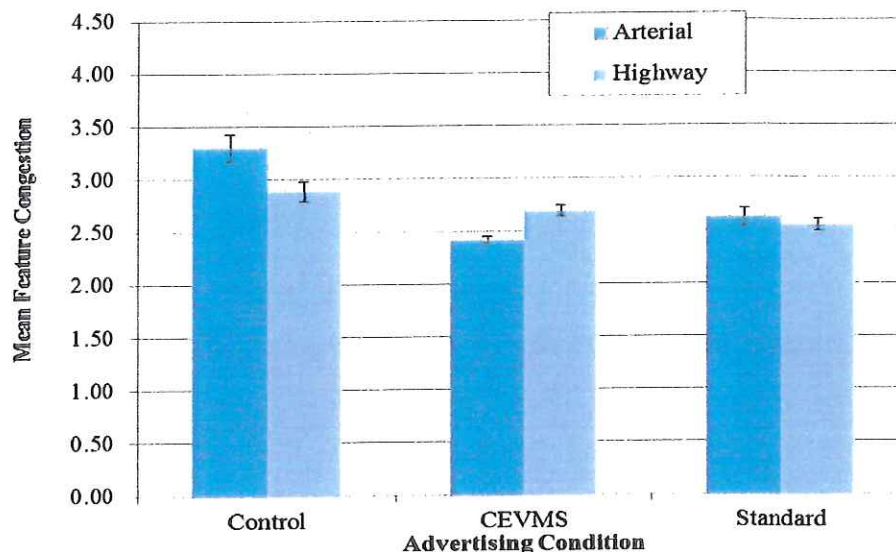


Figure 31. Mean feature congestion as a function of advertising condition and road type.

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.

<i>Advertising Condition</i>	<i>Arterial</i>	<i>Freeway</i>
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.

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

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

Fixations to CEVMS and Standard Billboards

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

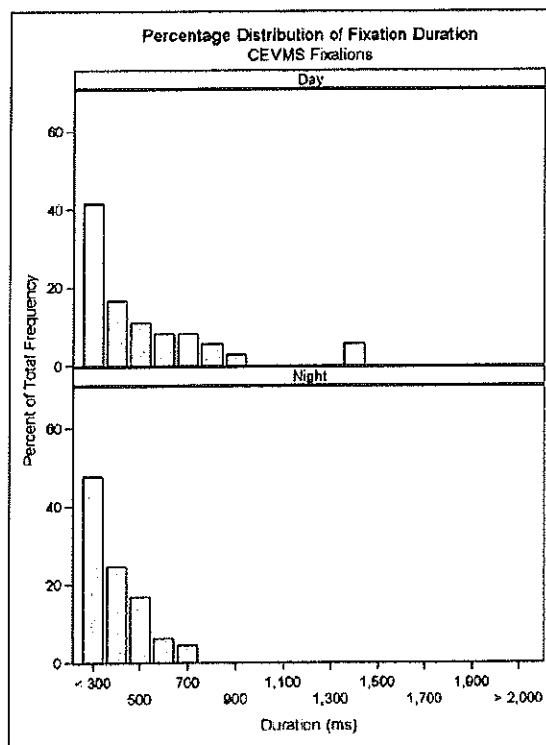


Figure 32. Fixation duration for CEVMS in the day and at night.

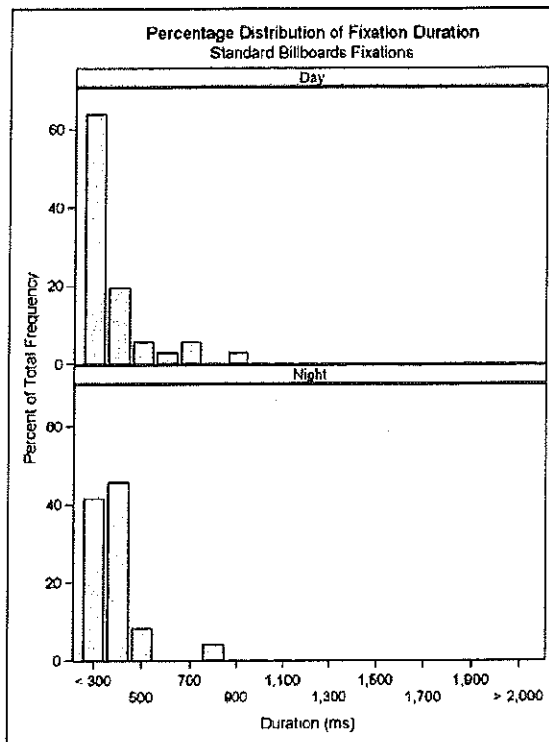


Figure 33. Fixation duration for standard billboards in the day and at night.

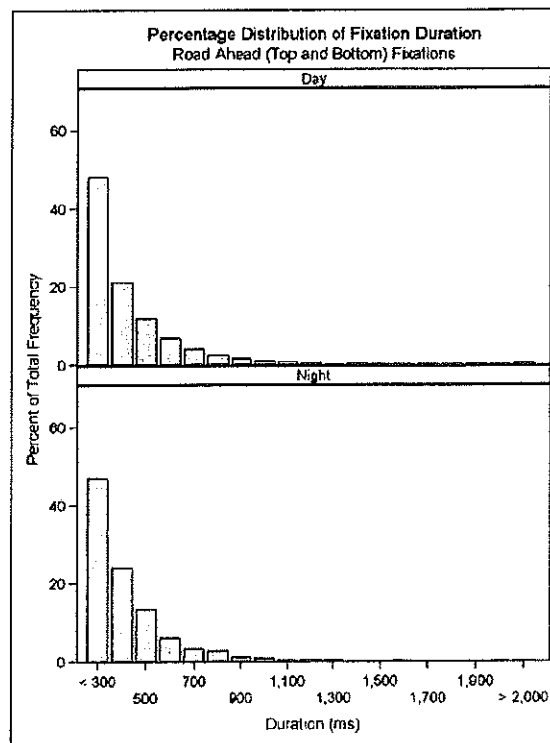


Figure 34. Fixation duration for the road ahead in the day and at night.

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

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

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

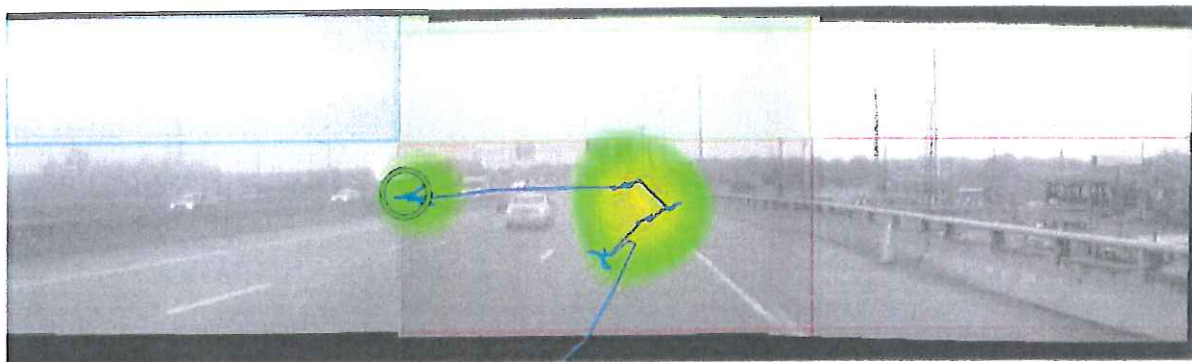


Figure 35. Heat map for first fixation to CEVMS with long dwell time.



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

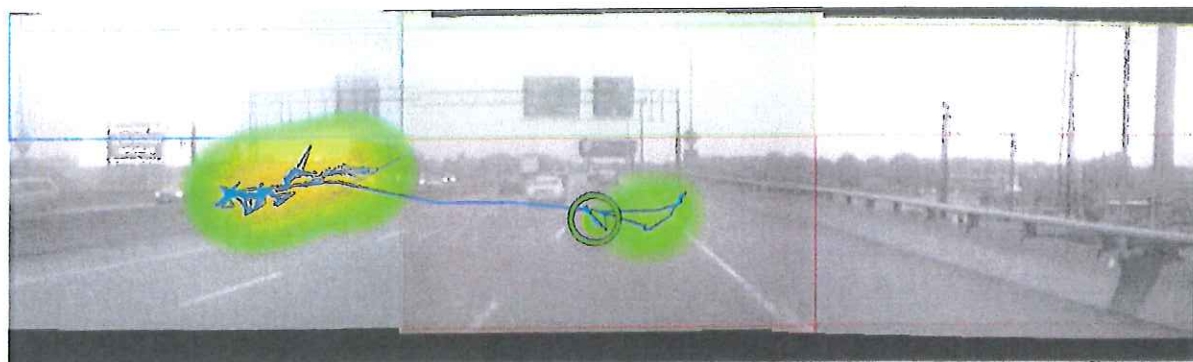


Figure 37. Heat map at end of fixations to CEVMS with long dwell time.

Comparison of Gazes to CEVMS and Standard Billboards

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

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

Observation of Driver Behavior

No near misses or driver errors occurred.

Level of Service

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

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

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

DISCUSSION OF RICHMOND RESULTS

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

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

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

driver started looking back to the road ahead as the sign moved out of the forward field of view. On the video there were no vehicles near the subject driver's own lane or in adjacent lanes.

Only the central 2 degrees of vision, foveal vision, provide resolution sharp enough for reading or recognizing fine detail.⁽⁵⁷⁾ However, useful information for reading can be extracted from parafoveal vision, which encompasses the central 10 degrees of vision.⁽⁵⁷⁾ More recent research on scene gist recognition³ has shown that peripheral vision (beyond parafoveal vision) is more useful than central vision for recognizing the gist of a scene.⁽⁵⁸⁾ Scene gist recognition is a critically important early stage of scene perception, and influences more complex cognitive processes such as directing attention within a scene and facilitating object recognition, both of which are important in obtaining information while driving.

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

The results showed that drivers are more likely to look at CEVMS than standard billboards during the nighttime across the conditions tested (at night the average probability of gazing at CEVMS was $M = 0.71$). CEVMS do have greater luminance than standard billboards at night and also have higher contrast. The CEVMS have the capability of being lit up so that they would appear as very bright signs to drivers (for example, up to about $10,000 \text{ cd/m}^2$ for a white square on the sign.). However, our measurements of these signs showed an average luminance of about 56 cd/m^2 . These signs would be conspicuous in a nighttime driving environment but significantly less so than other light sources such as vehicle headlights. Drivers were also more likely to look at CEVMS than standard billboards on both arterials and freeways, with a higher probability of gazes on arterials.

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

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

GENERAL DISCUSSION

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

CONCLUSIONS

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

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

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

The results for the off-premise advertising conditions are consistent with Lee et al., who observed that 76 percent of drivers' time was spent looking at the road ahead in the CEVMS scenario and 75 percent in the standard billboard scenario.⁽⁹⁾ However, it should be kept in mind

that drivers did gaze away from the road ahead even when no off-premise advertising was present and that the presence of clutter or salient visual stimuli did not necessarily control where drivers gazed.

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

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

Minnesota



ROGER PETERSON
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December 2, 2008

To Whom It May Concern,

Approximately one year ago, Magic Media offered to incorporate the national Amber Alert System into their digital billboards in Rochester, MN. If the need arises, the Rochester Police Department can immediately take over all of the digital billboards letting the public know that an incident exists. Not only is this program being provided at no expense to the taxpayers, but Magic Media also had a technician train me on its operation without a fee. Time is of the essence in the case of a child abduction, and this system is unsurpassed in getting the name and photograph in front of the public.

To the best of my recollection, Magic Media installed its first digital display about two years ago. They placed them on city streets where the vehicle speed is slow and some traffic signals exist. In fact, one location is at two main intersecting streets, Broadway and Civic Center Drive. Despite being placed on heavily traveled city streets, there has not been one accident attributed to a driver being distracted by the billboard.

Magic Media has been generous and law abiding in working with the public safety agencies in Rochester, MN and I have no reason to believe that the new digital billboards are unsafe to motorists.

Sincerely,


Gary Mulleneaux, Communications Manager
Rochester Police Department
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Rochester, MN 55904
Phone: (507) 328-6908
Fax: (507) 287-2672
E-Mail: gmulleneaux@rochestermp.gov



ROCHESTER

Minnesota



December 1, 2008

As the City of Rochester Council President, I listened to many opinions and concerns about off-premise digital billboards before there was one in place in our city. After working with Magic Media and learning of the standards and policies they were adhering to, the city agreed to allow them to install their first one about two years ago. Since then, four additional existing static billboards were converted and history has proven that the initial concerns were unfounded.

Magic Media has worked with the City of Rochester and agreed to a policy of not allowing the messages to flash, scroll or have any streaming video. The ambient lighting is within our ordinance standards and most importantly, there has not been any suggestion that these displays have remotely caused any accidents.

Furthermore, these displays can be used for informing the community instantaneously of events, concerts, promotions and even traffic issues. In addition, Magic Media has teamed with the City of Rochester and the Sheriff's Department to allow all of the units to display local or national disasters. At the touch of a button, the Sheriff can take control of all of the displays and inform the public of a train derailment, display a criminal they are trying to apprehend or any other such community emergency. Magic Media also participates in the national Amber Alert system to inform the public on these displays to be on the look out of a missing child or person.

In my opinion, dynamic digital billboards enhance our city and we are grateful to Magic Media for teaming with us in helping to make Rochester a safer and more informed city.

Sincerely,

A handwritten signature in cursive script, appearing to read "Dennis L. Hanson".

Dennis L. Hanson
City Council President



EL PASO COUNTY SHERIFF'S OFFICE

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We Serve with Pride

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Special Operations Bureau
6825 Cicero Vista Drive, Box 4
El Paso, Texas 79925

Victim Narcotics Task Force
915-772-8805
915-772-0369 fax

HHFPA Enterprise Task Force
915-832-6011
915-832-6356 fax

Volunteer Program
3850 Justice Drive
El Paso, Texas 79938
915-538-2117
915-538-2028 fax

Emergency 911
Non-Emergency 546-2280

July 13, 2009

Honorable Mayor and City Representatives
City of El Paso, Texas
#2 Civic Center Plaza
El Paso, Texas 79901

Dear Mayor and Representatives:

As you may know, during my tenure as El Paso Chief of Police, in 2007 I was presented the opportunity to testify before the Texas Department of Transportation regarding digital billboards. At that time, I had been working with Clear Channel Outdoor to display Amber Alert and similar messages in El Paso on the digital billboards that were in place. I saw this as an opportunity to bring to El Paso a dynamic method of informing the traveling public about items of critical interest to our community.

I testified to the Texas Transportation Commission that I had no concerns whatsoever that digital billboards presented a safety hazard to El Paso residents. My duty as Chief of Police would prevent me from allowing, much less enthusiastically endorsing, anything that I believed would place our citizenry at risk. In addition to my own, I brought Mayor Cook's endorsement of the digital billboards to the Commission.

I had, and to this day still have, no indication that digital billboards pose any safety threat to the traveling public. With the number of digital signs that are currently in El Paso, both of the business and billboard type, and the long time in which they have been present in our City, any safety issues surely would have surfaced by now. Those in El Paso who claim there are safety problems with the digital billboards are ignoring the evidence.

In closing, when operated as Clear Channel is currently, digital billboards are an asset to El Paso. I endorse their use and respectfully request the City Council to prudently allow more to be erected.

Sincerely,

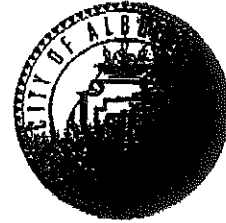
Richard D. Wiles
Sheriff



First Nationally Accredited Sheriff's Office in Texas
First Two Nationally Accredited County Jails in Texas



CITY OF ALBUQUERQUE



July 30, 2008

El Paso Chamber of Commerce
10 Civic Center Plaza
El Paso, Texas 79901

Dear Chamber Members:

As Planning Director for the City of Albuquerque, within which digital billboards have been in use for almost three years, Clear Channel Outdoor requested that I present you my opinion regarding the use of digital displays contemplated for the City of El Paso.

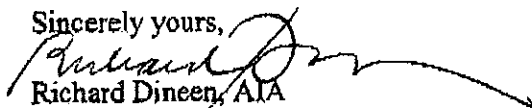
I would endorse their use in any city that is concerned about aesthetic quality and in any city that is at the same time wishes to benefit local business and promote public service advertising in a compact format.

The digital displays erected by Clear Channel Outdoor in Albuquerque significantly improve the image quality of the message, and thus the overall appearance of the structure. The compact nature of the panels and the format are much more effective in message delivery than larger billboards. The copy and image quality is very sharp and completely legible during the day without having undue brightness at night. While there is distinctively sharper image, I am not been made aware of any safety issues caused by the light intensity of the billboard image, nor have I heard of, or received, any complaints of driver distraction caused by the level of sign information. I also have not received or heard of any complaints regarding excessive nighttime brightness levels.

I believe the reason for the success of the billboard program in Albuquerque is primarily due to the responsible and sensitive manner in which Clear Channel Outdoor has deployed this new technology. Clear Channel has also worked diligently with the city to insure that all proper safeguards and considerations were undertaken prior to placement and erection of the signs.

In summary from my experience as Planning Director of the City of Albuquerque, I see no reason why any city would shun the use of this exciting technology. If you have any question, please do not hesitate to contact me at 505 924 3352.

Sincerely yours,


Richard Dineen, AIA
Planning Director
City of Albuquerque

JOHN COOK
MAYOR

JOYCE WILSON
CITY MANAGER

RICHARD D. WILES
CHIEF OF POLICE



CITY COUNCIL
ANN MORGAN LILLY, DISTRICT 1
SUSANNAH M. BYRD, DISTRICT 2
ALEXANDRO LOZANO, DISTRICT 3
MELISSA CASTRO, DISTRICT 4
RACHEL QUINTANA, DISTRICT 5
EDDIE HOLGREN, JR., DISTRICT 6
STEVE ORTEGA, DISTRICT 7
BRIAN O'ROURKE, DISTRICT 8

OFFICE OF THE CHIEF OF POLICE

December 3, 2007

Mr. John Campbell
Director, Right of Way Division
Texas Department of Transportation
125 E. 11th Street
Austin, Texas 78701-2488

Dear Mr. Campbell:

As Chief of Police I support electronic displays on billboards. I commend TX DOT's recent decision to consider allowing the use of such displays in Texas. Our local experience with these displays has clearly demonstrated the safe and effective use of this technology. In addition, I have included my comments before TX DOT on Wednesday November 28 for your review.

Good Morning. Richard Wiles, Chief of Police of El Paso.

Texas - - and I don't know if anybody noticed, but Mr. Smith and I are actually color coordinated. I just caught that.

Anyway, I'd like to read into the record a letter from the Honorable Mayor of El Paso, John Cook, and then say just a couple of words:

"The City of El Paso looked into the issue of billboards several years ago. As a result, we had a comprehensive rewrite of the ordinance regarding off-premise signage. Subsequently, we examined the potential for improving the image billboards had in our community, and amended the ordinance to allow for electronic billboards.

We have found that they are not only accepted by the community, but are more attractive than other technologies. As Mayor of the sixth largest city in Texas, I would certainly encourage other cities to consider modernizing their off-premise sign ordinances.



As a result of our experience, the City of El Paso supports TxDOT's efforts to allow us to expand our program to those highways under state jurisdiction."

That's from Mayor Cook. In regards to the Police Department's stance on this issue, there's two major issues that I see. One is the issue of safety. Certainly traffic crashes and the injuries and fatalities that are related to those are of great concern to me as a law enforcement professional. And I would not want to have something on the roadway that would distract the drivers.

But I have to tell you that in my conversations with the deputy chief in charge of our traffic units, certainly over the last five years that we've done research, we have found no instances of traffic collisions being caused as a result of inattentiveness for billboards.

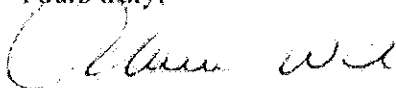
And as Mr. Smith mentioned, the electronic billboards have gone up on city streets, eight of them, and since they've been up over the last several months, we have had no instances that they have contributed to any driver inattention that has resulted in a collision. So I don't believe that that's an issue. Certainly not within the City of El Paso.

And the second issue is in regards to the support that these billboards can give to law enforcement in times of crisis. As you're well aware, when an Amber Alert occurs, TxDOT flashes information on their electronic message boards, but it's all -- there's no photos, it's all writing.

And the problem with that is, the information does not catch the attention of the traveling motorist many times and it's not -- and because human beings are visual animals, it is not as -- it doesn't give us the same impact as if we can put up a photo of the missing a child, of a vehicle involved, of the subject that's involved.

So we think these billboards will be a great asset to any community, certainly in El Paso, by providing our community with information related to crises such Amber Alerts or other emergencies that could occur within the city. Thank you very much.

Yours truly,



Richard D. Wiles
Chief of Police





South Carolina
Department of Transportation

September 6, 2007

Mr. W. Scott Shockley
General Manager
~~Lamar Outdoor Advertising~~
1221 Atlas Road
Columbia, South Carolina 29209

Dear Mr. Shockley:

Thank you for your request of August 29, 2007, regarding safety concerns about the digital billboards in and around the Columbia area. We have evaluated crash history in the vicinity of three digital billboards recently installed on US 378 at Mineral Springs Road in Lexington County, I-77 northbound of SC 768 (Shop Road) in Richland County, and I-26 westbound west of St. Andrews Road in Lexington County. I have attached a copy of our findings for your information.

A comparison was made between the six-month period following installation of the digital billboards with the same timeframe from the prior year. Please note on safety related studies, it is our procedure to review crash history for three years before and three years after the event being studied. The three digital billboards have not been up long enough for us to formulate an official opinion, however, the attached study based on the period of review does not highlight a problem with the digital billboards. Also, as of August 28, 2007, the South Carolina Department of Transportation (SCDOT) has not received any complaints in regard to the digital billboards.

Research will be evaluated as it comes available concerning any safety issues related to digital billboards, but currently SCDOT has no opinion on this issue.

Sincerely,

Dipak M. Patel
Deputy State Highway Engineer

DMP:jb
Enclosure
cc: Tony L. Chapman, State Highway Engineer
John Hardee, Lamar Outdoor Advertising
File:SHE/DMP



US-378 @ Mineral Springs Road
Lexington County
(8/11/06-2/10/07) vs (8/11/05-2/11/06)

Year	type		Crashes	PERSONS INJURED	PERSONS KILLED
	INJURY	PROPERTY DAMAGE ONLY			
8/11/05 - 2/10/06	3	3	6	3	0
8/11/06 - 2/10/07	1	3	4	1	0
TOTAL	4	6	10	4	0

I-77 Northbound North of SC-768 (Shop Road)
 Richland County
 (11/16/06-5/15/07) vs (11/16/05-5/15/06)

Year	type		Crashes	PERSONS INJURED	PERSONS KILLED
	INJURY	PROPERTY DAMAGE ONLY			
11/16/05 - 5/15/06	2	4	6	2	0
11/16/06 - 5/15/07	0	3	3	0	0
TOTAL	2	7	9	2	0

I-26 Westbound West of St. Andrews Road
Lexington County
(11/16/06-5/15/07) vs (11/16/05-5/15/06)

Year	type		Crashes	PERSONS INJURED	PERSONS KILLED
	INJURY	PROPERTY DAMAGE ONLY			
11/16/05 - 5/15/06	10	20	30	19	0
11/16/06 - 5/15/07	3	23	26	6	0
TOTAL	13	43	56	25	0







BRIAN DEWINE
PRESIDENT & MANAGING MEMBER

To Whom It May Concern:

We have used Lamar Outdoors' digital billboards for numerous years now. Through their Twitter technology, we are able to change our marketing message as many times a day as we want. We often start each day during the season with a simple message such as "Game Today," "Games All Weekend" or "Fireworks Tonight!" At about 7:00 pm each day we often change the message to "Game Tomorrow" or "Games All Weekend." Our marketing team schedules the messages about a week in advance through Hootsuite and an anonymous Twitter account. However if the weather or pre-sale dictate a new message, we can instantly change it.

We also use do a countdown to Opening Day on the billboards as the season approaches. I often have fans come up to me on the street and tell me exactly how many days till Opening Day. They always tell me they saw it on our billboard.

We believe digital billboards are one of the best marketing tools we have. Not only does it help build our brand, but they educate people of when we are playing. If you have any questions about how we use them, please feel free to contact me at 828-258-0428 x400 or bdewine@theashevilletourists.com.

Sincerely,

Brian DeWine



ASHEVILLE TOURISTS BASEBALL CLUB
DEWINE SEEDS SILVER DOLLAR BASEBALL, LLC

30 Buchanan Place - Asheville, NC 28801 - PH 828.258.0428 - FAX 828.258.0320
TheAshevilleTourists.com



ISS. 337222 - 1/5 LONG SHEDS RV. 800 / END US 25 2018-09-12 EDT 09:11:23



135.3037333 - 115.1016333 - 115.1016333 - 115.1016333

2013-09-25 EDT 13:21:55



CITY OF HIGH POINT

AGENDA ITEM



Title: Motorola Radio Purchase

From: Steve Lingerfelt, Director of Information
Technology Services

Meeting Date: July 15, 2019

Public Hearing: No

**Advertising Date /
Advertised By:**

Attachments: Motorola Solutions Inc. Radio Quote

PURPOSE:

The City needs to purchase Motorola portable and mobile radios to replace older radios as part of the annual replacement program.

BACKGROUND:

Information Technology Services is recommending the City of High Point purchase one hundred and one (101) portable radios as part of the annual eight (8) year radio replacement cycle. The radios purchased will be replacing radios in the Electric and Public Services Departments.

BUDGET IMPACT:

The City of High Point will use existing funds in the FY 2019-20 budget to purchase the radios from Motorola Solutions, Inc. The total cost of the radios is \$457,014.90 which is the state contract price.

RECOMMENDATION / ACTION REQUESTED:

The Department of Information Technology Services recommends approval of the contract and that the appropriate City official and/or employee be authorized to execute all necessary documents.



MOTOROLA SOLUTIONS

TO: City Of High Point
Radio Replacement
Lee Stanley

Motorola Solutions
Scott Hurt
336 312-9165

scott.hurt.ii@motorolasolutions.com

Qty	Model Number	Description or Specification	Unit Discounted Price	Extended Discounted Price
<u>APX 6000 3.5 PORTABLE RADIO</u>				
101	H98UCH9PW7BN	APX 6000 3.5 PORTABLE RADIO Standard with the following: GPS Bluetooth,ADP ASTRO 25 INTEGRATED VOICE & DATA	\$ 2,522.15	\$ 254,737.15
101	Q806	ASTRO DIGITAL CAI	\$ 375.95	\$ 37,970.95
101	H38BS	SMARTZONE	\$ 876.00	\$ 88,476.00
101	Q361	P25 9600 BAUD	\$ 219.00	\$ 22,119.00
101	QA01648	HARDWARE KEY	\$ 3.65	\$ 368.65
101	H869	MULTIKEY	\$ 240.90	\$ 24,330.90
101	G996	ENH: OVER THE AIR PROVISIONING	\$ 73.00	\$ 7,373.00
101	Q58AL	3 YEAR ESSENTIAL SERVICES	\$ 110.00	\$ 11,110.00
101	QA01833	EXTREME NOISE REDUCTION	\$ 18.25	\$ 1,843.25
101	QA00580AC	TDMA	\$ 328.50	\$ 33,178.50
101	NNTN7687A	APX INSERT	\$ 33.75	\$ 3,408.75
101	QA05575AA	TIA4950 BATTERY IMPRESS 4500MAH	\$123.75	\$12,498.75
101	Trade in -400 per radio		\$ (400.00)	\$ (40,400.00)

TRADE IN -400 dollars Per Radio Must receive P.O. by July 19th

Terms: Net 30 days after shipment

Delivery 6 Weeks

Date 4-Jun-19

State Contract # 725G

Proposal #6419 Taxes not included

Equipment	\$457,014.90
Total	\$457,014.90



**FORMAL BID RECOMMENDATION
REQUEST FOR COUNCIL APPROVAL**

DEPARTMENT: Information Technology Services

COUNCIL AGENDA DATE: July 15, 2019

BID NO.: NC State Contract CONTRACT NO.: NC 725G DATE OPENED:

DESCRIPTION:

Motorola radio replacement purchase.

PURPOSE:

The City of High Point utilizes an eight year replacement cycle to replace older radios in it's inventory. One hundred and one portable radios will be replaced this year. The radios will be replaced in the Electric and Public Services Departments

COMMENTS:

This purchase is made using the NC procurement contract 725G.

RECOMMEND AWARD TO: Motorola Solutions Inc. AMOUNT: \$457,014.90

JUSTIFICATION:

The purchase is needed to replace older radios in inventory as part of an eight year replacement cycle.

ACCOUNTING UNIT	ACCOUNT	ACTIVITY	CATEGORY	BUDGETED AMOUNT
501243	522601			\$457,014.90
TOTAL BUDGETED AMOUNT				

DEPARTMENT HEAD: Steve Lingerfelt Digitally signed by Steve Lingerfelt Date: 2019.07.02 13:55:37 -04'00' DATE: July 2, 2019

The Purchasing Division concurs with recommendation submitted by the IT and recommends award to the lowest responsible, responsive bidder Motorola Solutions in the amount of \$ 457,014.90.

PURCHASING MANAGER: Erik Conti Digitally signed by Erik Conti Date: 2019.07.02 13:59:31 -04'00' DATE:

Approved for Submission to Council

FINANCIAL SERVICES DIRECTOR: Bobby Fitzjohn Digitally signed by Bobby Fitzjohn Date: 2019.07.02 14:03:10 -04'00' DATE: 7/2/2019

CITY MANAGER: Greg Demko Digitally signed by Greg Demko Date: 2019.07.02 16:21:46 -04'00' DATE: 7/2/2019

CITY OF HIGH POINT AGENDA ITEM

**Title: Library Bookmobile****From:** Gary Smith, Fleet Director**Public Hearing:** N/A**Attachments:** Quote**Meeting Date:** July 15, 2019**Advertising Date /** N/A**Advertised By:** N/A

PURPOSE:

The Library is requesting the purchase of a new bookmobile. Using the Houston-Galveston Area Council (HGAC) national contract AM10-18, a new bookmobile is being recommended for council approval.

BACKGROUND:

The current Library bookmobile has become increasingly difficult to maintain, as parts are becoming obsolete through the manufacturer and aftermarket. According to Matthews Specialty Vehicles, the average lifespan of a mobile library is 12 years. We have been running this vehicle for almost 19 years. The bookmobile is on the road five days a week serving over fifty daycares and preschools in High Point. It is also used at special events such as festivals and the holiday parade. The price of \$136,100 is for the Ford E450 chassis, body installation, and delivery. Estimated delivery is 120-240 days.

BUDGET IMPACT:

Funds are available in the 2019-20 budget.

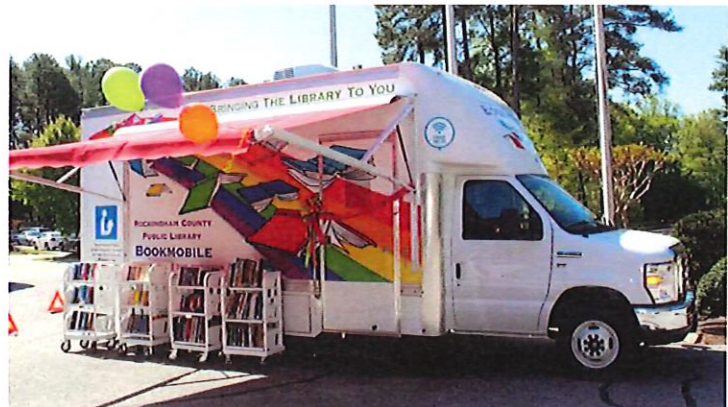
The High Point Library received a \$50,000 grant from the State for this purchase.

RECOMMENDATION / ACTION REQUESTED:

The Fleet Services Department recommends purchasing the new bookmobile from Matthews Specialty Vehicles at a price of \$136,100.



Existing



Proposed



**FORMAL BID RECOMMENDATION
REQUEST FOR COUNCIL APPROVAL**

DEPARTMENT: **Fleet Services**

COUNCIL AGENDA DATE: **July 15, 2019**

BID NO.: **HGAC** CONTRACT NO.: **AM10-18** DATE OPENED:

DESCRIPTION:

Ford E450 Bookmobile

PURPOSE:

The current Library bookmobile has become increasingly difficult to maintain, as parts are becoming obsolete through the manufacturer and aftermarket. According to Matthews Specialty Vehicles, the average lifespan of a mobile library is 12 years. We have been running this vehicle for almost 19 years.

COMMENTS:

The price of \$136,100 is for the bookmobile, training, and delivery. The estimated delivery is 210-240 days

RECOMMEND AWARD TO: **Matthews Specialty Vehicles** AMOUNT: **\$ 136,100**

JUSTIFICATION:

Using this bid allows the City of High Point to take advantage of the volume discount offered through the HGAC national contract.

ACCOUNTING UNIT	ACCOUNT	ACTIVITY	CATEGORY	BUDGETED AMOUNT
401450	533101	401201026705	55310	\$ 136,100
TOTAL BUDGETED AMOUNT				\$136,100

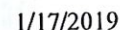
DEPARTMENT HEAD: **Gary L. Smith** Digitally signed by Gary L. Smith
DN: cn=Gary L. Smith, o=City of High Point, ou=Fleet Services, email=gary.smith@highpointnc.gov, c=US
Date: 2019.07.03 12:48:22 -0400 DATE: **Jul 3, 2019**

The Purchasing Division concurs with recommendation submitted by the **Fleet Services** and recommends award to the lowest responsible, responsive bidder **Matthews Specialty Veh.** in the amount of \$ **136,100.00**

PURCHASING MANAGER: **Erik Conti** Digitally signed by Erik Conti
Date: 2019.07.03 13:56:39 -0400 DATE: **Jul 3, 2019**

Approved for Submission to Council
FINANCIAL SERVICES DIRECTOR: **Bobby Fitzjohn** Digitally signed by Bobby Fitzjohn
Date: 2019.07.10 10:15:54 -0400 DATE: **Jul 10, 2019**

CITY MANAGER: **Greg Demko** Digitally signed by Greg Demko
DN: cn=Greg Demko, o=High Point, ou=High Point, email=greg.demko@highpointnc.gov, c=US
Date: 2019.07.10 10:18:15 -0400 DATE: **Jul 10, 2019**



F. Trade-Ins / Special Discounts / Other Allowances / Freight / Installation / Miscellaneous Charge			
Description		Cost	Cost
			Subtotal F:
Delivery Date:		210-240 Days	G. Total Purchase Price (D+E+F): 136100



YOUR VEHICLE WILL BE BUILT ACCORDING TO THIS DRAWING!
All dimensions are approximate. The physical measurements of your shell, upon arrival at our facility, could affect the design layout of your vehicle including but not limited to: door locations; wheel well size and location; wall thickness; ceiling height; underbody obstructions; and suspension systems. You will be notified of substantial changes in design layout by a revised drawing for your review before production begins. Modifications to this document must be in writing and executed by an authorized representative of MATTHEWS SPECIALTY VEHICLES. Your signature confirms that this drawing is accurate to your design/layout expectations.

PLAN VIEW

- ☐ Approved as drawn with NO changes
☐ Approved as drawn with noted changes

Signature _____

Date _____

HIGH POINT PUBLIC LIBRARY



101 S. SWING ROAD
GREENSBORO, NC
27409
1-877-905-4078
www.mvvehicles.com

SHELL: FORD E450 CHASSIS
ROCKPORD 17' BODY

DRAWN BY:
A.SLACK

DATE:
1/28/2019

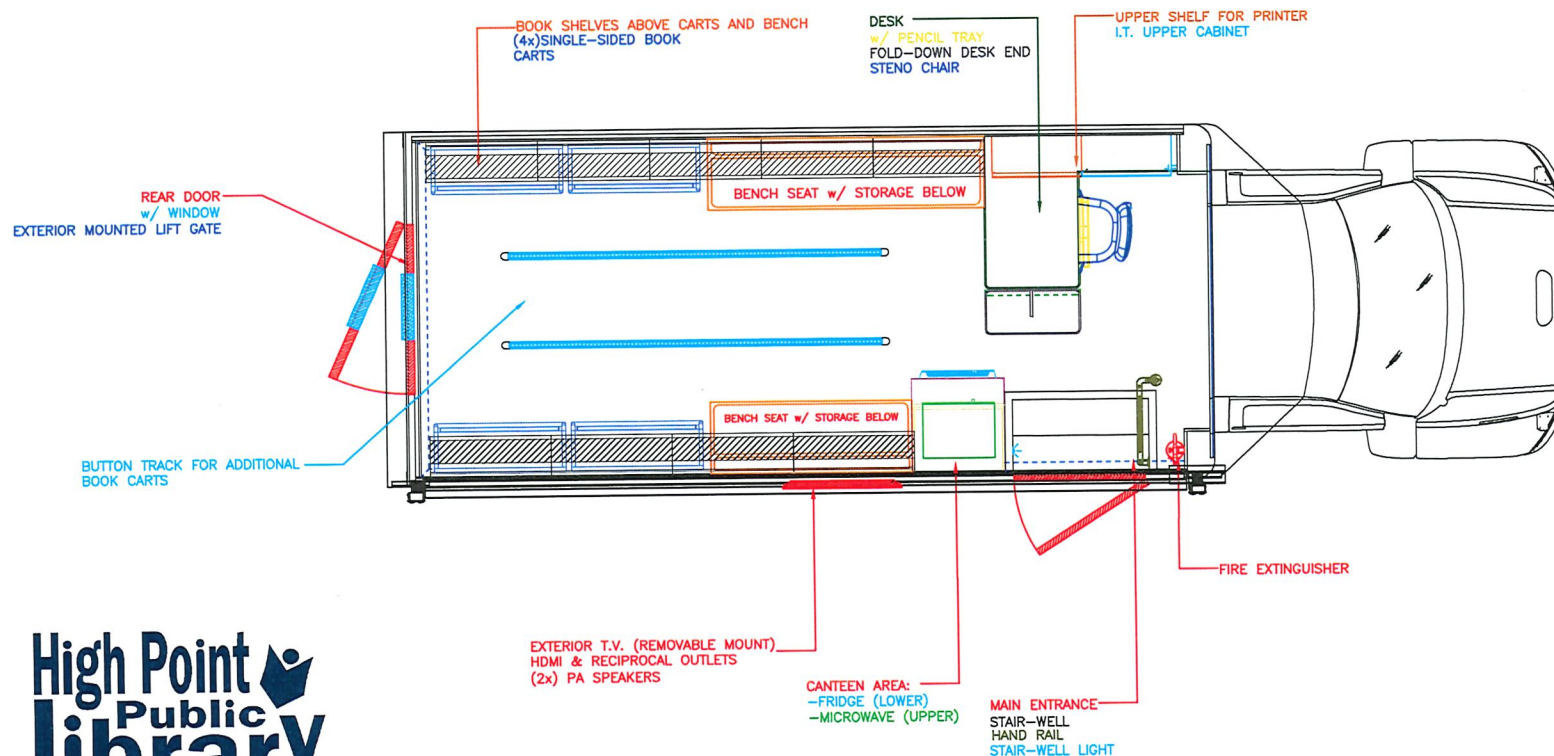
REVISIONS:

DRAWING NUMBER:
BID DRAWING

SCALE:
3/8" = 1' 0"

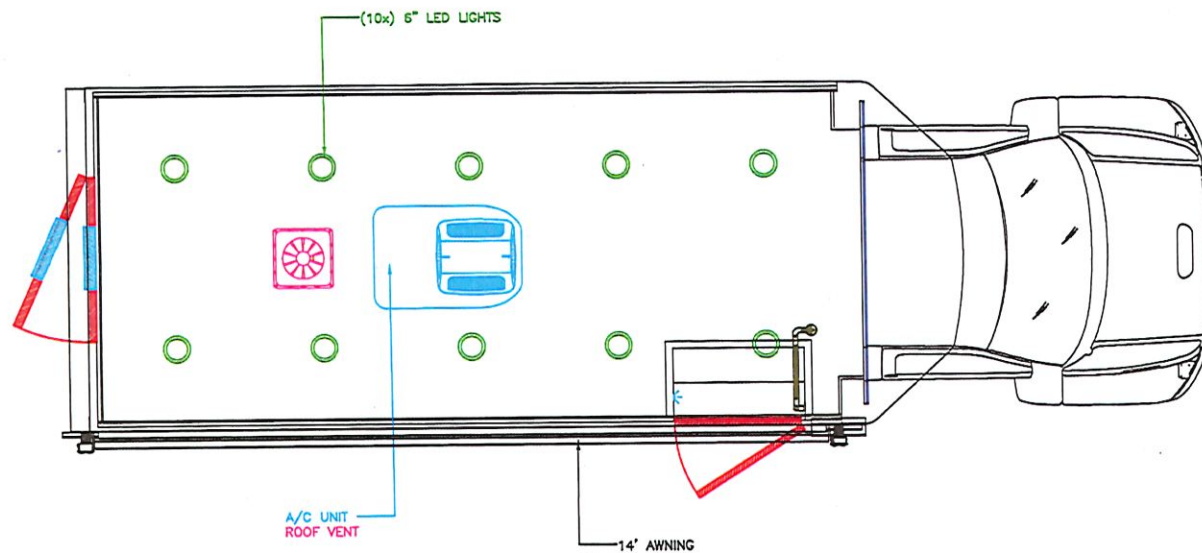
REVISION DATE:

PROPRIETARY DRAWINGS
THE VEHICLE DEPICTED FOR CONSTRUCTION IN THESE
DRAWINGS IS THE PROPERTY OF MATTHEWS SPECIALTY
VEHICLES AND NOT TO BE USED FOR ANY OTHER CONSTRUCTION.



Sheet:

1



**High Point
Public
Library**

YOUR VEHICLE WILL BE BUILT ACCORDING TO THIS DRAWING
All dimensions are approximate. The physical measurements of your shell, upon arrival at our facility, could affect the design layout of your vehicle including but not limited to: door locations; wheel well size and location; wall thickness; ceiling height; underbody obstructions; and suspension systems. You will be notified of substantial changes in design layout by a revised drawing for your review before production begins. Modifications to this document must be in writing and executed by an authorized representative of MATTHEWS SPECIALTY VEHICLES. Your signature confirms that this drawing is accurate to your design/layout expectations.

CEILING VIEW

- ☐ Approved as drawn with NO changes
☐ Approved as drawn with noted changes

Signature _____ Date _____

HIGH POINT PUBLIC LIBRARY

**MATTHEWS
SPECIALTY VEHICLES**

101 S. JEWING ROAD
GREENSBORO, NC
27409
1-877-465-4678
www.matthews.com

SHELL: FORD E450 CHASSIS ROCKPORD 17' BODY		DRAWING NAME: BID DRAWING	
DRAWN BY: A.SLACK	DATE: 1/28/2019	SCALE: 3/8" = 1' 0"	
REVISIONS: A.SLACK - 1		REVISION DATE: 02/21/2019	
PROPRIETARY DRAWINGS THE VEHICLE DEPICTED FOR CONSTRUCTION IN THESE DRAWINGS IS THE PROPERTY OF MATTHEWS SPECIALTY VEHICLES AND NOT TO BE USED FOR ANY OTHER CONSTRUCTION.			

Sheet:

2

CITY OF HIGH POINT

AGENDA ITEM



Title: Truck Mounted Vacuum

From: Gary Smith, Fleet Director

Public Hearing: N/A

Attachments: Quote

Meeting Date: July 15, 2019

Advertising Date / N/A

Advertised By: N/A

PURPOSE:

The Stormwater Division of Public Services is requesting the purchase of a truck mounted vacuum leaf & debris collector to be used for cleaning storm drains, gutters, etc. Using the NC Sheriffs' Association contract #20-04-0506 a new Freightliner truck with ODB Model DCL800SM-25 Vacuum Leaf & Debris Collector is being recommended for council approval.

BACKGROUND:

The Streets Division is currently using a 2007 Freightliner truck with a OBD leaf & debris collection body. These type of trucks have provided excellent service and reliability since their original purchase. This truck will increase collection efficiencies and has eliminated the need for pull behind type leaf collection machines. The price of \$204,960 is for the truck, vacuum body installation, and delivery. Estimated delivery is 180-240 days.

BUDGET IMPACT:

Funds are available in the 2019-20 budget

RECOMMENDATION / ACTION REQUESTED:

The Fleet Services Department recommends purchasing the new truck mounted vacuum debris collector Model SCL800DM-25 from Carolina Industrial Equipment at a price of \$204,960. Recommendation also includes declaring old equipment as surplus and disposing through the online auction process.





**FORMAL BID RECOMMENDATION
REQUEST FOR COUNCIL APPROVAL**

DEPARTMENT: **Fleet Services**

COUNCIL AGENDA DATE: **July 15, 2019**

BID NO.: **NC Sheriffs' Association** CONTRACT NO.: **20-04-0506** DATE OPENED:

DESCRIPTION:

Freightliner with ODB DCL800SM25 Leaf & Debris Collection Body

PURPOSE:

The Streets Division is currently using a 2007 Freightliner truck with a OBD leaf & debris collection body. These type of trucks have provided excellent service and reliability since their original purchase.

COMMENTS:

The price of \$204,960 is for the truck, training, and delivery. The estimated delivery is 180-240 days.

RECOMMEND AWARD TO: **Carolina Industrial Equipment** AMOUNT: **\$ 204,960**

JUSTIFICATION:

Using this bid allows the City of High Point to take advantage of the volume discount offered through the NC Sheriffs' Association contract. This truck will increase collection efficiencies and has eliminated the need for pull behind type leaf collection machines.

ACCOUNTING UNIT	ACCOUNT	ACTIVITY	CATEGORY	BUDGETED AMOUNT
501271	532401			\$ 204,960
TOTAL BUDGETED AMOUNT				\$ 204,960

DEPARTMENT HEAD: **Gary L. Smith** Digitally signed by Gary L. Smith
DN: cn=Gary L. Smith, o=City of High Point, ou=Fleet
Services, email=gary.smith@highpointnc.gov, c=US
Date: 2019.07.02 11:54:19 -04'00' DATE: **Jul 2, 2019**

The Purchasing Division concurs with recommendation submitted by the **Fleet Services** and recommends award to the lowest responsible, responsive bidder **Carolina Industrial Equip** in the amount of \$ **204,960.00**.

PURCHASING MANAGER: **Erik Conti** Digitally signed by Erik Conti
Date: 2019.07.02 13:05:23 -04'00' DATE: **Jul 2, 2019**

Approved for Submission to Council
FINANCIAL SERVICES DIRECTOR: **Bobby Fitzjohn** Digitally signed by Bobby Fitzjohn
Date: 2019.07.02 13:22:46 -04'00' DATE: **Jul 2, 2019**

CITY MANAGER: **Greg Demko** Digitally signed by Greg Demko
Date: 2019.07.02 16:22:54 -04'00' DATE: **7/2/2019**

City of High Point
Attn: Gary Smith
3524 Triangle Lake Road
High Point, NC 27261

Phone: 336-883-6699

gary.smith@highpointnc.gov

April 29, 2019

WE ARE PLEASED TO SUBMIT THIS NC SHERIFFS' ASSN. CONTRACT #20-04-0506 PROPOSAL:

Xtreme Vac by ODB DCL800SM25 chassis mount automated one-man leaf & debris vacuum system

3-axis joystick controlled hydraulic boom (up/down, left/right, in/out)
25 cubic yard capacity self-dumping hopper
Kubota 87 HP 4-cylinder gas engine (Optional diesel available)
Electronic engine controls with engine safety shutdown system
Remote electric throttle & remote clutch engagement
Fully enclosed engine compartment with louvered side doors
40-gallon polyethylene fuel tank
Boxed perforated pleated radiator screen
28" diameter impeller with six 3/8" thick steel blades
4-groove power band belt drive for suction impeller
13" clutch assembly with 2.25" diameter PTO shaft & safety engagement
16" x 144" Urethane suction hose
Hopper constructed of 12-gauge steel
Top of hopper is equipped with replaceable exhaust screens
Top hinged rear door with hydraulic door locks
LED DOT lights and two oval LED flasher lights at rear
Light bar on hopper nose cone with 4 front facing flashing amber LEDs
Poly fenders on rear wheels
Rear view color camera with 5.6" screen
Paint: Hopper white / Engine and vacuum blower housing battleship grey
Chassis frame underside of hopper painted gloss black
Mounted on 2020 or newer 35,000 lb. GVW Freightliner M2-106 chassis with dual steering
Also includes destination charge, dealer prep, delivery to any NC or SC location and operator training



NC Sheriffs' Association
CONTRACT #20-04-0506
Discounted Price

	<u>MSRP</u>	
Total for above, 7% NCSA discount ...	\$197,513.00	\$183,687.00
Options, accessories & attachments, 6% NCSA discount:		
John Deere 4045TFC03 74 HP 4-cylinder diesel engine final Tier 4 ...	7,152.00	6,722.00
Bottom exhaust ...	8,954.00	8,416.00
11 gauge perforated top screens with 3/16" holes in ILOS ...	2,872.00	2,699.00
LED traffic directional light bar mounted on the rear door ...	1,436.00	1,349.00
Urethane coated liners for blower housing ...	1,126.00	1,058.00
Two surface mounted LED flashers at front ...	<u>1,095.00</u>	<u>1,029.00</u>
Total ...	\$220,148.00	\$204,960.00

Terms: Net 15 days

F.O.B. Any NC or SC destination

Plus applicable sales tax

Prepared by:

3/19

Jeff Yoxthiemer, Area Manager

704-307-7758

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CITY OF HIGH POINT

AGENDA ITEM



Title: Salt Supplier City Wide

From: Terry Houk – Public Services Director
Robby Stone – Asst. Director Public Services

Meeting Date: July 15, 2019

Public Hearing: N/A

Advertising Date: April 18, 2019

Advertised By: Purchasing

Attachments: Bid Tab
Recommendation Form

PURPOSE:

The City budgets on an annual basis for suppliers to provide de-icing materials to city crews. The de-icing materials are used to prepare brine mixtures and apply to public streets in order accelerate melting of ice and snow that can create difficulty or safety hazards during commutes.

BACKGROUND:

The city retains a stock supply of 800 tons of bulk road salt supplies for the purpose of accelerating the melting of ice and snow on the public roadways within the city. At the April 30th, 2019 bid opening, Mid-Atlantic Salt, LLC was the low bidder. Their prices are competitive with historical pricing for this type of supplied material. This contract is for a three-year period with the option to renew for two additional one (1) year periods if terms and pricing are agreeable to the City of High Point and the vendor.

BUDGET IMPACT:

Funds for this project are in the following account: Various Accounts

RECOMMENDATION / ACTION REQUESTED:

City Council is requested to award a contract to Mid-Atlantic Salt, LLC for the purchase of Bulk Road Salt in the annual amount of \$73,450.00 for a total contract award of \$220,350.00. The contract is for a three-year period with the option to renew for two additional one-year periods beginning July 1, 2019 thru June 30, 2022.

BID TABULATION BULK ROAD SALT Bid 57-043019					
Vendor	Qty	U/M	Unit Price	Delivery	Total Bid
Mid-Atlantic Salt LLC	650	TN	\$113.00	3-5 Days	\$73,450.00
Cargill, Inc	650	TN	\$121.42	3-5 Days	\$78,923.00
Detroit Salt Co, LLC	650	TN	\$114.93	3-7 Days	\$74,704.50