Outdoor Advertising Report: Changeable Message Signs

March 28, 2018

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EXECUTIVE SUMMARY

The California Department of Transportation (Caltrans) has prepared this report in response to Senate Bill 853 (Committee on Budget and Fiscal Review, Chapter 27, Statutes of 2014) regarding advertising on changeable message signs (CMS) on the State highway system. The report examines only the feasibility of conducting a pilot to place commercial outdoor advertising on State-owned CMS and includes net revenue estimates for such an effort.

The report identifies the critical factors and approaches for developing a comprehensive pilot program from a historical and contemporary perspective. It provides a potential business model to be evaluated to accomplish the anticipated and appropriate cost recovery for Caltrans personnel and oversight of the construction and maintenance of CMS activated by the private industry partner as well as the operation of the CMS locations in the demonstration project, while generating the highest possible net revenue. In addition, the report examines the potential of advertising revenues to fund the next generation of CMS at existing and planned locations.

The conclusion is that it could be feasible to conduct a pilot project on CMS. A pilot project would allow the State to evaluate any potential safety implications and assess how much potential revenue could be generated to support CMS infrastructure and the State highway system as a whole. There are significant challenges to implement a pilot project including concerns of safety to the traveling public, local agency, community approval, and operational impacts to the State highway system. In addition, Caltrans does not have the State or the federal authority to move forward with this project. A waiver or exemption would be needed from portions of the federal outdoor advertising regulations, the California Outdoor Advertising Act (OAA), and sections of the Federal Manual on Uniform Traffic Control Devices. It should be noted that if a pilot occurs, there is no guarantee this proposed initiative would go beyond the pilot.

If the appropriate authority is received, the report concludes that it would be feasible to conduct a phased four-year demonstration pilot project of 25 CMS to provide the appropriate test environment for the concept. The 25 locations would be on corridors in the Los Angeles, San Francisco, and Sacramento regions, which are the highest three revenue markets in the State. The demonstration pilot project would study the safety and operational impacts of this concept, assist in evaluating revenue assumptions, and determine risks or dis-benefits of a next generation CMS displaying traditional Caltrans messaging and advertising. The demonstration pilot project would cost $10.2 million to build and $500,000 annually to operate, which is anticipated to be fully recovered from advertising revenue, and provide projected average net revenue to Caltrans of $8.5 million to $10.2 million over the four-year project.

Safety is paramount. In California, Caltrans, the California Highway Patrol, and the Office of Traffic Safety work collectively to reduce deaths and injuries related to the transportation system. Should implementation of a pilot be advanced, it must not be in conflict with safety. Any pilot would have to be crafted to manage risk of distraction to drivers – this would include not only risk of drivers being distracted by advertising displays and reducing their attention to other transportation users, but also motorists being distracted and missing other safety notices and signs. Because CMS are also used for the AMBER alert program, as well as the Silver and Yellow alert programs (pending federal approval), public access and use of the displays for these purposes must not be delayed or reduced in any way. Any pilot should be phased, such that any safety effects of the initial phase of any CMS, will be sufficiently evaluated prior to any subsequent phase being implemented. If, at any time, a safety problem is identified with the advertising displays and it cannot be fully addressed, the advertising messages would be immediately discontinued.

OUTDOOR ADVERTISING OVERVIEW

Outdoor Advertising – An Evolving Medium

Origins

Outdoor advertising arose as a function of peoples' need and desire to be informed about goods or services throughout their daily travels and a business' desire to attract customers for the good or service. The outdoor advertising industry began more than 150 years ago when painted signs or glued posters were attached to walls or fences to draw attention to nearby businesses or to promote upcoming events. In the early 1900s, the first standardized billboard (outdoor advertising) structures were created so national advertisers could produce the same size creative advertisements for all displays throughout the country. For almost a century, there was little change as outdoor advertising displays were either printed on paper or painted on wooden screens and building walls. Incremental advancements included illumination of posters to allow for evening viewing and the introduction of tri-vision panels that allowed for the mechanical rotation of three messages on a single structure. During the mid-1980s, new digital technology began to transform the industry by allowing hand-painted displays to be replaced by computer-generated advertisements that were printed on vinyl material. This transformation reduced lead times for planning a campaign to posting the ads from up to a month to a week or two and created consistently vibrant images that matched what consumers were used to seeing in magazines. However, this still required manual labor to post the advertisement, which then would be displayed on a location for weeks or months at a time until the next advertisement was posted.

Transformation

Digital display technology is transforming the outdoor advertising industry from a passive traditional media form into a dynamic medium. Introduced in 2005, this new form of outdoor advertising has increased advertising revenues for individual structures and reduced operational expenses per advertising campaign. Traditional static outdoor advertising displays can carry only one message at a time, whereas digital displays can be shared, typically in eight second increments, among multiple advertisers. Digital displays can be dynamically scheduled by time of day and campaign length to allow multiple forms of advertisement for an individual advertiser throughout the day or longer advertising cycles, as well as allowing multiple advertisers to share advertising time in a display loop lasting approximately one minute. While only static messages may be displayed, advertisers can schedule multiple designs to vary the messaging, change messaging at different times of the day and integrate dynamic variables to trigger specific messaging (hot coffee in cold weather, iced coffee in warm weather). This transition from selling locations to selling time, as with radio or television, allows advertisers to be more efficient with their outdoor advertising campaigns, making the campaigns more effective, and allows display operators to sell each location to more advertisers, increasing the overall value of each display. These improvements, coupled with emerging opportunities to integrate social, mobile, location, and other consumer data into real-time programmatic advertising campaigns, will continue to attract a growing share of advertising budgets to the digital outdoor advertising medium.

Digital billboards allow advertisers to do more than just post static, unmonitored messages created weeks in advance to be displayed passively for long periods of time. Content is created, scheduled, loaded, and monitored remotely, typically from an operating center where personnel oversee a portfolio of displays. Once created, the content is scheduled by time, place, and any number of additional variables requested by the advertiser and loaded into the network. A secure data connection, either wired or wireless, transmits the content to network site where it is displayed according to the schedule. Monitoring tools, such as a camera pointed at the face of the digital billboard and diagnostic software, report back through the same data connection. Continuous monitoring ensures that each site is working and that the content is displayed as intended. Monitoring software can provide an audit trail that confirms messages ran as scheduled. Automated review and human observation of the look-back camera feed ensures proper message display, and can identify and troubleshoot any problems in near real-time. Failsafes are designed into the scheduling software and are embedded in the message file or are on the local server to prevent display of content beyond its expiration. In addition to encryption, a dual validation process can be used to prevent unauthorized messages from being displayed.

Public Receptiveness

Industry claims there is an increased acceptance of digital outdoor advertising by the public. Local community opposition to billboards in general is a factor of concern. A pilot would allow Caltrans to better determine public and local community acceptance and / or opposition to digital outdoor advertising, and specifically the use on public roads. The 2008 Arbitron Digital Billboard Report: Cleveland Case Study (Appendix A) found that:

- More than half of all Cleveland travelers noticed digital billboards
- In excess of 80 percent felt that digital signage provided important and timely emergency information
- Fifty percent felt that digital signage displayed current and relevant information
- Eight out of ten travelers could recall the digital billboard advertisements
- Almost two-thirds of commuters agreed that digital billboard advertisements were “a cool way to advertise”

This study concluded there is an increase in public acceptance of digital outdoor advertising and demonstrates that digital signs are viewed, accepted, and relied upon by the public for various types of messaging. A pilot would help assess the accuracy of this conclusion.

New Audience Measurement

Industry cites that a contributing factor to the growth of outdoor advertising is better audience research and measurement as exemplified by the new industry audience measurement system, which was developed by the Traffic Audit Bureau (TAB) working with the advertising community and outdoor advertising industry. After several years of research, testing, and development, the ratings were released in January 2010 under the brand "Eyes On" as the first measurement system to provide advertisers with specific information about the commercial audience who saw the advertising. 'Eyes On' was later rebranded to the current "Out of Home Ratings" (see Appendix C).

The factors taken into consideration for the "Out of Home Ratings" systems are:

- Weekly Circulation Count – People Passing By
    - Traffic counts from state, county, or local levels, and pedestrian counts

- Visibility Adjustments – People Seeing
    - State of the art technology to determine number of people noticing an advertisement with regards to format, size, and the position of the roadway

- Trip Surveys – Demographics, Reach, and Frequency
    - U.S. Census Bureau data to document the demographic characteristics of the audience and trip surveys to model the number of people who pass the location of an advertisement

Since the initial release of the new audience research model, the TAB has expanded the measured media to include moving posters (transit) and shared displays (digital). The combination of these factors creates a measurement system that advertisers, national brands, and agencies use in their advertising campaign planning tools.

Digital Signage Technology

History

The quality and production of Light Emitting Diode (LED) technology has advanced rapidly over the past decade. LED technology has been used for digital sign displays since the mid-1970s. Early LEDs were only available in three colors: red, green, and amber. Early LED sign systems were not durable or bright enough for outdoor use. As a result, the displays were typically used in a controlled indoor environment, such as sports arena scoreboards. During the 1990s, significant advancements in technology made high-intensity LEDs available in all colors of the spectrum. These new generation LEDs have made it possible to produce displays bright enough for outdoor use in the brightest of sunlight conditions and a variety of viewing angles. Through its evolution, LED has emerged as the preferred digital signage technology solution over Liquid

Crystal Diode (LCD) and plasma because of its long life, low power consumption, high light intensity, and stability in varied operating environments.

LED Functionality

LED pixel resolution, color uniformity, brightness, and display contrast have advanced over the past five years. The image resolution (detail level) capability for a sign is measured as "pixel pitch," which refers to the distance measured in millimeters between each pixel or picture element. The proper pixel pitch for a sign depends on the desired image quality and the audience's viewing distance. Most digital displays deployed in North America have a 16-20mm or smaller pitch. This pixel pitch provides a sharp visual quality for displays that are situated adjacent to a highway right-of-way.

Manufacturers have developed sophisticated software control systems for LED displays. These systems provide diagnostics that typically include monitoring electrical supply, status of the sign, automatic calibration of pixels, automatic dimming of light intensity, and temperature control. Automatic dimming systems detect ambient light levels and optimize the light intensity to reduce brightness at night and increase the life of the LED. LED displays now have a 100,000-hour operating life, meaning that if the sign is properly maintained and monitored, it could last longer than ten years before needing to be replaced.

The content management systems used to remotely control modern digital displays are designed with security measures that allow open and limited access through the use of passwords. They provide a variety of options to manage the access in the system. Access can be restricted to one content manager who is the gatekeeper for all content changes, or direct access can be assigned to designated users permitted to make content changes. The content management system is also capable of designating specific slots for community messages and allowing system managers to preempt the scheduled content at any time to display emergency messages when necessary.

To audit, monitor, and provide real-time viewing of the LED display, small cameras are mounted on an extension projecting several feet out from the sign face. The cameras look back at the sign face so the messages can be viewed at any time.

To minimize distraction to the traveling motorist, LED digital display messages are not allowed to scroll, flash, or emit intermittent light. LED technology allows multiple messages to be shown on a single display with content flexibility to target specific messages to various groups and change messages at interval times during the day. In addition, a new digital message or design can be created within hours and can be displayed on the digital sign within minutes to allow placement within a specific time of day.

Advertising on Public Property

Some government agencies across the United States have active programs that allow for outdoor advertising on their assets or land as a revenue-generating program. Cities and transit agencies across the United States and around the world have transit advertising franchise programs that allow placement of advertising in and on buses, in trains, and at stops and stations. An emerging trend seen in cities across the country is the expansion of existing street furniture programs. These advertising-supported street furniture programs typically require the advertising operator to provide furniture and perform required maintenance service at no cost to the agency in exchange for the right to place advertising. Most programs also include a revenue share component to the agency or city as part of the franchise agreement. In addition to transit and street furniture programs, cities and public agencies are exploring the revenue potential of outdoor advertising on their property.

Large landholding agencies, including commuter rail systems and transportation departments, have a portfolio of displays that can generate tens of millions of dollars in annual revenue when developed to their best advertising use. Some cities have also recognized the opportunity to create special programs to permit select outdoor advertising displays that in turn provide funding to specific civic or public programs. In 2013, the City of Chicago entered into a billboard development deal for 34 digital billboards that is expected to generate revenue over 20 years. This program is not for advertising on CMS so there was no need for federal approval. In 2014, the City of New York announced a franchise for approximately 10,000 public information kiosks to replace public payphones. Again, this program is not for advertising on CMS so there was no need for federal approval. This franchise will be fully funded by outdoor advertising, and the city will receive 50 percent of the advertising revenue with a guaranteed minimum over the 15-year franchise. This acceleration of large scale outdoor advertising programs on public assets could increase the public share of industry revenue.

Outdoor advertising companies historically have paid nominal flat or fixed rents to landlords for the right to build and operate a display on the landlord’s property with rents equal to 15 to 20 percent of net advertising revenue. Landlords have negotiated more favorable contract terms that pay rent from 35 to 50 percent of net revenues, and sometimes as high as 60 percent, and often include a minimum guaranteed rent with periodic increases. The City of New York Information Kiosk franchise and the growing number of public billboard programs are indicators of the potential public agencies can achieve in non-tax revenue. The advertising value of the asset, size, and term of the franchise, and capital and maintenance obligations, all play a role in determining the franchise value and combination of benefits and revenue share available to the agency or city.

Advertising on public highway right of way over travel lanes on CMS previously reserved for traveler information and safety / emergency messages causes some transportation professionals hesitation. Does it distract motorists? Will it detract from relaying importation information? Is it a proper use of the public right of way? What is the true revenue opportunity? Will it impact local communities or residents? A pilot will allow us to answer these and other related questions.

CONCEPT: ADVERTISING SUPPORTED CMS PROGRAM

Current CMS Program

Over the past 40 years, Caltrans has developed and operated its current CMS program to communicate with motorists on the State highway system. Caltrans manages more than 15,000 centerline highway miles on 265 routes throughout the 58 counties of the State and currently operates 904 CMS placed along 94 highway routes throughout 52 counties. Caltrans currently has a wide vintage of CMS in its inventory, with the first CMS being installed in 1975 and the majority installed after 1988. A traditional CMS costs Caltrans approximately $225,000 to install, and the current CMS program costs Caltrans approximately $5 million annually to operate. Although Caltrans has a planned program for 1,185 CMS locations, only 82 CMS were built in the past three years.

The CMS network is an essential communications tool for Caltrans to broadcast real-time site specific road and traffic conditions, travel time estimates, safety announcements, detour, and delay alerts. In addition, the network has been an aid to the AMBER Alert program to help publicize missing children and the wanted suspect as well as the Blue Alert program that notifies the traveling public when a suspect has assaulted a law enforcement officer and is believed to be traveling on the highway system. At times, the CMS network provides information to support safety, and maintenance and construction activities, like “Slow for the Cone Zone,” “Click It or Ticket,” and “Hands Free Cellphone.” The current CMS technology can display up to three lines of yellow alphanumeric text, using up to 16 characters per line, at a character size between 12-18 inches. This current display capability is limited in its messaging capabilities.

The authority for the use of CMS can be found in the 2009 Federal Highway Administration’s (FHWA) Manual of Uniform Traffic Control Devices (MUTCD), which Caltrans adopted in 2012. Caltrans operates the CMS program under the CMS guidelines established by the Caltrans Headquarters Division of Traffic Operations in 2006 to provide clear guidance on the use of CMS on California’s highways.

CMS have become an important part of the Intelligent Transportation System (ITS) programs for the FHWA throughout the country. In general, the term “ITS” refers to information and communication technology that improves transportation outcomes, such as safety, productivity, reliability, travel choices, social equity, environmental performance, and network operations. Congestion reduces the efficiency of the transportation infrastructure and increases travel time, air pollution, and fuel consumption. As highway congestion has increased throughout the country, ITS has developed a synergy with new information technologies to allow for traffic simulation, real-time highway control, and advanced communications networks with the traveling public. Additionally, ITS can support the surveillance of the roadways, which is a priority for homeland security, and can play a role in the rapid mass evacuation of people after a large catastrophic event occurs such as a natural disaster.

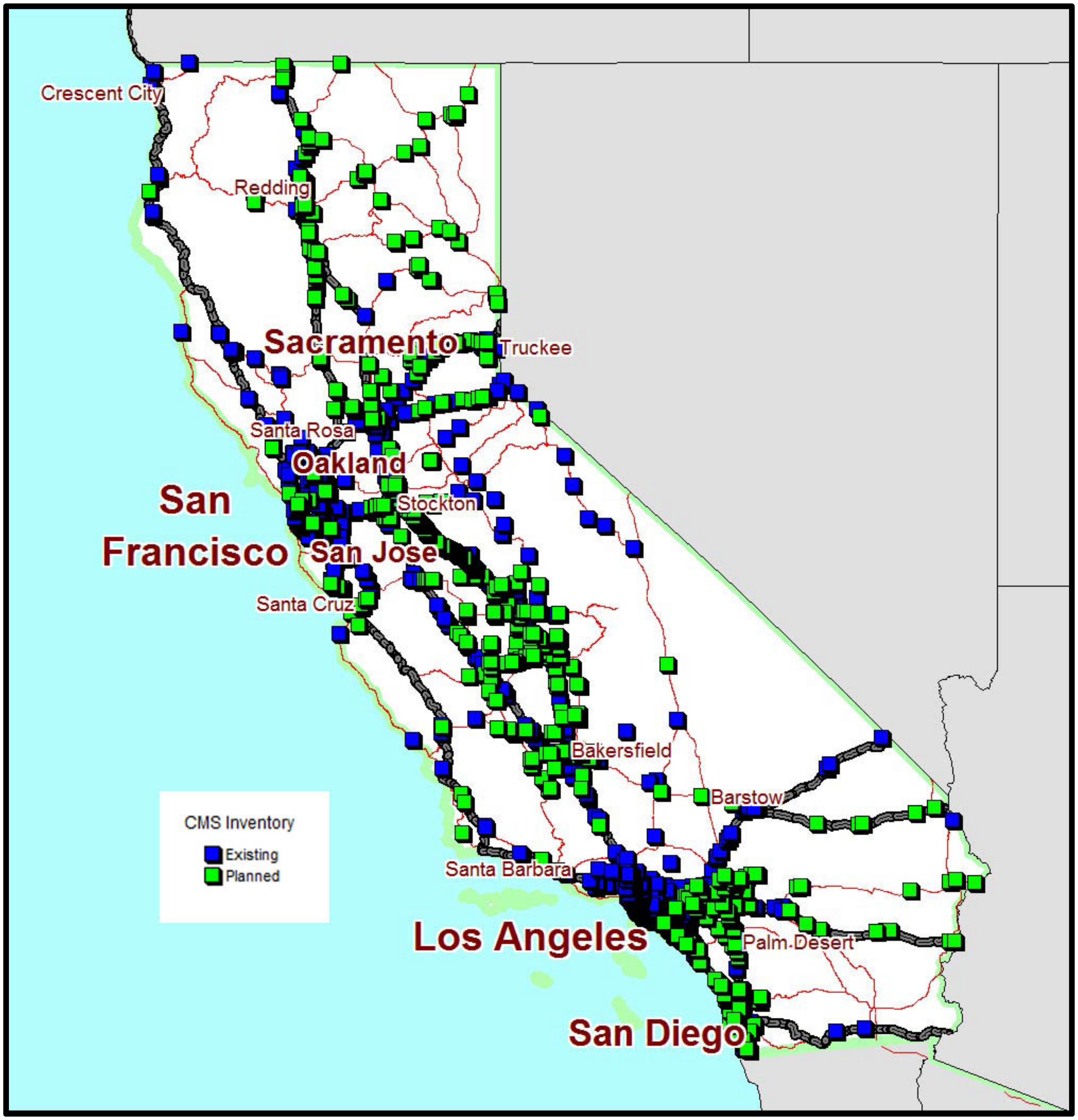
The location of a CMS is determined in accordance with the CMS guidelines at a preferred distance of one or two miles in advance of major decision points such as interchanges or intersections. It must be located so motorists can detect the sign, read, and understand the message in time to make a decision. Other recommended locations are upstream from major special events facilities like stadiums, convention centers, and traveler destinations like airports. It should also be located in advance of areas that may experience severe weather conditions.

CMS Locations

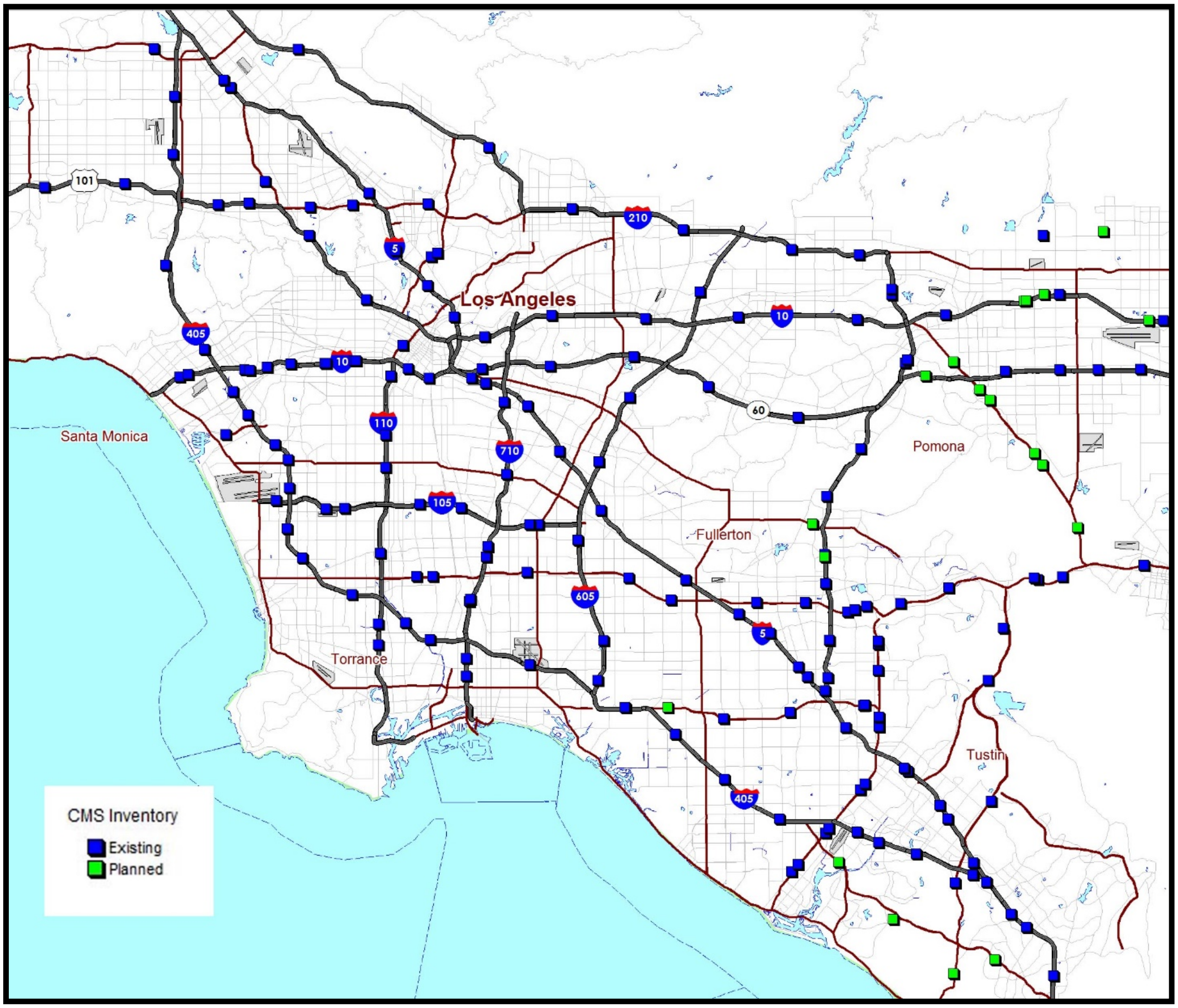
Chart 1: Caltrans CMS Location List

County	Existing	Planned	Total	County	Existing	Planned	Total
Alameda	53	3	56	Orange	64	-	64
Alpine	1	-	1	Placer	21	4	25
Amador	2	-	2	Plumas	3	-	3
Butte	1	3	4	Riverside	25	19	44
Calaveras	1	-	1	Sacramento	31	34	65
Colusa	2	1	3	San Benito	3	-	3
Contra Costa	33	1	34	San Bernardino	45	46	91
Del Norte	5	-	5	San Diego	63	-	63
El Dorado	9	18	27	San Francisco	26	2	28
Fresno	36	35	71	San Joaquin	46	-	46
Glenn	-	2	2	San Luis Obispo	6	-	6
Humboldt	4	-	4	San Mateo	33	1	34
Imperial	3	-	3	Santa Barbara	4	-	4
Inyo	2	-	2	Santa Clara	33	2	35
Kern	34	31	65	Santa Cruz	4	-	4
King	9	9	18	Shasta	19	-	19
Lake	4	-	4	Siskiyou	7	-	7
Lassen	3	-	3	Sierra	-	-	-
Los Angeles	126	2	128	Solano	16	2	18
Madera	12	9	21	Sonoma	11	-	11
Marin	10	-	10	Stanislaus	12	-	12
Mariposa	3	-	3	Sutter	-	4	4
Mendocino	5	2	7	Tehama	7	-	7
Merced	21	-	21	Trinity	-	-	-
Modoc	-	-	-	Tulare	14	17	31
Mono	6	-	6	Tuolumne	3	-	3
Monterey	3	-	3	Ventura	8	-	8
Napa	4	-	4	Yolo	2	22	24
Nevada	6	9	15	Yuba	-	3	3
					904	**281**	**1185**

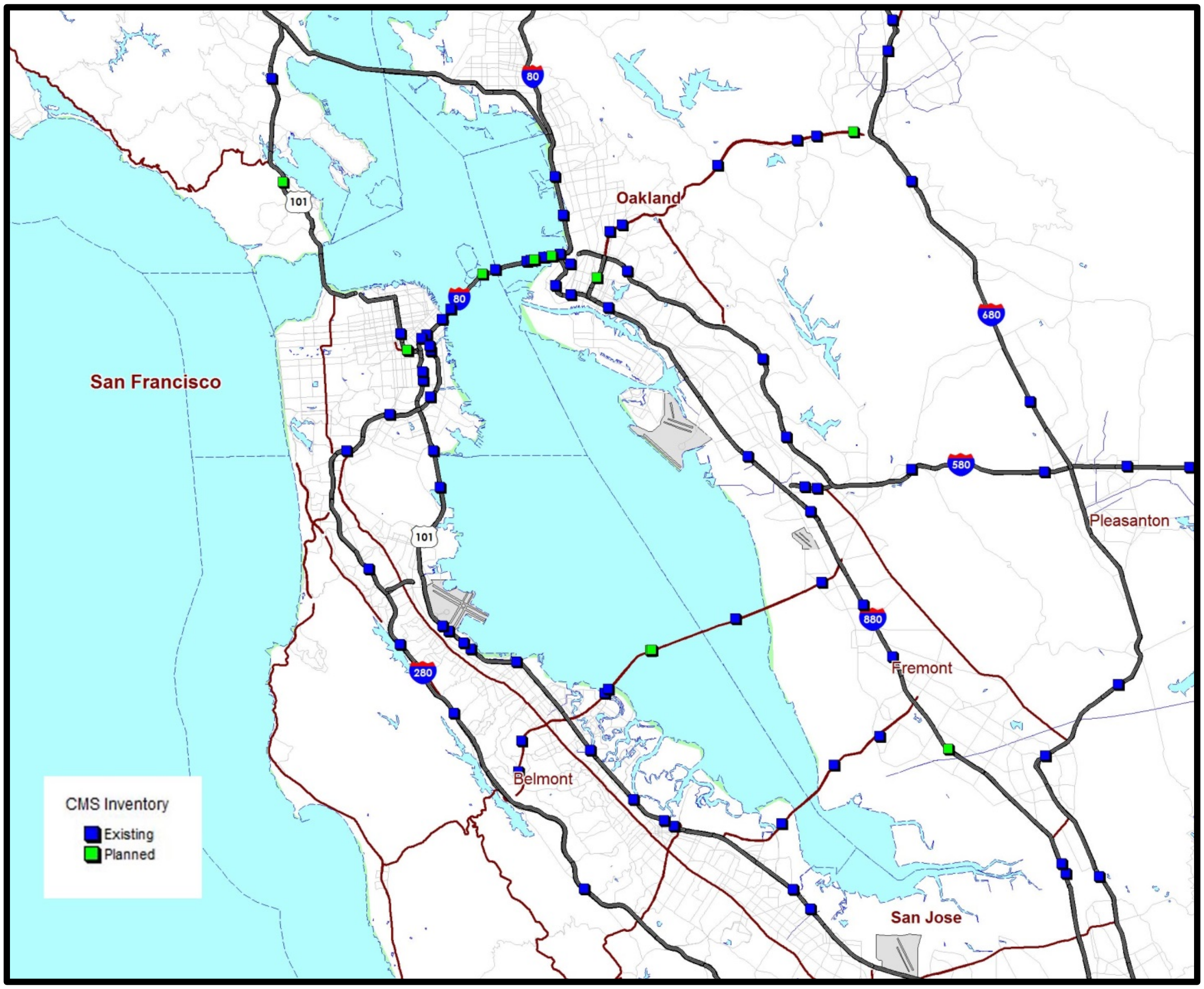
Map 1: Caltrans Total CMS Inventory



Map 2A: Los Angeles CMS Inventory



Map 2B: San Francisco Bay Area Total CMS Inventory



Map 2C: Sacramento Total CMS Inventory

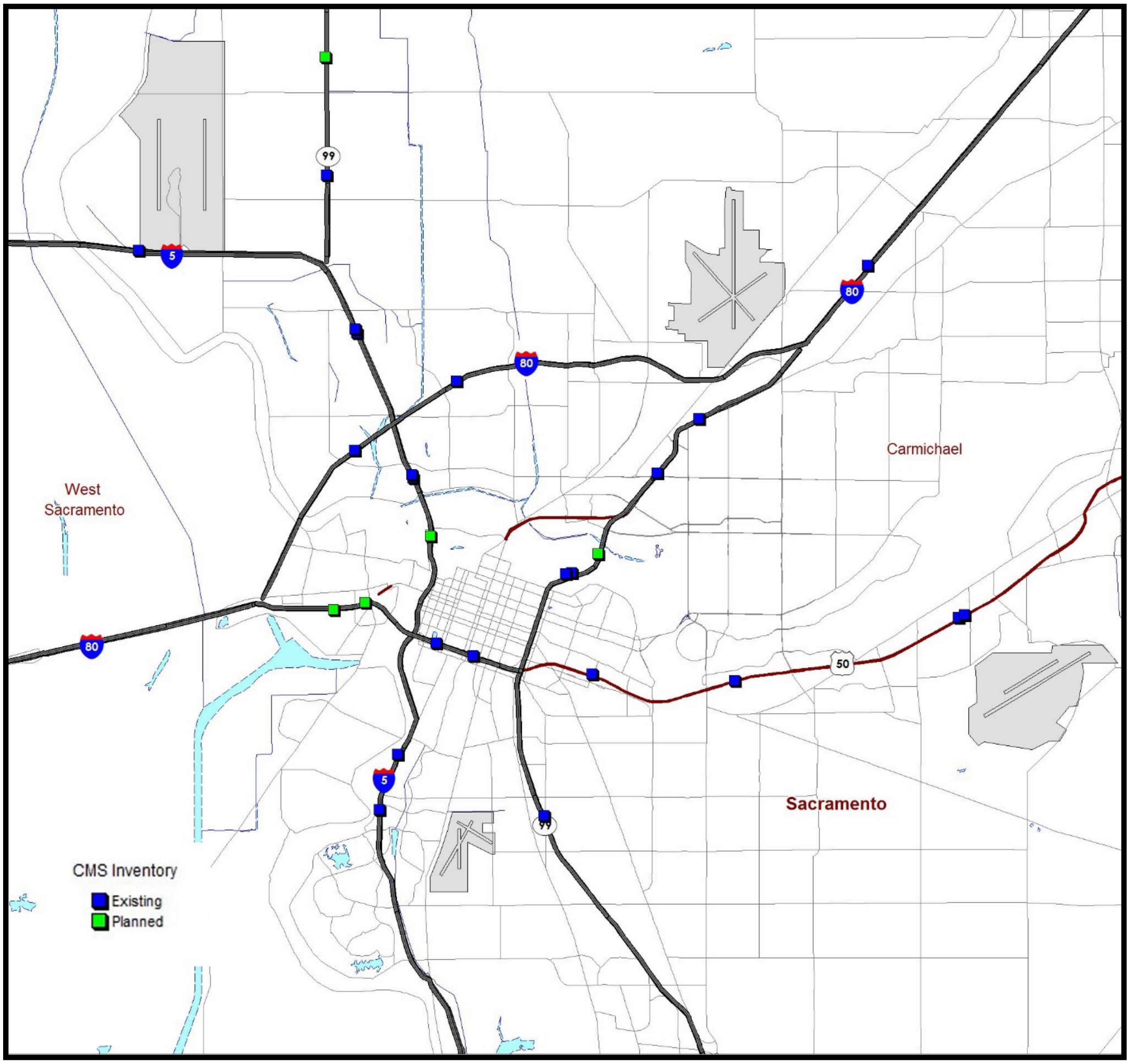


Photo 1: Example of a Travel Time Message

Photo 2: Example of a Traffic Delay Message

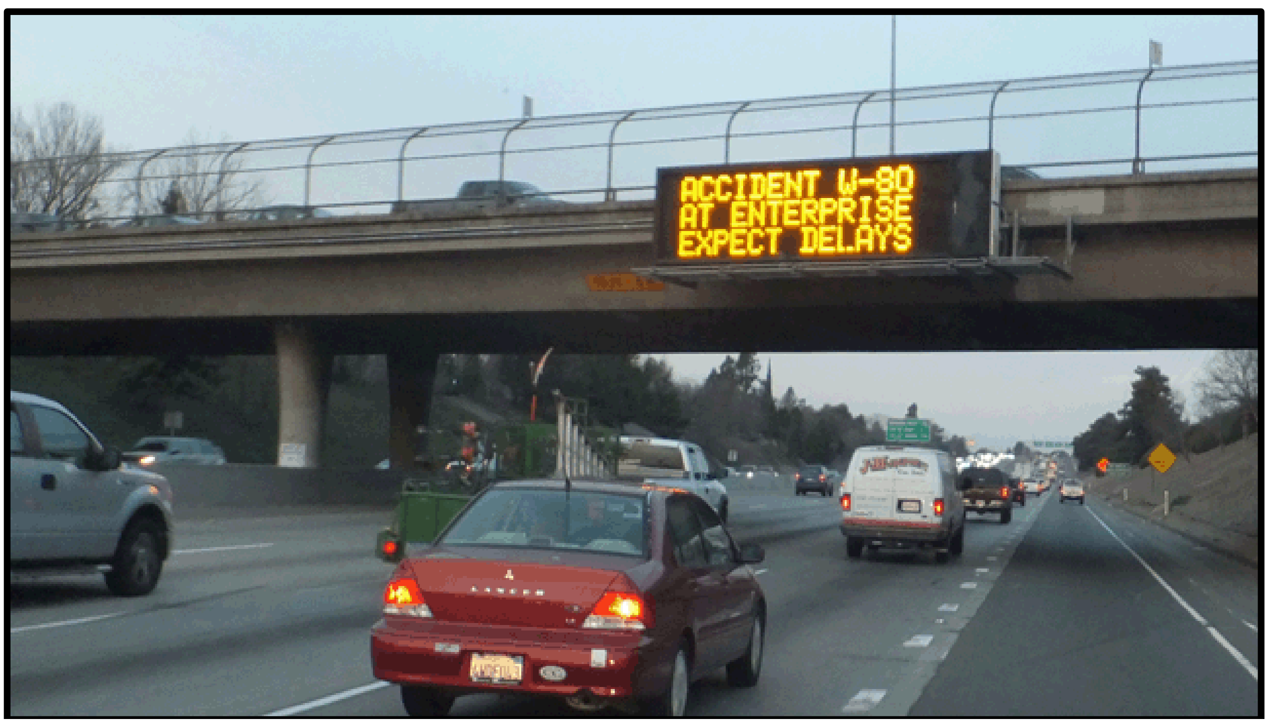


Photo 3: Example of a Safety Message

Photo 4: Example of an AMBER Alert Message

Funding Challenges

As the network ages and CMS are not upgraded or replaced, current CMS can show signs of aging, suffer burned out bulbs, or experience brightness control issues. The current displays have limited display technology capabilities compared to what is currently available on the market. Due to budget constraints, Caltrans has been unable to complete the full program rollout, or upgrade the displays and network to new and improved technology. The full new CMS network would cost an estimated $322 million to build and would require an additional $308 million in current day dollars every seven to ten years to replace/upgrade the displays for total capital cost of $938 million over 20 years. In addition to the capital costs, the network would incur annual operating and maintenance expenses of $18 million to $30 million.

Photo 5: Example of a malfunctioning CMS

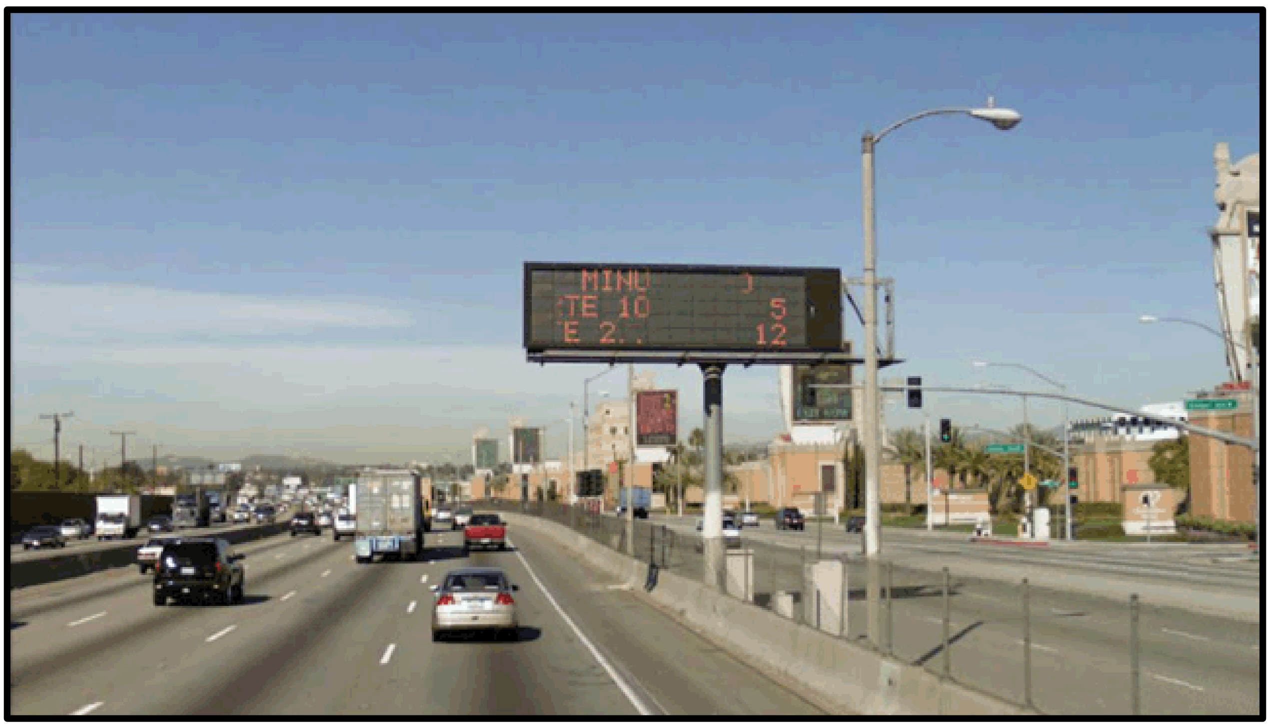


Photo 6: Example of a malfunctioning CMS

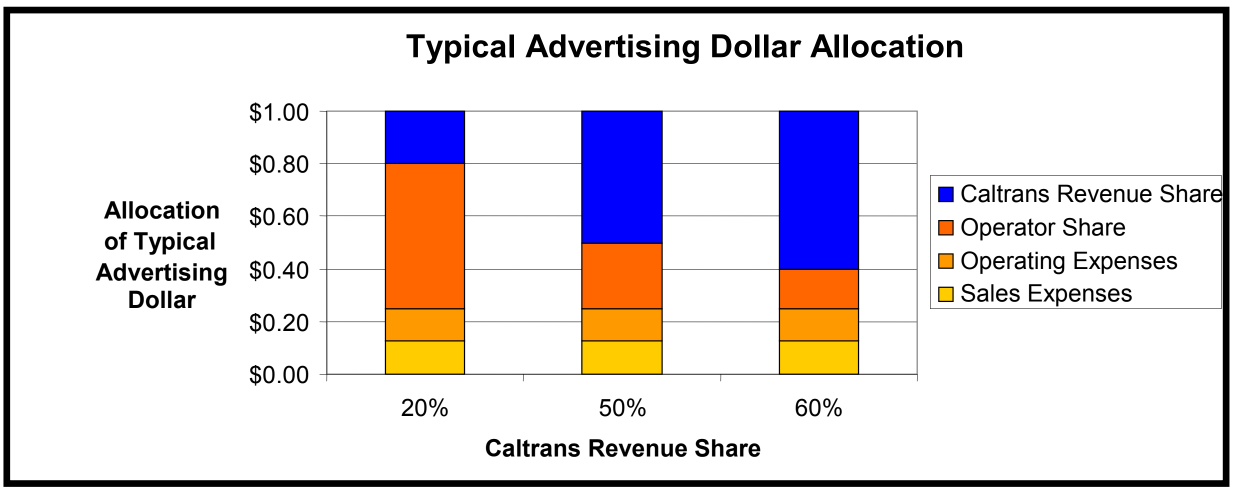
Advertising Supported Solution

A demonstration project would evaluate if the following potential benefits would be realized in exchange for granting advertising rights to private sector companies:

- A private industry partner responsible for constructing, maintaining, and operating the network infrastructure.
- Recovery of the $5 million currently spent annually to operate the CMS program plus any future cost increases through in-kind services and program reimbursement cost negotiated into license agreements with outdoor advertising companies.
- Continued utilization by Caltrans for its own safety campaign messaging with a potential enhanced effectiveness.
- A next generation CMS network with new displays at existing and planned locations.
- Net revenues to Caltrans of up to $8.5 million to $10.2 million on average annually, including any combination of payments of a base annual fee, a prepayment of fees, and revenue shared from the sale of advertising on the signs.

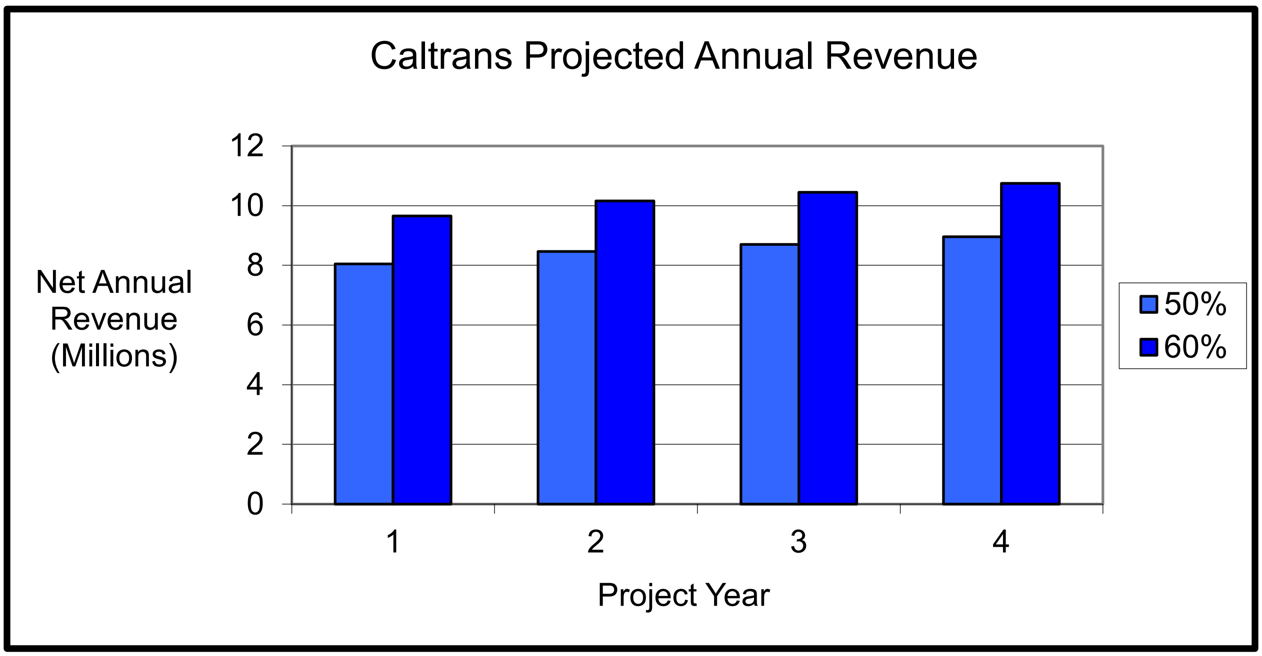
While the industry standard for billboard agreements is 20 percent to 30 percent of gross advertising revenue, Caltrans revenue assumptions in the demonstration project of 50 percent to 60 percent could be justified in this case by both the quantity of displays and the unprecedented positioning of these displays relative to the traveling public.

Chart 2: Typical Gross Advertising Revenue Dollar Allocation



The calculation of net annual revenue to Caltrans is determined from the gross advertising revenues after accounting for the appropriate cost recovery for both Caltrans and the private industry partner. Caltrans would be able to recoup the personnel costs and operating expenses for administering the program, oversight of the construction and maintenance of CMS activated by the private industry partner as well as the operation of the CMS locations in the demonstration project. In addition, the private industry partner would be able to recover its reasonable expenses for sales and marketing, the capital expenditure costs to build the network, and the costs to maintain the CMS locations in the demonstration project. The end result would be the distribution of the net revenue at the agreed upon percentages.

Chart 3: Projected Demonstration Project Net Revenue



Caltrans would control the operation and management of the pilot program by directing the timing and location of the site implementation schedule; and by entering into specific rights and use license agreements for the construction, maintenance, and advertising sales. Caltrans should either own the physical network from the outset of the program or retain a contract right to take ownership of the network at its sole discretion.

The advertising sales company should hold only license rights to sell advertising under a sales agreement or license agreement with specified rights in exchange for financial commitments. The sales license should contain minimum guarantee payments to Caltrans plus net revenue participation above those minimum guarantee payments to ensure Caltrans is both protected on the downside and a participant in the upside of advertising sales and any future revenue growth.

The cost of building the CMS network would be paid by advertising sales. Financing of the construction could be from any single or a combination of Caltrans resources, advance payment, or securitization from advertising sales licenses, or other financing sources. It is important that Caltrans actively engage in the management of the program beyond construction and operation of the network. Caltrans' direct control of the displays would protect its interests and ensure that the advertising sales licensee continually delivers the full value and benefits of the program to Caltrans.

Benefits

An advertising-supported CMS network could provide improved communication with the traveling public. Instead of displaying simple text messages, the next generation CMS would have full-color, high-definition capabilities making messages sharper and easily readable.

The primary messaging function of the CMS is to provide:

- Traffic Alerts (accidents, delays, closures, detours)
- Road Conditions (fog, ice, chain requirements)
- Travel Times
- Safety Campaigns (Buzzed Driving, Slow for the Cone Zone, Don't Text)

In addition to the primary functions, the new CMS would provide high-resolution quality messages, including photos, to the motorists and could include emergency and community messages such as:

- Disaster Alerts (earthquake, fire, flood)
- Homeland Security (fugitive photo, threat level change)
- AMBER Alerts (child abduction)
- Blue Alerts (police)
- Local Community (events, announcements)

The demonstration project would also evaluate any risks or dis-benefits that may materialize including:

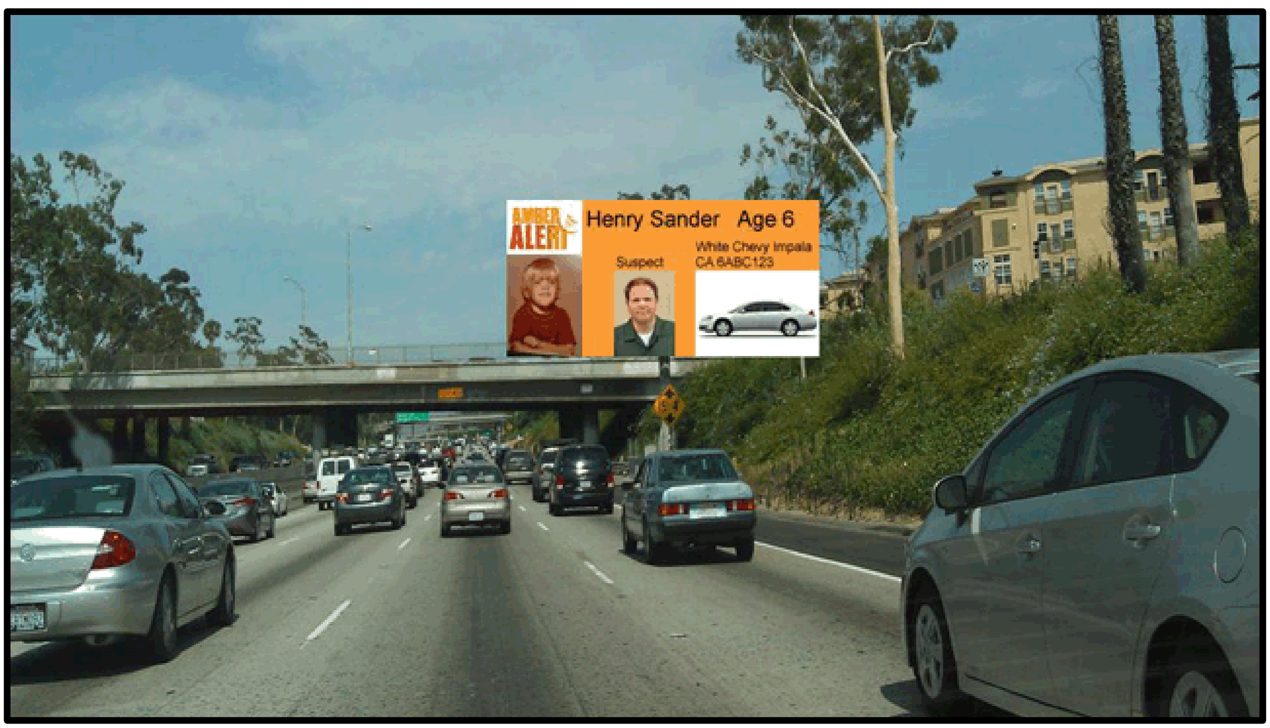
- Distraction to motorists or the creation of safety concerns to the traveling public
- Erosion of effectiveness of traveler information and safety messages
- Operational impacts to the State highway system
- Local entity and public receptiveness

Of these, safety is paramount. In California, Caltrans, the California Highway Patrol, and the Office of Traffic Safety work collectively to reduce deaths and injuries related to the transportation system. Should implementation of a pilot be advanced, it must not be in conflict with safety. Any pilot would have to be crafted to manage risk of distraction to drivers – this would include not only risk of drivers being distracted by advertising displays and reducing their attention to other transportation users, but also motorists being distracted and missing other safety notices and signs. Because CMS are also used for the AMBER alert program, as well as the Silver and Yellow alert programs, pending federal approval, public access and use of the displays for these purposes must not be delayed or reduced in any way. Any pilot should be phased, such that any safety effects of the initial phase of any CMS, will be sufficiently evaluated prior to any subsequent phase being implemented. If, at any time, a safety problem is identified with the advertising displays and it cannot be fully addressed, the advertising messages would be immediately discontinued.

If there are no safety or operational impacts identified during the demonstration project and the total revenue is sufficient for full cost recovery, Caltrans would have the opportunity to examine a statewide program that could generate additional net revenue and provide additional upgrades or expansion of the statewide CMS network. However, with the potential need for additional State and federal approval for a full statewide program and potential safety implications, there is no guarantee the program will expand beyond the demonstration phase. In either case, the net revenue generated would be used for general transportation funding, including the operation, maintenance, and repair of the State highway system and other critical needs within Caltrans.

Photo 7: Example of a Concept Safety Message

Photo 8: Example of a Concept AMBER Alert Message



Demonstration Project

The demonstration project is subject to FHWA and State legislative approval and would allow for evaluation of key success metrics, which include no impact to the safety of the traveling public, operational functionality for the State highway system, community engagement, and sufficient revenue generation to ensure full cost and capital expenditure recovery.

State and Federal Approval

The State and Federal authority that would allow for the demonstration project does not exist and both State and Federal approvals would be required before the project could move forward.

Federal Approval

Federal approval is required to waive or exempt certain provisions of the Federal-State Agreement in order to allow advertising on CMS inside and over right-of-way and the Bonus Act; and to waive spacing requirements to other off-premise and changeable signs. A waiver or exemption from MUTCD restrictions on advertising would be required to allow for placement of advertising on CMS.

State Approval

Authorizing legislation from the State Legislature would be required for Caltrans to seek Federal approval and allow Caltrans to move forward with the demonstration project. In addition to approving the demonstration project, the State legislation would need to incorporate waivers or exemptions from certain provisions of the OAA, including but not limited to, spacing, local permit/approval, and possibly freeway landscape classification.

Safety

Digital signs would be limited to changing static messages at varying intervals. Lighting intensity can be raised to ensure visibility in bright sunlight and reduced for nighttime or less intense sunlight conditions. The FHWA has issued guidelines and the outdoor advertising industry has adopted policies for signs outside highway right of way that:

- Limit messages to static images that transition instantly without animation and do not display movement to address driver distraction concerns
- Continuously monitor and control lighting intensity to address concerns over brightness

In a September 2012 study titled "Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)," FHWA reported results of a literature review and primary research findings it conducted.

In the review of prior literature, FHWA found no consistent evidence showing safety or a distraction effect due to off-premise advertising. These findings were corroborated by the primary field research that found the following:

- The presence of CEVMS did not appear to be related to a decrease in looking toward the road ahead.
- Driver glances to CEVMS did not result in unacceptably long glances away from the road, based upon the widely accepted threshold identified in a National Highway Traffic Safety Administration (NHTSA) naturalistic driving study.
- Drivers were generally more likely to gaze at CEVMS than standard billboards but the gaze dwell time was still well below the threshold identified by the NHTSA as safe.

While the findings of this FHWA study are consistent with other billboard safety studies done in the United States, the report summary states that its results add to the knowledge base but do not present definitive answers on the subject. Therefore, if a demonstration project occurs, a study to review what, if any, safety issues are created from installation of the demonstration signs will be conducted. If any new safety study determines from research and findings that displaying commercial advertising on CMS impacts the safety of the traveling public, Caltrans would suspend the demonstration project. Depending on the specific concerns regarding safety, Caltrans and the advertising operator would investigate solutions to mitigate the issues or terminate the program. If Caltrans were to terminate the demonstration project, specific language will be provided in the contract to address the terms and process for early termination.

With the guidance of the Caltrans policies and procedures, a full safety program would be incorporated into the final outdoor advertising display structure design standards and would be implemented into the installation, operation, and maintenance of the structures and displays. The program would be required to conform to California Occupational Safety & Health Administration; American Association of State Highway and Transportation Officials; and Caltrans' safety guidelines, rules, and regulations.

Operational Functionality

The demonstration project should also exhibit the consistent operation of the displays, execution of the program, and the opportunity to test add-on features for additional value to the overall program.

General signage display features would include but are not limited to:

- Display durability
- Real-time flexible messaging capability
- Content management tools
- Lighting controls with dimming capabilities

Caltrans attributes could include:

- Building the interface with each of the 12 Caltrans transportation management centers and training staff to effectively use the new displays to their full capabilities
- Integration with Caltrans district transportation management centers for timely posting and removal of emergency and safety messages and data collection for real time traveler information distribution
- Training, implementation, and management of messaging features including those for AMBER Alerts, Blue Alerts, and other safety messaging
- Traffic cameras and other equipment to fully utilize the physical and communications infrastructure of the CMS network

Revenue Generation and Cost Recovery

The proposed demonstration project of 25 locations is designed to provide full cost recovery for Caltrans and the advertising operator from the projected annual gross advertising revenues of $18 million to $20 million. This would include complete capital expenditure recovery for the construction of the CMS and the supporting network as well as operating expenses for both Caltrans and the advertising operator.

If Caltrans implements the proposed demonstration project, it would enter into (an) agreement(s) with (an) advertising operator(s) to fund, build, and operate the network and fulfill the requirements of the demonstration project. The demonstration project is estimated to cost $10.2 million to build and install and approximately $500,000 per year to operate the proposed 25 demonstration locations.

The cost recovery provisions for Caltrans should be included in the agreement such that all expenditures in terms of personnel, operating expenses, and material for oversight of the project during the development, design, and construction phases of the demonstration project as well as the operation of the 25 locations and the supporting network can be recouped.

Under a long-term (example: 20-year) license, an advertising operator could be expected to absorb all capital expenses from its share of revenue. Since the demonstration project is a four-year term, the selected advertising operator should be allowed to fully recover its investment within the demonstration time period. This can be achieved a number of ways:

<u>Prorated over Four Years</u>

- First dollar up to 25 percent of total capital expenditure annually.
- Spreads the recovery over the four years of the demonstration project but allows for accelerated recovery up to the allowed amount each year before any revenue share to Caltrans.

Allocated

- Twenty-five percent of every revenue dollar until capital expenditure recovered.
- By allocating 25 percent of revenue to capital expenditure recovery, Caltrans would participate in revenue sharing at a reduced rate from the start of the project until capital expenditure is fully recovered.

Operator Risk

- Capital expenditure recovered solely from operator revenue share.
- Allows Caltrans to participate fully in revenue share from the outset of the project and requires the greatest level of revenue in order for the operator to fully recover its capital expenditure during the demonstration project.

Accelerated

- First dollar until full capital expenditure recovered.
- Advertising operator receives the quickest, lowest risk return of the capital expenditure because all revenue after expenses is allocated to capital expenditure recapture until fully recovered.

The State will require a provision in the agreement that defines the terms and process for early termination.

Caltrans should require that all costs and revenues be subject to audit and approval to ensure open and transparent accounting of capital expenditures and revenues.

PROJECT CONSIDERATIONS

Building an advertising-supported next generation CMS network would require balancing regulatory, aesthetic, and community interests and concerns with commercial needs to generate revenue with the paramount focus on ensuring the public's safety. These specific variables are examined in detail to identify the tradeoffs required to make the program potentially viable.

Regulation and Rules

Regulatory

Federal regulatory approval and State authorizing legislation, as addressed previously, would be needed for the demonstration project.

Rules

There are several Federal and State statutes implemented by the California OAA. The significant rules that impact a location's availability for advertising are:

1) <u>Outdoor Advertising Inside/Over Right-of-Way</u>

   Outdoor advertising displays are not permitted inside/over right-of-way per Title 23 of the United States Code, and the OAA.

   This restriction would need a Federal waiver as all CMS are located in right-of-way.

2) <u>Zoning and Proximity to Commercial Activity</u>

   Outdoor advertising displays are only permitted in industrial and commercial zones, and must be within 1,000 feet of a commercial activity or use. These restrictions are incorporated into Title 23 of the United States Code and the OAA.

   Freeways are either not zoned or zoned public and are often adjacent to non-commercial or non-industrial zoned land making them ineligible for outdoor advertising without Federal and State waivers.

3) <u>Spacing</u>

   Under federal and State law, an advertising display may not be placed within 500 feet of another advertising display on the same side of any portion of an interstate highway or a primary highway that is a freeway. No advertising display may be placed within 500 feet of an interchange, or an intersection at grade, or a safety roadside rest area on any portion of an interstate highway or a primary highway that is a freeway and if the interstate or primary highway is located outside the limits of an incorporated city and outside the limits of an urban area. No advertising display may be placed within 300 feet from another advertising display on the same side of any portion of a primary highway that is not a freeway if that portion of the primary highway is located outside the limits of an incorporated city and outside the limits of an urban area. No advertising display may be placed within 100 feet from another advertising display on the same side of any portion of a primary highway that is not a freeway if that portion of the primary highway is located inside the limits of an incorporated city or inside the limits of an urban area.

There are spacing conflicts with permitted off premise signs at several locations statewide with additional CMS having spacing issues to on premise signs. In general, CMS locations provide a primary traffic safety function and cannot be relocated from spacing conflicts and would therefore require a Federal and State exemption or waiver.

4) Landscaped Classified Freeway

"Landscaped freeway" means a freeway section that is improved by the planting at least on one side or on the median of the freeway right-of-way of lawns, trees, shrubs, flowers, or other ornamental vegetation requiring reasonable maintenance.

The prohibition of outdoor advertising displays adjacent to a landscaped freeway is stated in Section 5440 of the Business and Professions Code; "Except as otherwise provided in this article, no advertising display may be placed or maintained on property adjacent to a section of a freeway that has been landscaped if the advertising display is designed to be viewed primarily by persons traveling on the main-traveled way of the landscaped freeway." Several sections of Article 8 detail exceptions to allow outdoor advertising signs within a landscaped freeway section.

New outdoor advertising displays are prohibited on landscaped freeways. There are several CMS locations for traveler information on designated landscaped freeways. Any State authorizing legislation for a pilot project would have to consider the appropriateness of a waiver from landscape restrictions.

5) Bonus Segment

"Bonus Segment" means any segment of an interstate highway which was covered by the Federal Aid Highway Act of 1958 (Bonus Act) and the Collier Z'berg Act. This is any segment of highway constructed upon right-of-way, the entire width of which was acquired subsequent to July 1, 1956.

Several CMS locations are on bonus segment freeways. CMS locations provide a primary traffic safety function and cannot be relocated from bonus segment freeways and would therefore require an exemption or waiver if deemed appropriate.

6) Scenic Highways

An officially designated "scenic highway" or "scenic byway" is any State highway that has been officially designated and maintained as a State scenic highway pursuant to Sections 260, 261, 262, and 262.5 of the Street and Highways Code or that has been officially designated a scenic byway as referred to in Section 131(s) of Title 23 of the United States Code. The prohibition of an outdoor advertising display is stated in Business and Professions Code Section 5440.1; "Except as otherwise provided in Section 5442.4, no advertising display may be placed or maintained along any highway or segment of any interstate or primary highway that before, on or after the effective date of Section 131(s) of Title 23 of the United States Code, is an officially designated scenic highway or scenic byway.

A small number of CMS locations for traveler information are on designated scenic highways. CMS locations within designated "scenic highways" should not be considered in the pilot.

7) Local Acceptance

For this demonstration pilot to be successful, the program has to be implemented in a manner that best benefits Caltrans while at the same time remaining sensitive to community and local concerns. Although some communities are accepting of outdoor advertising and welcoming of the public benefit tied to many of the programs, there are others that do not welcome outdoor advertising and could oppose any signage regardless of the mitigation efforts and public benefit. Caltrans would need to balance the intent of the program with local considerations and can offer a local benefits program to go along with placement of advertising on CMS. The program should include specific design and placement elements and options to allow for local input where possible. In addition, Caltrans could offer a number of benefits to each community where advertising CMS are placed, including public messaging, local business advertising discounts, and an allowance for offsetting community beautification projects.

8) Travel Times

CMS in select high traffic and high congestion areas have evolved into dedicated travel time displays showing estimated real time travel time to popular destinations. There is no time that these displays are not in use for Caltrans purposes. Currently, there are 130 dedicated travel time CMS locations in the network. Given the increasing need and desire for this information and ease of supplying it, it is not unreasonable to expect additional CMS locations to be added to this program over time. Because these high traffic locations are also considered high value advertising locations, dedicating them to travel time and removing them from advertising inventory could reduce the net revenue potential of the program. With the potential for additional travel time locations over time, it is likely that the travel time/advertising value conflict would increase. A split-screen solution could be employed that would separate the advertising from the travel time and routine Caltrans messaging.

Recommendation

In order to successfully implement the advertising-supported CMS demonstration project for purposes of evaluating viability, an exemption should be considered from State and federal authority including OAA for relief from the spacing requirements between outdoor advertising displays, and the spacing requirements from interchange configurations contained in the OAA.

Display Configuration

Existing/Legacy Model CMS

A majority of Caltrans permanent CMS are the 500 model. There are a limited number of 510 and 520 models that are currently in operation as well.

<u>CMS Model 500</u>

25' x 6.5'	Fixed Location		
3 lines of text	16 characters per line	18" characters	Full Matrix Display

Installed on freeways and expressways

Photo 9: CMS Model 500

<u>CMS Model 510</u>

14.5’ x 4.5’ Fixed Location

3 lines of text 16 characters per line 12” characters Full Matrix Displays

Installed on freeways, expressways and conventional highways

Photo 10: CMS Model 510

CMS 520
8' x 4.5' Fixed Location
3 lines of text 8 characters per line 12" characters Full Matrix Display
Installed on conventional and rural highways

Photo 11: CMS Model 520

Next Generation/Proposed New Model CMS

The next generation CMS features would include dramatically improved image quality, hardware and software features, and controls that would impact the display. The CMS technical features that play a role in sign selection include aspect ratio, shared display time, physical display size, and backup advertising display.

Aspect Ratio

The ratio between the height and width of the display is the aspect ratio. Like televisions, digital signs come in different sizes. Choosing a single standard aspect ratio for digital signs allows a single piece of content to be displayed on different displays, regardless of actual size; much like television programming would play on any size television screen. Selecting a few standard configurations would make the implementation more efficient due to a standardized set of options and fewer parts to be managed. Standardized display configurations would benefit content management for both the advertising operator and Caltrans.

Designing the advertising space to scale to the standard digital outdoor advertising display, 14' x 48' aspect ratio would provide maximum flexibility to advertisers, allowing them to deliver standard advertising designs to the CMS advertising program.

Text Size / Visible Approach (Display)

The current CMS guidelines call for 18-inch high alphanumeric characters. With higher quality signage technology, the display message may be readable from a greater distance. This would be the starting point from which to develop a full feature CMS creative design specification.

Display Zones – Split Screen / Shared Screen

If the screen does not have a separate display zone dedicated to advertising, the content area would have to be shared between advertising and CMS messaging. Important CMS messaging may take away from peak advertising revenue times, and the display time available to generate advertising revenue would decrease because only one message could be displayed at a time. This conflict could be mitigated by splitting a display into Caltrans messaging and advertising zones, ensuring dedicated space for Caltrans messages, and making advertising space inventory more predictable to manage. A portion of time on the advertising zone would be available for routine Caltrans messages, and the advertising zone would still be subject to emergency message priority override.

Potential Backup Advertising Display

It is common practice in the outdoor advertising industry to place a second or "backup" display onto the back of an existing structure to be viewed by traffic in the opposite direction in order to create two advertising revenue opportunities from a single location. Under the OAA permitting protocols, a backup display is permitted on the primary permit if flush to the primary display or on a separate permit if angled from the primary display in a 'spread' or 'V' formation.

Physical Display Size

The size of the display can be influenced by a number of important factors including:

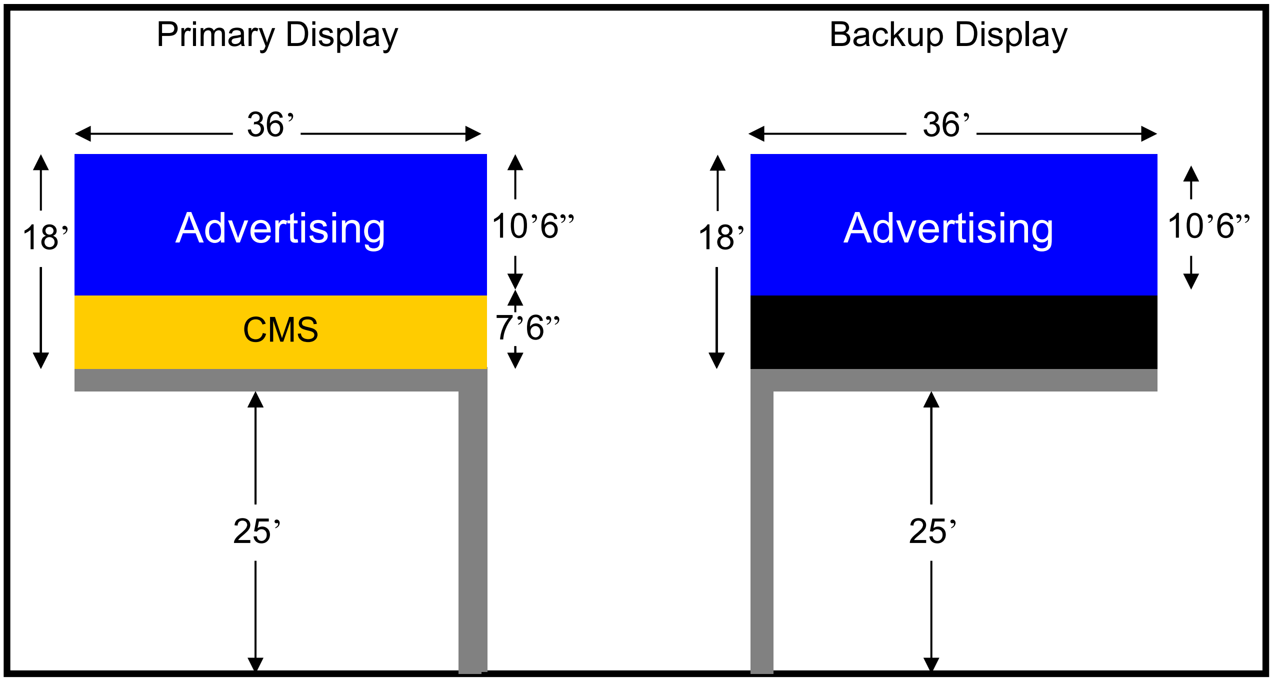
Outdoor Advertising Industry Norm (Advertising Display)

The outdoor advertising industry has adopted the 14' x 48' digital bulletin as its standard digital outdoor advertising display size. A common scaled 'junior bulletin' of 10'6" x 36' is also a standard size in the industry. The current 6'5" x 25' CMS scales approximately to a 7' x 24' display.

Potential Display Configurations

18' x 36' Dual Content Zone Display Structure Configuration

Drawing 1: 18' x 36' Dual Content Display



Dedicated Caltrans Messaging Zone plus Advertising Display Zone
Positives

- Allows CMS messaging to be above or below advertising, can change by site or across network
- Allows for larger emergency message display area
- Dedicated Caltrans message zone
- Maximizes advertising revenue opportunity

Negatives

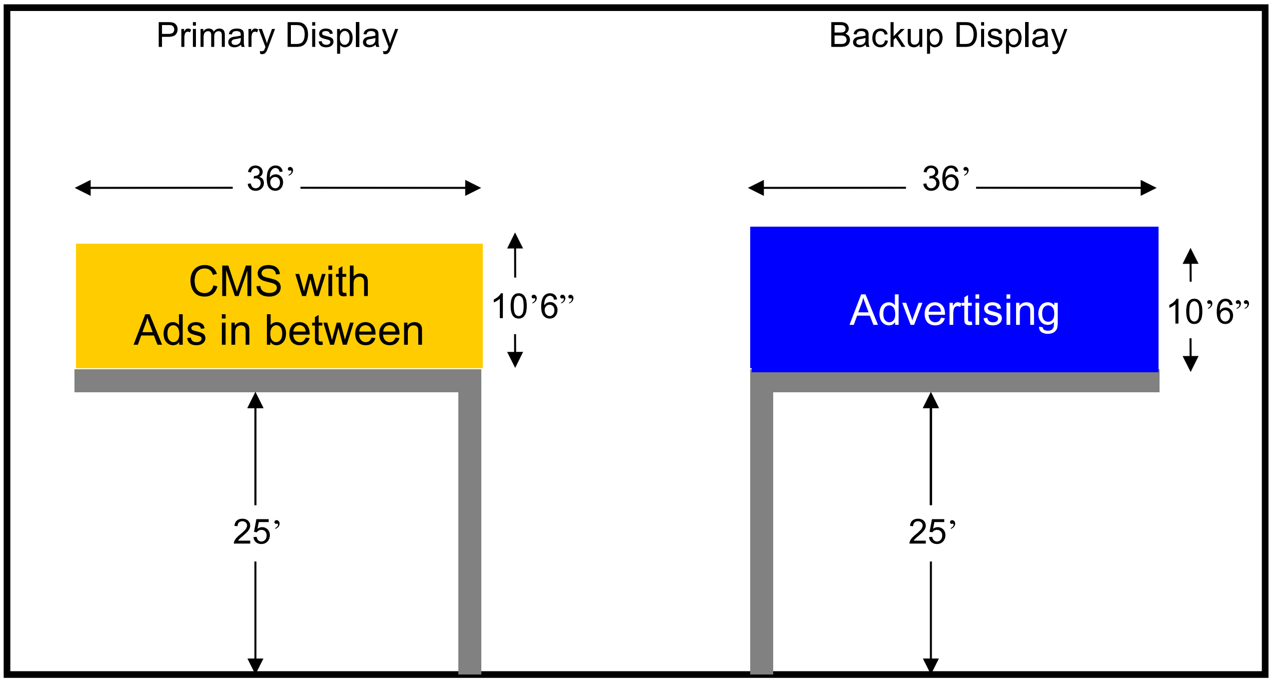
- Greater cost due to larger display and structure
- Potential for driver confusion on applicability of multiple messages

Options

- No backup display
- Scale to 12' x 24'

10’6”’ x 36’ Shared Content Zone Display Structure Configuration

Drawing 2: 10’6” x 36’ Dual Content Display



Primary CMS with advertising during unused time.

Positives

- Cost efficient means to allow for advertising placement at lower-use CMS locations
- Cost efficient means to allow for advertising placement at low advertising demand CMS locations
- Can accommodate all standard advertising and Caltrans messaging format

Negatives

- Reduced or no advertising opportunity if display is significantly or fully committed to travel times or other routine Caltrans messaging

Options

- No backup display
- Scale to 7’ x 24’

Recommendation

For the highest advertising value locations, CMS with advertising display configuration with an 18' x 36' split screen should be considered. This configuration would balance the Caltrans messaging purpose of the CMS with revenue generation opportunities by allowing both initiatives to be served simultaneously during peak traffic periods, which also offer the best advertising revenue opportunities. The primary advertising display area would be 10'6" x 36', and the CMS messaging display area would be 7'6" x 36'. In addition, it is recommended that a 10'6" x 36' backup advertising display be installed if warranted by advertising value.

For nominal advertising value locations, CMS display configuration of either 10'6" x 36' or 7' x 24' with an optional backup display of the same size, should be considered at each site. At these locations Caltrans and the advertising operators can share display time without substantially impairing either the public communications or advertising revenue goals of the CMS program.

Systems Management

Network Security

The secure network should be designed to ensure safeguards to prevent network or site specific intrusion. The custom network should incorporate best practices including:

- User authentication, encryption, and limited user-based rights with inactivity safeguards to limit access and verify identity in a secure manner
- Firewalls, communication encryption, and intrusion protection and detection systems to protect against hacks, spoofs, and other attacks
- Tamper protection and other physical and technology based protections at the display site to alert for a broken connection, unauthorized entry attempt, including shutdown of display until reset by authorized personnel
- As a basic framework concept, the network should be hosted inside a secure Caltrans transportation management center with walled areas of access for district office and public safety stakeholders to place the different categories of travel, safety, and public information messaging. Advertising content and schedules would be created and uploaded by the sales company and routed through Caltrans where they would be authenticated and pushed to the individual displays. All content should be converted to a proprietary format and/or specially encrypted and site-based players programmed to only run the specially coded files. In addition to the user authentication, encryption, and limited user-based rights a special advertising company password protocol should be established that requires frequent changing of complex passwords and periodic active administrative user verification to reduce risk of loading/scheduling of unauthorized content.

Content Management System

Content management systems are computer systems that provide management tools to control digital sign displays from remote location(s). Modern content management systems are highly configurable to enable effective usage of the system in an organized and controlled manner. Through the implementation of a content management system, Caltrans would have the ability to take control of and manage any portion of the CMS network at any time, including the ability to preempt the scheduled content messaging or advertising to display Caltrans emergency messaging.

Caltrans would provide management of the CMS network and the advertising program in the following areas:

- Develop and enforce an advertising content policy
- Install and maintain the equipment required for the content management network
- Create policies and procedures for operator and Caltrans personnel
- Review and approve advertising content as they are submitted by vendors
- Post advertisements to individual locations
- Standardize Caltrans messaging
- Oversee the operational function of each CMS

The operator license agreement could include provisions that contractually allow Caltrans to establish and modify an advertising policy that limits or restricts specific types of content and puts the responsibility for content review and enforcement on the operator under risk of contract termination for non-compliance. The advertising policy would be similar to those in place for existing advertising programs using public assets and could include limitations on non-commercial speech and restrictions on alcohol, firearms, tobacco, and explicit content. The agreement could also include provisions to preempt or override commercial content with emergency messaging.

System Management Tools

Content zone management allows a display to be segmented into different zones with different management hierarchies and approvals, and different group configurations, as if they were a completely different network. This would allow Caltrans to divide a primary facing screen into an independent Caltrans messaging zone and an advertising zone, while reserving the right to override either or both zones for emergency messaging.

Content management systems allow management via secure web connection and can even be accessed remotely by field personnel from a Smartphone. An on-site media player stores content and plays it according to a designated schedule. This method requires that each piece of content only be loaded once and ensures continuous operation in case of a technical glitch in the communication line. Content is loaded in data packets in advance of its first scheduled play and is held for different durations after the schedule is completed. This minimizes bandwidth requirements while keeping control lines available for priority data when it is most likely to be needed and loading in off hours. It would allow Caltrans to pre-load safety messages and to activate them in the scheduler without having to re-transmit the file to the on-site media player from the central control system.

User Profiles

Creating user profiles within the content management system would allow Caltrans to establish a content approval process for internal and advertising messages. This check and balance system would allow a media buyer or an advertising agency to create and load content, a scheduler to program the message, and a manager to approve it to run. User permission or "authority" levels can include content loading, approval, scheduling, auditing (the ability to monitor system activities but not make changes), and removal of content.

A view-only auditing capability would allow Caltrans to designate personnel to monitor what is being displayed on the screens at any time. The system would allow the appointed Caltrans personnel to remove advertising that is not in compliance with Caltrans advertising policy. Multiple user profiles would allow the manager to grant specific rights to specific users for specific signs. For instance, a Caltrans headquarters employee might be allowed to schedule traffic safety messages across the network while a district representative is only allowed to post within a specified district.

Recommendation

A robust modular suite of tools would be required to manage content, systems, and user authorizations to facilitate inter-operability across the 12 district transportation management centers, and allow integration of Caltrans functionality across different networks. Given the fast changing nature of technology a software-as-a-service (SaaS) model is recommended to support upgrades and consistency over time.

Site Selection

CMS Sites

Caltrans has an established protocol for determining its existing and planned CMS site selection. The Caltrans Traffic Operations Program determines the proper location of each permanent CMS before it is designed and installed. The most appropriate locations to install or place a CMS is in advance of major decision points, such as interchanges or intersections, where motorists can respond to specific information displayed on the CMS.

The recommended locations for installation or placement of the CMS, as described in the CMS guidelines are:

- Upstream of major special event facilities (stadiums and convention centers)
- Upstream of locations which may experience severe weather conditions (fog, dust, wind, ice, or snow)
- Upstream of locations where information regarding travel times and delays are appropriate (construction zones and airports)

A CMS should be located so motorists can safely:

- Detect the sign
- Read and understand the sign
- Initiate a response
- Make appropriate decisions based on the information gained from the message

The placement of a CMS is important. A CMS that is too close to a decision point would not provide motorists adequate time to react to the message and would reduce the opportunity to respond. A CMS that is too far in advance of a decision point may reduce the overall impact or recall of the message. The recommended placement of a CMS is one to two miles in advance of a major decision point.

High Value Advertising Sites

To optimize both the public communication and revenue generation potential of the CMS locations, there are several factors and considerations that must be examined.

Key factors include:

Traffic Volume

High traffic volumes contribute to advertising value by increasing public exposure to the advertisements displayed.

Visibility

The length of time a person in a passing car is able to view the display, the position of the display relative to the highway (i.e. above, directly adjacent, adjacent, or offset but visible), and the lack of visual obstructions (i.e. wires, trees, other signs, traffic) all improve the value of a particular site location.

Market

National advertising spending tends to aggregate in larger markets. The country is divided up into statistical regions by the US Census, into television media markets by AC Nielsen (the television audience measurement and ratings supplier), and ranked by outdoor advertising spending on a Designated Market Area (DMA) level by Kantar

Media. Los Angeles (#2), San Francisco (#4), and Sacramento (#21) are three of the largest California outdoor advertising markets as ranked nationally.

Corridors

Selected freeway or interstate corridors are perceived to be more valuable for a combination of tangible and intangible factors, usually related to their prominence in a region or the communities that they connect. The selected demonstration project locations could include CMS locations on landscape designated segments which would require a waiver or exemption from the landscaped freeway restrictions of the OAA. An alternative approach to testing on a single corridor is to select locations throughout the market. This 'scatter' approach could select from non-landscaped locations and make the exemption from the landscaped freeway restriction unnecessary. Using the scatter market approach would dilute the impact of the program and makes testing and sampling more difficult to accomplish. It would spread operations across a larger area, increasing servicing costs, and may reduce the ability to test messaging effectiveness and public response. Restricting locations only to non-landscaped locations could reduce the overall advertising value.

Audience Characteristics

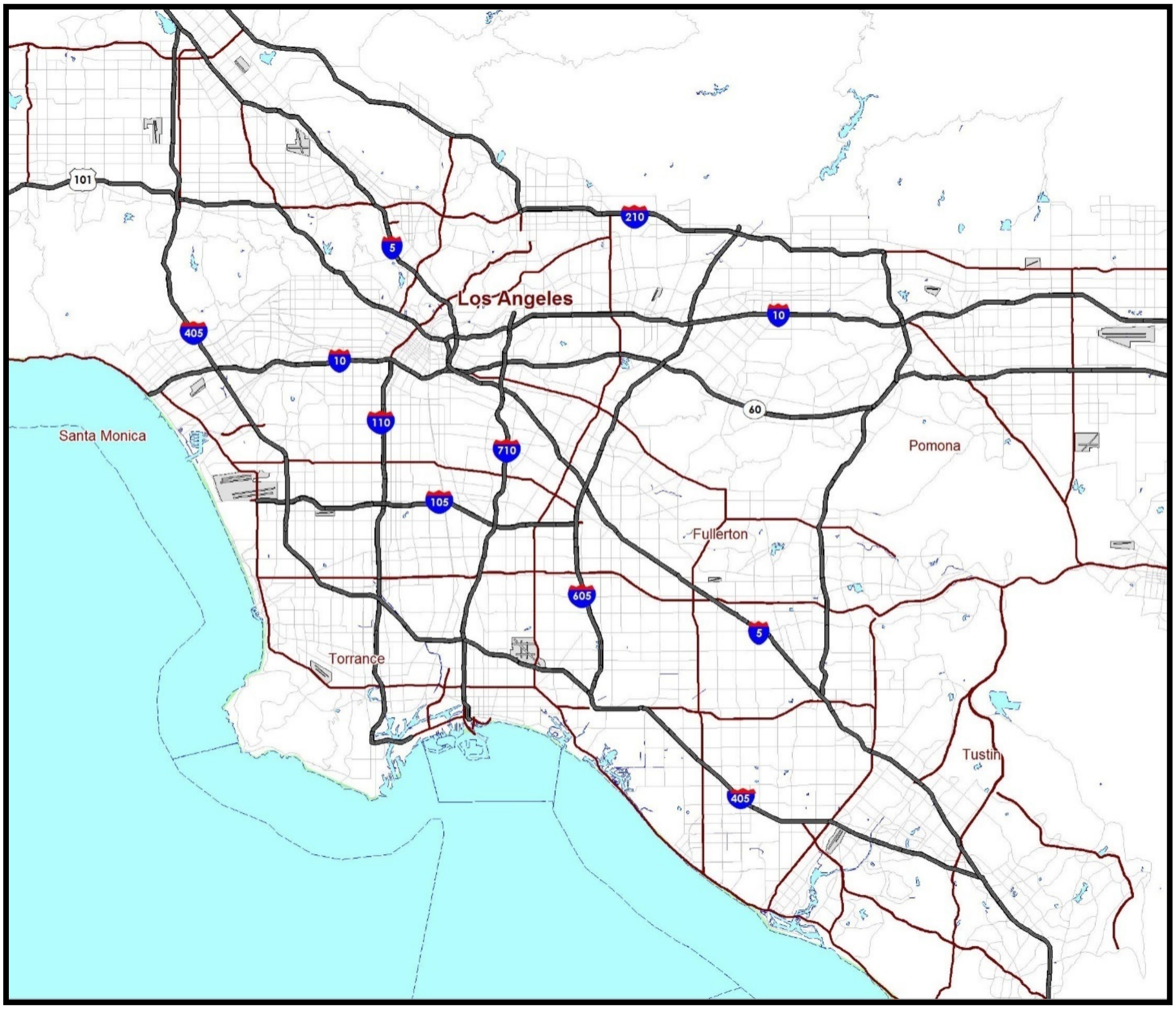
Advertisers like to buy advertising that reaches a large number of individuals with similar demographic, psychographic, and geographic characteristics and would generally pay more for advertising that can be proven to reach their desired audience.

- Demographic – facts including age, income, gender, race, education are all part of a person's demographic profile
- Psychographic – behaviors, propensity to do certain activities or make certain consumer purchases make up a person's psychological profile
- Geographic – home address, office location, highways travelled are elements of an individual's geographic profile

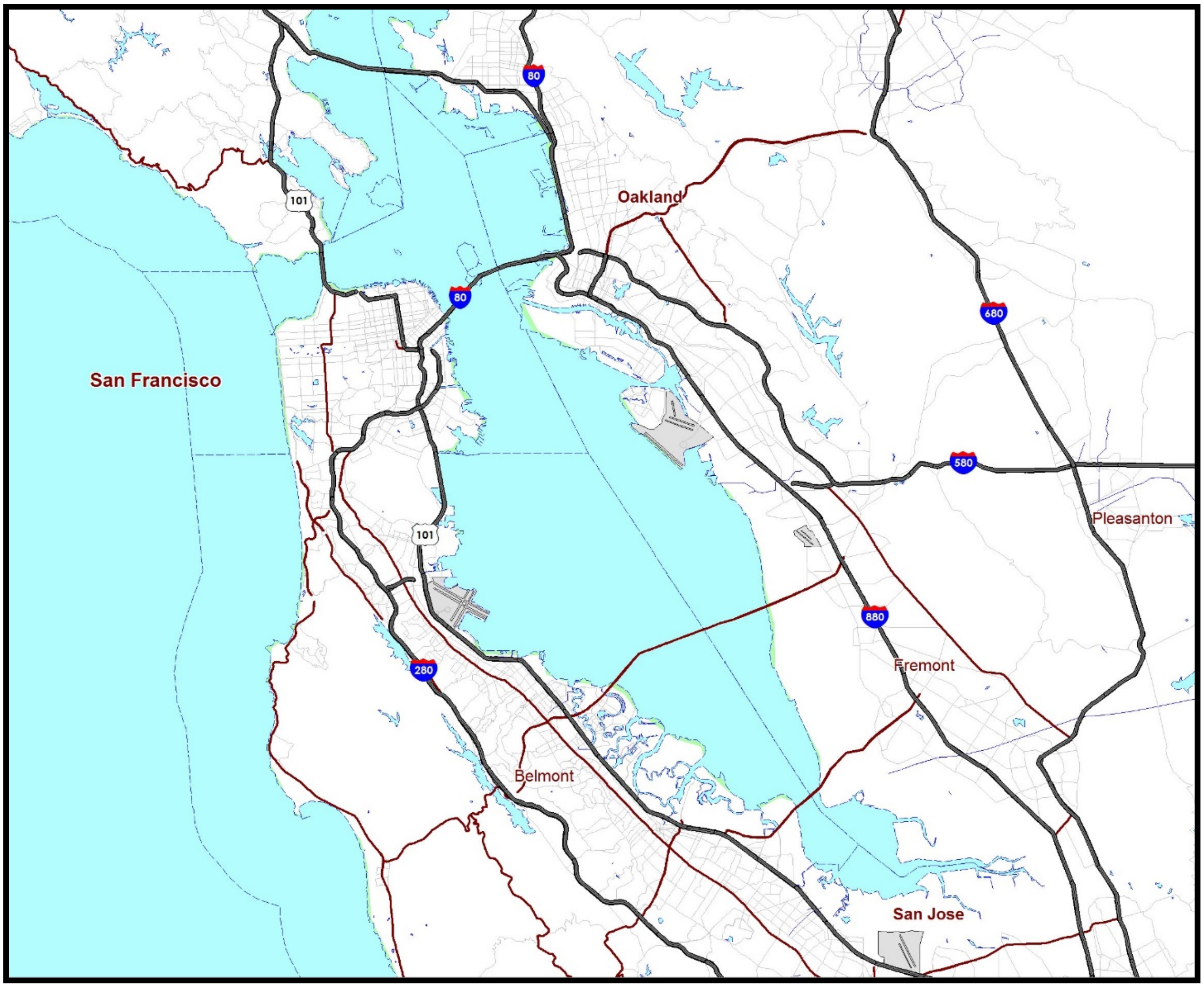
Recommendation

It is recommended to select locations along high traffic corridors in the Los Angeles, San Francisco, and Sacramento markets for the demonstration project. Several highway routes in these markets carry a significant amount of daily commuter traffic and would expose a large number of traveling motorists to the next generation CMS. From the advertising perspective, the corridors in these markets would have the highest demand, generate the most revenue, provide the advertising operator the best return on their investment, and provide Caltrans the best opportunities for revenue generation.

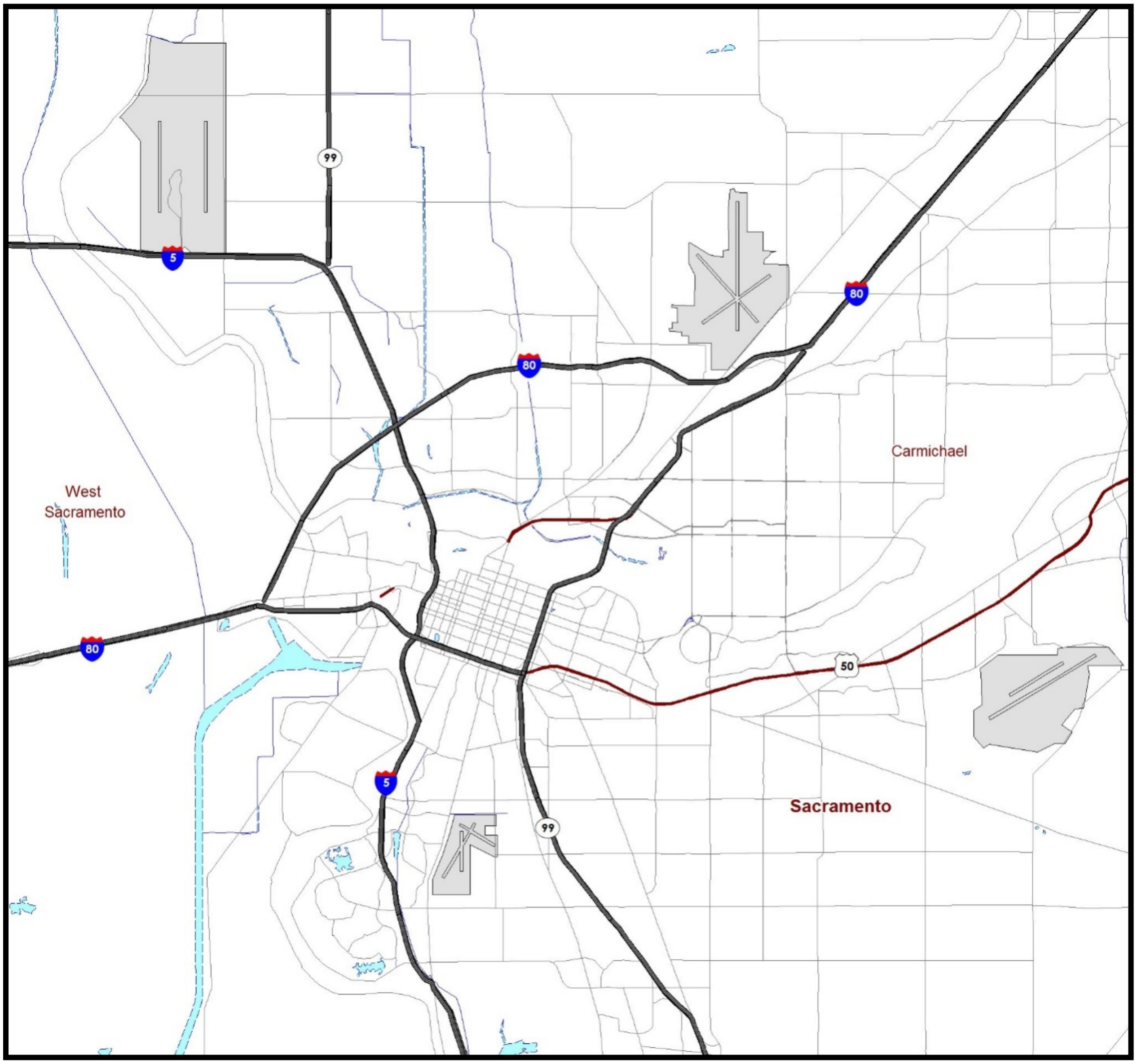
Map 3A: Los Angeles Corridors



Map 3B: San Francisco Bay Area Corridors



Map 3C: Sacramento Corridors



Stakeholders

Several stakeholders should participate in this program and will ultimately dictate the success or failure of the demonstration project. "Stakeholders" refers to both internal and external audiences with interest in this program. A significant local community member outreach effort would need to occur to provide information and to seek feedback about potential concerns regarding blight and other impacts to the community. Internal stakeholders would include Caltrans and partner State agencies. External stakeholders would include the following:

- Local community members and neighborhood associations
- City and County governments
- Outdoor advertising and marketing firms
- Transportation safety-focused organizations
- Corridor preservation groups
- Emergency management and local municipal organizations (AMBER Alerts and Blue Alerts)

Caltrans / State of California

During the planning and implementation of this project, it would be important to have consistent communication by soliciting input, providing insights, and facilitating the interaction with various programs within the Caltrans organization. The goal is to ensure that the project is organized and implemented to meet Caltrans guidelines and objectives.

To ensure successful implementation of the program, it would be beneficial to have direct communication with and between Caltrans programs and other State agencies, such as the California Highway Patrol (CHP) and the Office of Traffic Safety (OTS). Communication with the Caltrans Headquarters Division of Traffic Operations would be important to gain a better understanding of traffic data, permits, signs and work zones, electrical specifications, and traffic information. Caltrans Legislative and Public Affairs would be more involved to assist with communication with the public, other governmental agencies and developing Caltrans communication plans. Lastly, Caltrans Division of Budgets would assist in the analysis, estimates, revenue audits, revenue collection, expense audits, capital expenditures and all financial reporting for the demonstration project.

Federal Highway Administration

FHWA administers the system of federal highway development through financial aid and other programs in determining the framework and direction of highway policy and transportation project funding. FHWA is also responsible for ensuring that states are in compliance with the Federal HBA with regards to the enforcement and regulation of outdoor advertising displays. If a state is found to not be in compliance with the HBA, that state could be subject to a loss of 10 percent of its federal transportation funds. In California, that would equal $354 million for the 2014 federal fiscal year.

Public Entities and Communities

Local communities and organizations in California that may take an interest in the proposed demonstration project and any subsequent build-out program include, but are not limited to:

- Local community members and neighborhood associations
- City and County Governments
    - Local governments, incorporated cities or unincorporated counties, hold permitting rights for outdoor advertising within their jurisdictions and would have an interest in placement of advertising CMS within their boundaries
- League of California Cities
    - The leading advocacy organization for the common interest of California's cities
- California State Association of Counties
    - The association represents California's 58 counties to educate the public on the value and need for county programs and services.
- California Association of Councils of Government
    - The association represents joint powers agreements of cities, counties, and others created as transportation commissions by the State Legislature.
- Association of Bay Area Governments
    - The association provides the San Francisco Bay Area with advocacy, planning, and research to improve the quality of life
- Southern California Association of Governments
    - The association undertakes a variety of planning and policy initiatives to encourage a more sustainable Southern California now and in the future.
- California Alliance for Jobs
    - The organization represents heavy construction companies and union workers to advocate for the responsible investment in public infrastructure projects.
- Local Chambers of Commerce
    - An organization of businesses whose goal is to further the interests of its business members.

Federal, State, and local agencies that would benefit from the community, public safety, and emergency messaging provided in the demonstration project and any subsequent build-out program include:

- United States Department of Homeland Security
- Federal Emergency Management Agency
- Federal Bureau of Investigation
- California Highway Patrol

- Office of Traffic Safety
- County Sheriff Departments
- City Police Departments

Private Industry

Advertising trade associations whose members may take interest in the development of the pilot project and subsequent build-out program include, but are not limited to:

- Outdoor Advertising Association of America
    - The leading trade association representing the outdoor advertising industry to promote, protect and advance the industry's interests.
- California State Outdoor Advertising Association
    - The association provides leadership, services, and standards to promote, protect, and advance the outdoor advertising industry in California.
- American Association of Advertising Agencies
    - A national trade association that represent marketing firms and advertising agencies.
- American Advertising Federation
    - The organization protects and promotes the well-being of advertising through a unique, national coordinated grassroots network of advertisers, agencies, and media companies.
- Traffic Audit Bureau
    - The organization is an independent auditor of traffic circulation for the outdoor advertising industry and develops industry research initiatives for advertisers, agencies, and media companies.

Environmental Advocacy

Environmental and special interest groups that have taken public positions or action to restrict the outdoor advertising industry and may take an interest in the demonstration project include, but are not limited to:

- Scenic America
    - A nonprofit organization that helps citizens safeguard the scenic qualities of America's roadways, countryside, and communities.
- Sierra Club
    - A grassroots environmental organization that works to protect communities, wild places, and the planet itself.
- California Coastal Commission
    - The commission in partnership with coastal cities and counties that plans and regulates the use of land and water in the State's designated coastal zone.
- Various Community Advocacy Groups
    - Scenic East Bay was formed specifically regarding concerns about billboard blight.

Recommendation

A priority of the proposed demonstration project would require proactive communications with all of the involved stakeholders. The goal of the outreach and communications would be to involve all stakeholder in the evaluation of potential benefits and concerns.

Operator Procurement

The procurement process should consider the following common concepts to ensure that the selected advertising operator would deliver the "best value" to the CMS demonstration project. Below are areas that should be measured and evaluated for the development of the Request for Proposal (RFP) and competitive bidding process:

- Minimum marketing and advertising experience
- Project management experience and success
- Experience working with public agencies
- Financial security
- Experience with large construction projects
- Experience with digital technology
- Experience with advertising sales
- Proven success with marketing/advertising programs
- Guarantee build schedules
- Minimum annual guarantee amounts
- Minimum revenue sharing percentages
- Advertising sales estimates

Prior to the RFP being issued, the proposal would be reviewed by Caltrans to ensure that it is in compliance with the California Public Contract Code and the State's competitive bid requirements.

Approaches to Operator Procurement

A significant consideration for evaluation for the program is whether to have a single operator or have multiple operators. The contracting opportunities could be categorized and divided in different ways, some of which could be combined, including regional or market franchises, share of market or network, or an established geographic highway corridor with individual locations. This decision can be made after operator interest and capability can be gauged and analyzed from interest in the demonstration pilot project.

Single RFP Approach

Under a single RFP approach, one RFP would be issued to build and operate the network. Each proposer would be required to submit a proposal for all of the locations. All of the responsive proposals would be evaluated and ranked, and then a single contract would be awarded to the company that was ranked as the highest qualified compliant proposer. From a time and effort standpoint, a single RFP would be the simplest approach and would create a single point of contact to manage and operate the program. The single operator would be able to strategically sell and market the CMS advertising program as the sole provider on this unique opportunity maximizing revenues. The risks of this approach is that it would place all the responsibility with a single entity and might limit potential bidders due to the substantial cost and revenue commitments the operator would have to make.

Split Market (Multiple) RFP Approach

With a split market RFP approach, the CMS network would be divided into groups of locations by market, share of network, or share of market. Due to the need to fund all the CMS locations in the demonstration project, it would be important that all locations be addressed in the RFP packages. Allowing operators to bid on individual locations would not be recommended because operators might compete only for the best of the offered locations. The package of RFPs should be issued at the same time and allow operators to bid on any combination of site pools, but each proposer must be required to make an unconditional financial offer for each separate pool of locations on which it makes a proposal, without tying any proposal for one pool to the acceptance of any other proposal. The proposals would be evaluated and ranked, and a license would be awarded to the proposer whose proposal was highest ranked for that specific pool of locations. While more complex than a single procurement, this model could increase competitive bidding by making it more attractive and affordable for regional or smaller operators to submit proposals, and would potentially distribute risk across multiple operators. A risk of this approach is that it may not generate the highest level of competitive bidding, as some packages may not be perceived to have sufficient value to justify the capital and financial commitments.

Types of Agreements

Agreements between landowners and outdoor advertising operators generally take one of three forms: an operating, a license or a lease agreement. There are many variations to each of these types of agreements, and one form can be made to function similarly to others. The key features of each of these forms of agreement are:

Operating Agreement

An operating agreement would engage the advertising operator as a contractor to operate signs owned by Caltrans, but would not allow the operator to own the signs. An operating agreement would give no ownership to the operator in the outdoor advertising display network. The operating agreement may be preferable to Caltrans because it would own the entire sign infrastructure; however, this lack of ownership of the sign structure, where the operators are paying for the boards, would likely be met with objection from the advertising operators. Requirements for the operator to develop and implement a digital information network connecting the displays could be included in either an operating agreement or a license agreement.

License Agreement

A license agreement would give the outdoor advertising operator permission to build and operate the signs on Caltrans property in accordance with Caltrans requirements while retaining Caltrans underlying real property interest. License agreements typically provide that the terms and conditions of the contract between the parties rather than the property law of leases or easements govern the use by the operator of the landowner's property. A license agreement would reserve broad protections to Caltrans which might be more difficult or impossible to obtain in the context of a lease agreement. A license agreement may permit the sign operator to own the sign or, more like an operating agreement (discussed above), may provide that the landowner owns the sign equipment and the operator merely has permission to operate it.

Lease Agreement

A lease agreement would be for a fixed term and would involve the conveyance of a leasehold interest in real property to the operator. Thus, like a temporary easement, this kind of agreement grants a real property interest. The objectives of this program can be achieved without any material loss of value to Caltrans by utilizing alternative forms of agreement that generally do not grant any interest in the underlying real property to the operator of the signs.

Procurement Timing

If State authorizing legislation is enacted, Caltrans should consider procuring the advertising operator before Federal approval is sought. This could enable the operator to participate in further defining the project details and marshal operator resources to assist in the review and approval processes. The award should be structured to protect Caltrans from obligations beyond selection of the operator for the demonstration project should it proceed and should be predicated upon receipt of all required approvals and a final decision to proceed with the demonstration project.

Additional Operator Agreement Considerations

Caltrans may conclude after evaluation of the demonstration project that an extension of the operator agreement may be necessary to allow for additional study or delays beyond the control of the operator. However, the decision to extend the demonstration project should be solely at Caltrans discretion.

Operator Evaluation

The RFP should be structured to solicit a full spectrum of qualifications so that responses from the bidders may be evaluated for the following five important considerations:

Functionality

The LED displays selected for the next generation CMS network would be required to have full-color capabilities and a sophisticated diagnostics software system to monitor electrical supply, sign status, automatic calibration of pixels, dimming devices for light intensity, and temperature monitoring. A content management system capable of designating specific time-slots for commercial advertising, travel time messages, community messages, and an automatic system override when emergency messaging would be required.

Safety

Each advertising operator and subcontractor should be required to have the appropriate safety training and must be required to comply with all Caltrans safety regulations and other applicable laws.

Revenue

Revenue proposals should include both a minimum annual guarantee payment and a percentage of net sales revenue share to provide Caltrans with a minimum revenue stream and a share of the revenue from the system.

Experience

The successful bidder(s) should demonstrate significant knowledge of the outdoor advertising industry, including the permitting, placement, construction, maintenance, management, and removal of outdoor advertising displays. They also should have expertise in marketing and sales, development of outdoor advertising programs, and experience in assessing and improving outdoor advertising asset values.

Financial Strength

Documentation of each proposer's financial capabilities should be required in the form of audited financial statements. Proposers should be required to demonstrate, at a minimum net worth, market capitalization, and average annual gross sales generated from outdoor advertising over the past three years relative to the number of signs owned or operated by the proposer.

Recommendation

A single approach in the RFP procurement process would be the simplest approach by creating a single advertising operator to manage and operate the demonstration pilot project. The single advertising operator would have the unique opportunity to strategically sell and market the CMS to maximize revenues.

A lease agreement is not recommended because it would convey a lease hold interest to a private outdoor advertising operator on State property that is used for Caltrans operations. Caltrans should negotiate an operating or license agreement with the advertising operator who is procured through the RFP process. The type of agreement selected would depend on review and determination of the preferred format by Caltrans legal counsel. The agreement should include a Caltrans option to extend the demonstration project, if warranted.

REVENUE POTENTIAL AND PROGRAM COSTS FORECAST

Financial Assumptions

The Caltrans CMS pilot project will be a unique project with no exact comparative programs that use the same types of assets which are supported by advertising revenues. However, several of the program aspects are similar to current outdoor advertising assets being operated across the State that provide a benchmark to analyze the potential program assets and apply assumptions and projections to the CMS program assets based on those similar outdoor advertising standards.

Key assumptions in modeling the CMS pilot program projections include:

Advertising Revenue

Factors that affect the advertising revenue produced from a display within the program include:

- Traffic Volume - High traffic volumes contribute to advertising value by increasing public exposure to the advertisements displayed.
- Visibility - The length of time a person in a passing car is able to view the display, the position of the display relative to the highway (i.e. above, directly adjacent, adjacent, or offset but visible), and the lack of visual obstructions (i.e. wires, trees, other signs, traffic) all improve the value of a particular site location.
- Market - National advertising spending tends to aggregate in larger markets. The country is divided up into statistical regions by the US Census, into television media markets by AC Nielsen (the television audience measurement and ratings supplier), and ranked by outdoor advertising spending by Kantar Media. Los Angeles (#2), San Francisco (#4), San Diego (#19), and Sacramento (#20) are the four largest California outdoor advertising markets as ranked nationally.
- Corridors - Selected freeway or interstate corridors are perceived to be more valuable for a combination of tangible and intangible factors, usually related to their prominence in a region or the communities that they connect.
- Audience Characteristics - Advertisers like to buy advertising that reaches a large number of individuals with similar demographic, psychographic, and geographic characteristics and would generally pay more for advertising that can be proven to reach their desired audience.
    - Demographic – facts including age, income, gender, race, and education are all part of a person's demographic profile
    - Psychographic – behaviors, propensity to do certain activities or make certain consumer purchases make up a person's psychological profile
    - Geographic – home address, office location, and highways travelled are elements of an individual's geographic profile
- Competition – Multiple signs in a condensed area can lead to price competition and reduce value of any one display.
- Ability to Permit – If new signs are restricted in the immediate vicinity, then any increase in demand could result in increase in sales price and therefore value.

- Display Size – Standard size displays are often worth more than odd-size displays and standard bulletin (14’ x 48’) displays are often worth disproportionally more than standard poster (12’ x 25’) displays.
- Display Type – For high value locations, a digital display can be worth disproportionally more than a tri-vision or traditional static display.

The advertising revenue rate assumptions are based upon the current outdoor advertising environment in the California market. The factors noted above were reviewed for potential impacts on advertising revenue rates based upon the assets and structure build assumptions described in this report. In addition, advertising rates from a number of California outdoor advertising companies and comparative revenue rate data from advertising media buyers were analyzed to establish market advertising rates for the projections.

Outdoor advertising is commonly sold in multiples of four-week increments. Estimated individual four-week advertising rates for each type of structure, each size of display, individual markets, and the potential advertising demand for the assets were established from the different operator rates and media buyer valuation assessments.

Digital outdoor advertising is an in-demand medium with sustaining demand growth supporting ongoing growth in digital outdoor advertising inventory. The signs contemplated in this program could be premium digital displays and would be in demand by advertisers. The addition of the number of signs over the period of time contemplated in this program is not expected to materially change the per sign revenue projections or materially affect revenue or impact the demand curve for digital outdoor advertising displays.

The annual advertising revenue projections are based on several factors including the estimated individual advertising rates, the number of displays, the types of displays, the estimated advertising occupancy for each asset class, and other factors within the existing California outdoor advertising environments. The projections of the annual advertising revenue are based upon factors commonly used by the outdoor advertising industry to create pro forma revenue outlooks.

Capital Expenditures

The CMS pilot program could incur significant costs related to the identification, development, construction, erection, and other site development costs related to capital expenditures (Capex). For this report, Capex estimates were established through discussions with several vendors that currently build, erect, and install outdoor advertising signage. Technical characteristics of digital signage currently in the marketplace were reviewed. Potential construction aspects were analyzed, and Caltrans construction requirements were factored in the estimates. Finally, multiple quotes for each type of cost were secured in order to estimate the Capex for each type of structure described within this report. The selected operator should be expected to fund any capital expenditures to upgrade or replace signs or technology components during the life of the agreement.

Construction Schedules

The projections include estimated timelines for installation of structures. These construction schedule estimates are based upon the type of structure being developed, the geographic locations of those builds, the benefits of individual structures to Caltrans, the potential limitations of vendors, and other factors.

Cash Flow Projections to Caltrans

Part of the projection is an estimate of the amount of potential payments that the State may receive from the program. The industry standard for billboard agreements is between 20 and 30 percent of the gross advertising revenue. However, because of the unique location and high volume of traveling public viewing the CMS, Caltrans may be able to receive between 50 percent to 60 percent of the net advertising revenue.

Demonstration Project Advertising Supported CMS Network Projection

Estimated Cash Flows (1,000's):

		Year 1	Year 2	Year 3	Year 4
Total Advertising Revenue		$ 16,635	$ 19,469	$ 19,955	$ 20,454
Capex Recovery By Vendor	100%	$ 2,543	$ 2,543	$ 2,543	$ 2,543
Caltrans Payment					
Estimated Annual Share to Caltrans @	50%	$ 8,046	$ 8,463	$ 8,706	$ 8,956
Estimated Annual Share to Vendor		$ 8,046	$ 8,463	$ 8,706	$ 8,956
Estimated Annual Share to Caltrans @	60%	$ 9,655	$ 10,155	$ 10,447	$ 10,747
Estimated Annual Share to Vendor		$ 6,437	$ 6,770	$ 6,965	$ 7,164

Projected Capex and Inventory Overview:

	Year 1	Year 2	Year 3	Year 4
Beginning Structures	--	25	25	25
Add New Structures	25	--	--	--
Ending Structures	25	25	25	25
Beginning Advertising Faces	--	35	35	35
Add New Advertising Faces	35	--	--	--
Ending Advertising Faces	35	35	35	35
Beginning Non-Advertising Faces	--	--	--	--
Add New Non-Advertising Faces	--	--	--	--
Ending Non-Advertising Faces	--	--	--	--
	--	--	--	--
Beginning New Build Cap-Ex	--	$ 10,173	$ 10,173	$ 10,173
Additional New Build Cap-Ex	$ 10,173	--	--	--
Ending New Build Cap-Ex	$ 10,173	$ 10,173	$ 10,173	$ 10,173
Beginning Refresh Faces Cap-Ex	--	--	--	--
Additional Refresh Faces Cap-Ex	--	--	--	--
Ending Refresh Faces Cap-Ex	--	--	--	--

SUMMARY OF RECOMMENDATIONS

Regulation and Rules

In order to execute the demonstration project, State authorizing legislation and federal approval is required. The demonstration project cannot move forward without these two approvals.

As part of the regulatory approval process, a waiver or exemption is required from certain provisions of Title 23 of the United State Code, Federal/State agreements, the Bonus Act, and the California OAA to allow advertising on the CMS. These exemptions would be required to allow advertising inside the right-of-way, for spacing near other changeable message displays and outdoor advertising displays, and potential placement with respect to zoning requirements.

The potential of securing these waivers and exemptions would be dependent upon the local community and stakeholder support of the program.

Display Configuration

An 18’ x 36’ split screen primary display with 10’6” x 36’ backup display should be considered for use in high value advertising CMS demonstration locations. The 18’ x 36’ primary display would be split into two content zones, a dedicated 7’6” x 36’ Caltrans messaging zone and a 10’6” x 36’ advertising zone. This configuration would provide for a full-time screen to carry travel time, traffic alerts, safety announcements and all routine Caltrans messaging, and would provide two industry standard ‘junior bulletin’ size advertising displays to increase revenue potential.

The demonstration pilot project would include testing of alternate sizes and configurations of signs to allow for live field testing of a smaller 12’ x 24’ display. The Caltrans messaging zone of 5’ x 24’ approximates the current CMS standard, and the advertising zone maintains the aspect ratio of a junior bulletin but scales it down to a size that may not test as well with advertisers as they are accustomed to, and willing to pay more for, the larger size. A smaller display size could reduce revenue from the pilot program.

The larger CMS would provide for the same Caltrans messaging content it currently displays while allowing the development and testing of new CMS content to include full color and graphics capabilities. Caltrans would preempt all advertising content at any time for emergency messaging with full use of the entire display space.

The primary purpose of the CMS is to provide travel time, traffic alerts, and safety messages. The shared screen option that allows advertising when the display is not used for Caltrans messaging purposes may reduce available advertising time, eliminate locations that are dedicated to full time travel time display, and use significant portions of peak travel time for traffic alerts. An advertising operator would need to know with a high level of certainty what amount of time is going to be available for advertising in order to sell the space.

The backup display was added for consideration to the configuration to take advantage of the potential highest advertising value locations where the CMS structure is visible to opposing, or cross traffic. It is common practice in the outdoor advertising industry to build back-to-back signs on a single structure as it reduces site development cost and maximizes the revenue potential from each site.

Signs that are not identified as valuable advertising locations due to Federal restrictions or low advertising demand should be considered to be designed as small scaled, 7' x 24' display configurations. This would allow the implementation of full feature CMS, which could include promotional and safety messaging. The display could accept advertising should Caltrans and the advertising operator(s) choose to enable the site for shared display time and commercial advertising.

Systems Management

Digital signage management tools are rapidly evolving, becoming more robust, providing greater flexibility and expanded options to scale, and manage a large network of displays. Appropriate network requirements should be developed and the chosen hardware and software tool set is scalable and flexible to meet Caltrans current and projected management needs. The systems and content management solutions should have built-in fail-safes, redundancy, security, and functionality to integrate across divisions, districts, and networks to provide a consistent message interface between Caltrans and the public. A cloud based SaaS model should support network evolution and growth.

Site Selection

Actual CMS locations are selected by Caltrans for the benefit of the CMS program. For the demonstration pilot project, a corridor approach should be considered to test the program. The corridors should include potential high value advertising locations, factoring traffic volumes, viewing time, advertiser demand for the market and route, and audience characteristics for the area and route. The corridor approach includes building out of all locations in a corridor with the next generation CMS, including alternative display configurations in each market. Building out an entire corridor would reflect how the program could look if fully implemented, it would provide a more consistent and complete sample for safety study and analysis, and would allow the advertising company to test advertising demand and rate sensitivity in a controlled environment. A corridor approach would also expedite installation and reduce operation costs by minimizing travel time.

Stakeholders

A comprehensive, well-executed communications plan is necessary. Stakeholders need to be involved in the assessment of the pilot program, and would require proactive communication from Caltrans and local entities.

Operator Procurement

Contracting a single operator for the demonstration project under a license agreement or operating agreement gives Caltrans the greatest control and flexibility over the overall program. Due to the important communications aspect of the network and the location of displays in operating right-of-way, it is critical that Caltrans retain the property rights that would otherwise be relinquished in a lease agreement or easement. The operator would enjoy the opportunity to sell advertising at unique and high value locations otherwise unavailable to them at a market acceptable profit margin. Caltrans should include options in the advertising operator license agreement to extend the demonstration project with the operator.

Given the complex nature of the CMS demonstration project and the corridor concentration, multiple operators are not recommended. Introducing multiple operators at this stage adds layers of complexity to managing the installation, operating the network, and studying of safety.

The demonstration project should include a capital infrastructure investment recovery schedule for the operator as well as the terms and process for early termination should that occur. Once capital expenditure is recovered, the fee structure should include a minimum annual guarantee with periodic step ups against a revenue share payment, and capital commitments to build new structures and upgrade technology over the life of the project. The guarantee could protect Caltrans on the downside, allow for predictable budgeting, and provide a baseline for securitizing a revenue bond, should Caltrans choose to do so. The revenue share ensures upside participation for Caltrans. All financial terms would be subject to market and competitive pressures and should be negotiated to maximize the yield to Caltrans.

The agreement should contain standard provisions that allow for termination at the end of the demonstration phase, for early termination by Caltrans for safety concerns or non-performance at any time, maintenance and capital upgrade commitments, contain operating requirements, obligations, and covenants, and retain certain usage rights to Caltrans such as the use of a percentage of display time, rights to unsold time, and emergency message override rights.

PHASING PLAN

Site Selection

A demonstration project of 25 CMS locations would allow these units to be installed quickly to create a sample base to test different display configurations, ensure no safety impacts to the traveling public, and monitor factors affecting operation of the system.

The CMS would be installed at locations along corridors in the Los Angeles, San Francisco, and Sacramento markets. Testing in these three major markets should provide a sufficiently broad base for the demonstration pilot to assess the potential market revenue. This corridor approach would show impacts in a confined area and allow for the estimation of impacts that could be expected. Each site is subject to a formal design review for service and access. In any event, the selected operator would work with Caltrans to prioritize and develop an installation schedule. It will be necessary to prioritize advertising locations to the early installations in order to initiate the revenue stream that would provide cash flow to fund installation.

When the finalized site selection and planning and approval processes are completed, which is projected to take up to one year, it is anticipated that the initial phase of the CMS demonstration project would be installed and be fully operational within eight to 12 months. On average, a general contractor would be able to install four new CMS per crew, per month. Prior to any contractor performing work in the right-of-way, a complete safety crew training and oversight program would need to be implemented.

Site Development

A modular design approach that uses standard components with a limited number of alternate configurations would expedite supply chain management and installation. Each site would have a development plan identifying what needs to be done to prepare the site for installation of the CMS and removal of the old CMS, if applicable in accordance with Caltrans requirements. Each site plan would identify required work to conform the site to Caltrans standard specifications including guardrail and pullout or alternate access for installation and servicing of the site, source and connection of electrical connection, any necessary foundation studies, etc. Any locations requiring specialized installations such as suspended under an overpass or relocation would be separately tracked for resolution before placement in the design and build schedule.

Operator Procurement

If State authorizing legislation is enacted, Caltrans should consider procuring the advertising operator before Federal approval is sought. This could ensure that the advertising operator can support the approval process and prepare for the installation of the CMS and related systems. An exclusive option to extend the demonstration project if necessary for completion of the required studies should be considered. If these approvals are not obtained, Caltrans should ensure that its contract provides minimal exposure to the State.

Sign Construction

Once the site has been identified and developed, all necessary waivers and exemptions are received, and the operator is procured, the operator could construct the sign and enter it into revenue service. The installation process typically follows six steps:

- Site preparation
- Excavation
- Foundation
- Structure erection
- Display head installation
- Electrical connection

Project Oversight

Operational Oversight

Ongoing operational oversight would ensure safe installation and operation of signs. Appropriate resources, including personnel, should be accounted for in legislation or the State budget. Vendors, suppliers, installers, and operators require management and oversight to:

- Audit insurance compliance
- Audit safety compliance
- Review performance reporting from vendor(s)
- Review operational functionality of network

Financial Oversight

The operator would be required to provide financial documents, subject to audit and inspection as part of the financial oversight to:

- Verify the advertising revenue from the vendor(s)
- Audit vendor(s) advertising revenue reporting
- Match revenue reports to advertising placement records on signs
- Audit capital expenses

- Audit operating expenses
- Ensure proper payment from vendor(s)
- Audit compliance of vendor(s) contractual agreements

Communication and Coordination Oversight

Ongoing information management and the coordination of activities by Caltrans and the advertising operator would be necessary, which involves the following items:

- Communicating with the State Legislature and local community stakeholders
- Communicating with other public agencies
- Advertising content policy compliance
- Periodic maintenance inspections
- Technology sign display upgrades and improvements

CONCLUSION

Hundreds of millions of dollars are spent annually in California to advertise on outdoor advertising displays adjacent to freeways, highways, and surface streets throughout the state. Outdoor advertising operators and landlords generate revenue from these displays that are not on Caltrans infrastructure. The demonstration pilot project would provide the ability to evaluate the viability for Caltrans to garner financing opportunities for the CMS system to provide better information to the public while sharing in the revenue that is already being generated next to Caltrans' right-of-way. Advertising space on the CMS network could draw existing and incremental advertising revenue from current advertisers and attract new advertisers to the medium because of the desirable audience.

There are considerable challenges in pursuing this concept, the most notable being no State or federal authority to move forward. Several State and federal waivers and exemptions are required to undertake even a pilot. If these waivers and exemptions are secured, a phased four-year demonstration project of 25 CMS in Los Angeles, San Francisco, and Sacramento would provide the best test case for the concept. This effort would require significant stakeholder engagement with local community members and groups. The demonstration pilot project would evaluate any safety impacts to the traveling public, operational impacts to the transportation system and the potential viability of the revenue generating capability. The demonstration pilot project would cost $10.2 million to build and $500,000 annually to operate, which would be fully recovered from advertising revenue, and provide projected average net revenue to Caltrans of $8.5 million to $10.2 million over the four-year project. Specific language will be provided in the contract to address the terms and process if Caltrans were to terminate the demonstration pilot project early.

Caltrans concludes, therefore, a demonstration pilot project is feasible, given the necessary approvals and authorities are received, to assess the revenue potential of the next generation CMS, their safety and operational impacts, and their effectiveness in raising revenue and whether an upgraded system could deliver enhanced traffic, safety, and messaging alerts to California's motorists in a prudent manner. The demonstration pilot would inform the use of advertising CMS but regardless of the results, would not guarantee pursuing further authority beyond the pilot program.

Appendix A Cleveland Study

Arbitron Custom Research Report

Arbitron Digital Billboard Report: Cleveland Case Study

Presented by:

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Introduction

Welcome to Arbitron's evaluation of digital highway billboards. This survey is designed to measure travelers' awareness and attitudes towards digital billboards on major highways and to gauge their level of engagement with billboard advertising messages.

Some significant findings of the research include:

* More than half of all Cleveland travelers notice digital billboards and the more a person commutes, the more likely they are to be aware of the displays.
* Public reaction to digital signage is positive. The billboard's ability to display timely news, traffic, weather advisories and AMBER Alert notices makes the vast majority of commuters (over 80%) feel the digital signs provide an important community service.
* Digital billboards are an effective advertising platform. Over eight out of 10 travelers could successfully recall at least one of the ads running during the survey period and the majority of commuters agree digital billboards are a "cool way to advertise."

Description of Methodology

This case study focuses on seven digital billboards operating in Cleveland, OH. The digital displays are located on four interstate highways in the Cleveland, OH, area: I-77, I-90, I-271 and I-480.

Arbitron Inc. conducted random digit dial (RDD) interviews between November 27 and December 3, 2007, with 402 persons 18 years of age and older in the Cleveland, OH, Arbitron-defined Metro. To qualify for the survey, respondents had to have traveled in a vehicle (car, truck, bus or taxi) on I-77, I-90, I-271 or I-480 in the 30 days preceding the survey period.

The study was designed and conducted by Arbitron Inc. on behalf of the Outdoor Advertising Association of America. Data were weighed to reflect census figures and factored in the likelihood of each demographic group qualifying for the survey based on the above mentioned "roads traveled" screening criteria.

Digital Billboard Locations

1. **I-271:** west side, 125 feet south of Solon Road (facing north)
2. **I-480:** south side, 2 miles east of I-71 (facing east)
3. **I-90 (Innerbelt Freeway):** south side, 100 feet east of West 3rd Street (facing south)
4. **I-77:** west side, 0.3 miles south of Pershing Avenue (facing north)
5. **I-90:** south side, 70 feet east of West 55th Street (facing west)
6. **I-90:** south side, 0.5 miles west of Eddy Road (facing east)
7. **I-480:** north side, 0.5 miles east of Broadway (facing east)

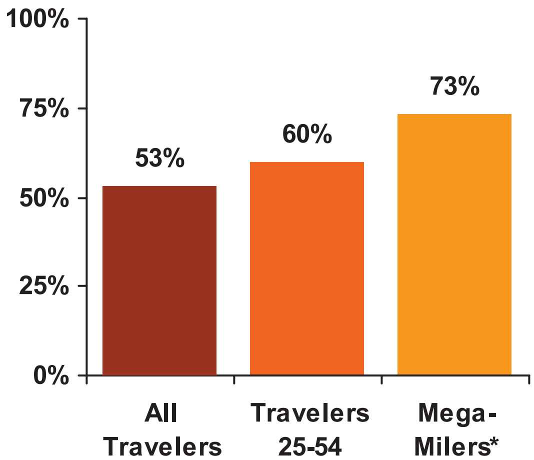
Key Findings

I. Digital Billboard Viewership and Engagement

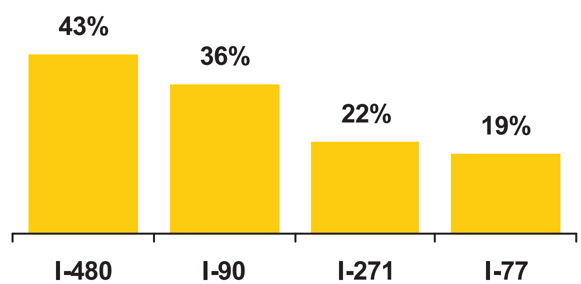
More Than Half of Cleveland Highway Travelers Noticed Digital Billboards in the Past Month

"One specific type of billboard is called digital billboards. These digital roadside billboards repeatedly change advertising messages electronically every eight seconds."

"Have you noticed any digital billboards in the Cleveland area in the past 30 days?"



"Do you recall ever seeing digital billboards on any of the following highways?"



Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

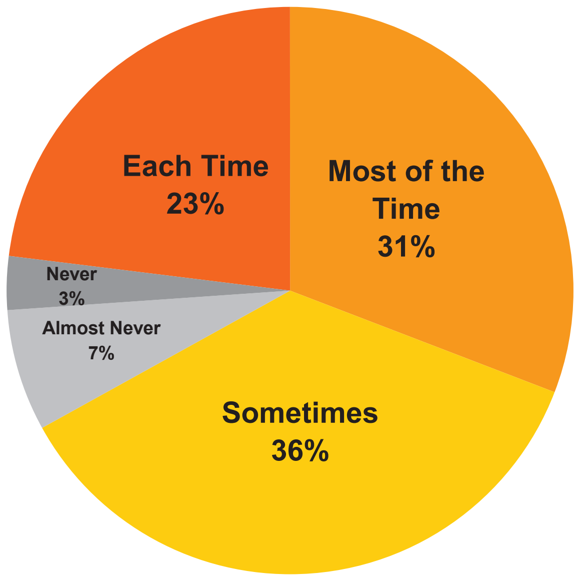
* *Mega-milers are those heavy commuters who travel 200 miles or more per week; they represent 30% of all Cleveland travelers.*

More than half of Cleveland highway travelers noticed digital billboards in the past month. Fifty-three percent of Cleveland Metro residents who traveled in a car, truck, bus or taxi on Interstate 77, 271, 480 or 90 in the past month noticed digital billboards on those roads. The core adult traveler demographic of 25- to 54-year-olds showed an increased awareness of digital billboards, with six in 10 (60%) noticing one in the past month.

Awareness of digital billboards increased with frequency of travel. Seventy-three percent of the heaviest commuters, known as mega-milers, recalled seeing at least one of these electronic displays during the past month.

Nine Out of 10 Digital Billboard Viewers Notice the Advertising Some, Most or Each Time They Pass a Board

"How often do you notice the advertising messages on digital billboards?"



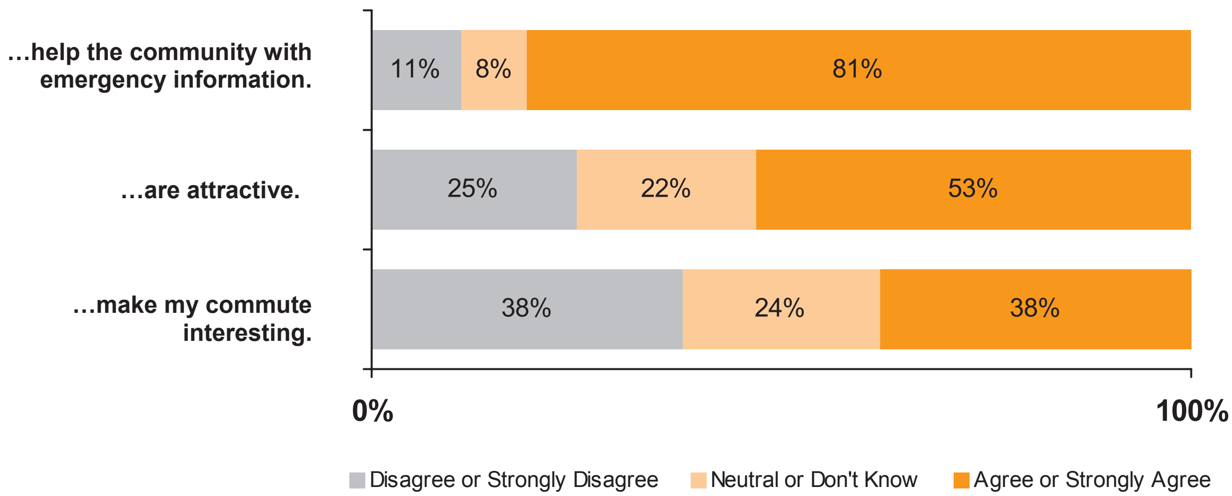
Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

Nearly all travelers who notice digital billboards look at the advertising messages at least some of the time. Ninety percent of respondents who notice digital billboards said they also note the advertising messages on them either sometimes, most of the time or each time. Nearly one-quarter of viewers say they notice the advertising message *each time* they see a digital billboard.

The Majority of Digital Billboard Viewers Find the Signs to Be Attractive and Helpful to the Community

"Now using a 5-point scale where a '1' means you 'strongly disagree' and '5' means you 'strongly agree,' how much do you disagree or agree with the following statements? You can also use a 2, 3, or 4 if you feel somewhere in between."

Digital billboards…



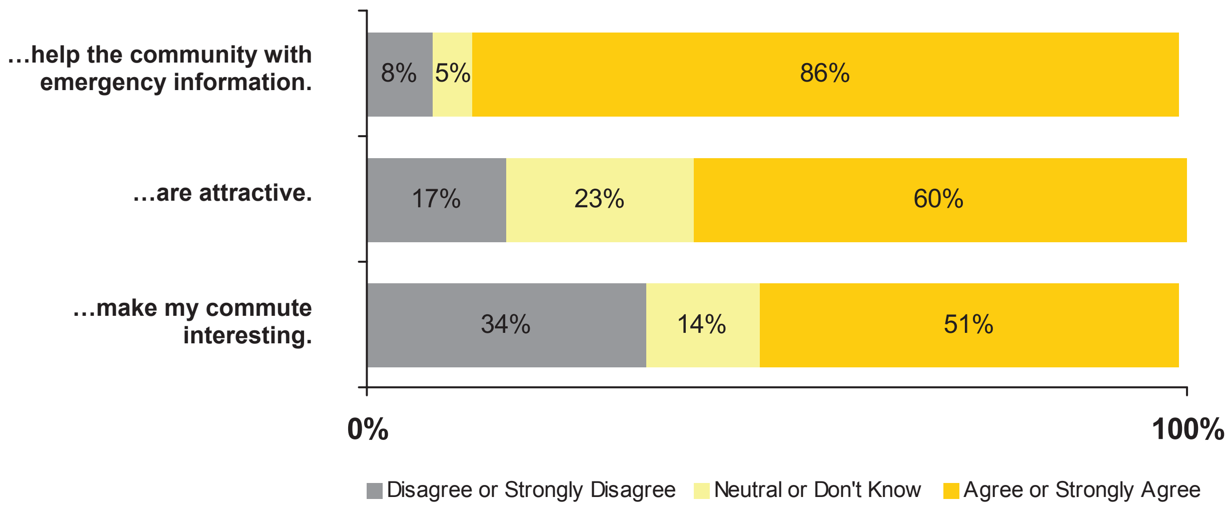
Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

Viewers strongly find digital billboards helpful in providing information about community emergencies. More than four out of five travelers (81%) who notice digital billboards think the signs help their community by providing important and timely emergency information, such as AMBER Alerts. More than half of viewers (53%) think the digital billboards are attractive, and 38% think the signs make their commute more interesting.

Young Adult Breakout: 18-to 34-Year-Old Travelers Have an Especially Positive Attitude Towards Digital Billboards

“Now using a 5-point scale where a ‘1’ means you ‘strongly disagree’ and ‘5’ means you ‘strongly agree,’ how much do you disagree or agree with the following statements? You can also use a 2, 3, or 4 if you feel somewhere in between.”

Digital billboards…



Base: Persons 18 to 34 years old living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.
Note: Totals subject to rounding.

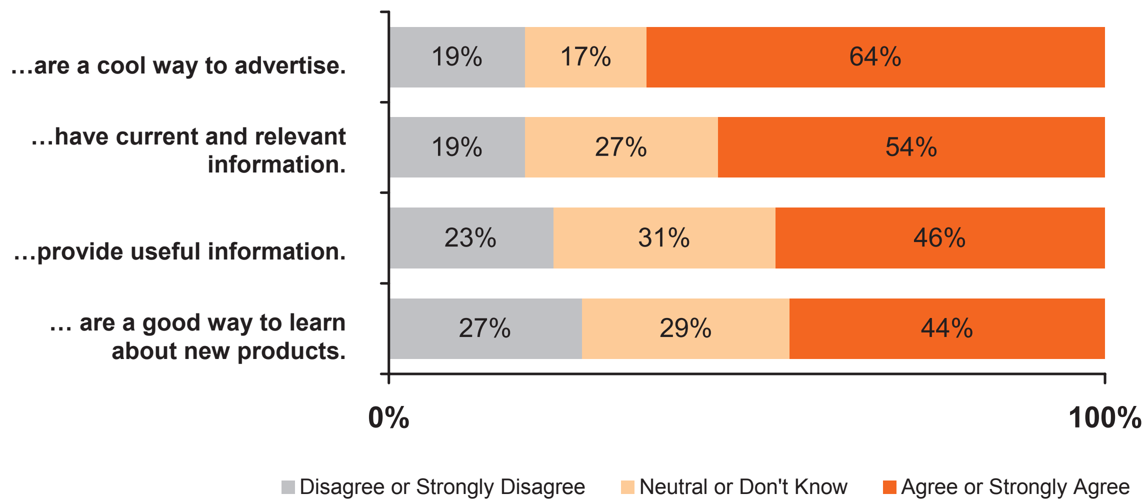
Young adults 18-34 have especially positive feelings about digital billboards. Eighty-six percent of young adults think digital billboards help their community with timely emergency information and six in 10 (60%) think digital billboards are attractive. Digital billboards make commuting more interesting for over half (51%) of young adults.

II. Digital Billboard Advertising Acceptance and Recall

Most Digital Billboard Viewers Have Positive Attitudes Toward the Advertising Messages

"Now using a 5-point scale where a '1' means you 'strongly disagree' and '5' means you 'strongly agree,' how much do you disagree or agree with the following statements? You can also use a 2, 3, or 4 if you feel somewhere in between."

Digital billboards…



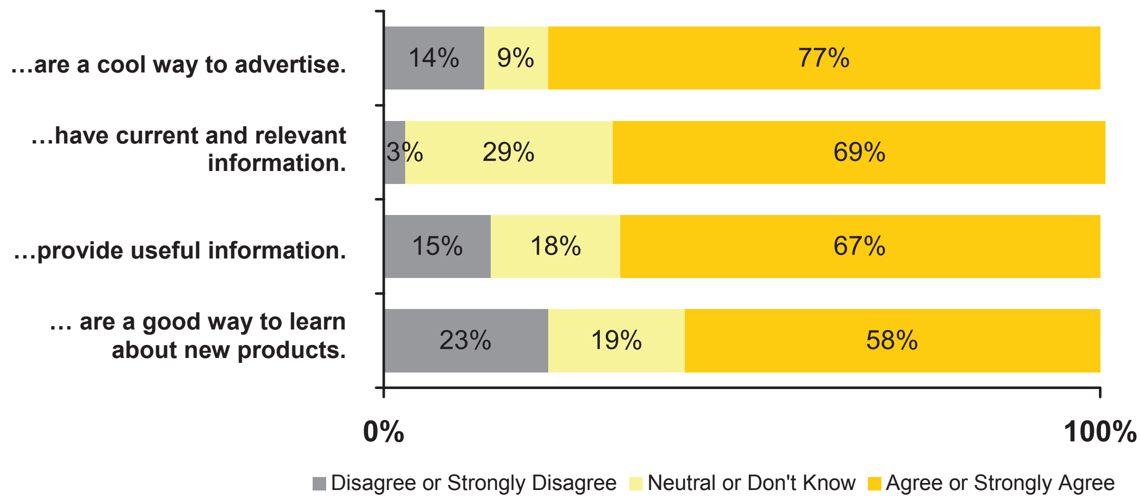
Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

Nearly two out of three viewers think digital billboards are a "cool way to advertise." Sixty-four percent of those who notice the digital billboards think the signs are a "cool way to advertise." More than half (54%) of viewers think the signs display "current and relevant information," and 46% think they "provide useful information." Forty-four percent of travelers feel digital billboards are a "good way to learn about new products."

Young Adult Breakout: 18-to 34-Year-Old Travelers Have Especially Positive Attitudes Toward Advertising Messages on Digital Billboards

"Now using a 5-point scale where a '1' means you 'strongly disagree' and '5' means you 'strongly agree,' how much do you disagree or agree with the following statements? You can also use a 2, 3, or 4 if you feel somewhere in between."

Digital billboards…



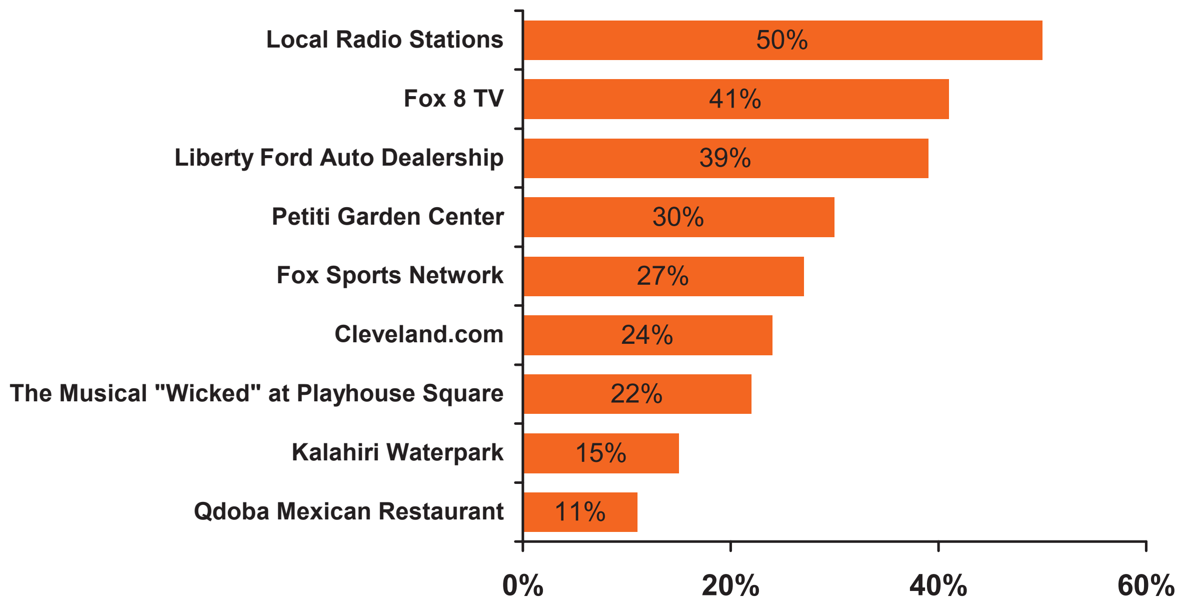
Base: Persons 18 to 34 years old living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

Note: Totals subject to rounding.

More than three-quarters of young adults think digital billboards are "a cool way to advertise." Seventy-seven percent of young adults 18-34 who notice the digital billboards feel the signs "are a cool way to advertise." Sixty-nine percent of young adults think the signs display "current and relevant information," and 67% think they "provide useful information." Fifty-eight percent of young adults feel digital billboards are a "good way to learn about new products."

The Local Radio Stations, a Local TV Channel and an Auto Dealership Generated the Highest Brand-Aided Advertising Recall

"Do you remember seeing messages for any of the following on digital billboards?"

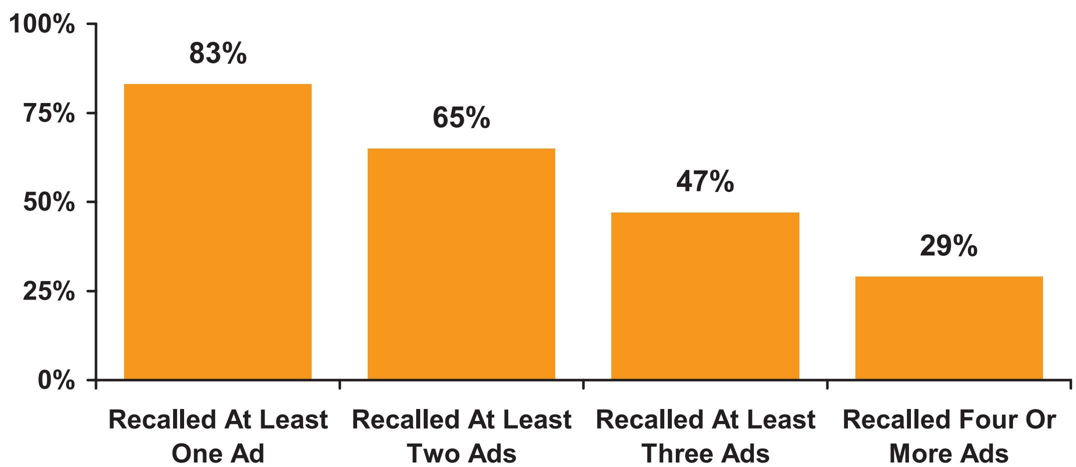


Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

Recall of specific brands of advertising on the digital billboards ranged from 50% to 11%. One out of two (50%) travelers who noticed digital billboards recalled seeing the specific ads for local radio stations that were running in the market during the survey period, and 41% remembered seeing the ad for the local Fox TV affiliate. The recall across all nine advertisers averaged 29%.

The Majority of Digital Billboard Viewers Recalled, on a Brand-Aided Basis, at Least One Advertisement

"Do you remember seeing messages for any of the following on digital billboards?"



Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days.

More than eight out of 10 viewers recalled at least one of the advertisements currently running on the digital billboards in Cleveland. Eighty-three percent of those who noticed the digital billboards recalled, on a brand-aided basis, at least one of the nine advertisements currently running, and 65% of viewers recalled at least two.

Something to Talk About

Nearly One in Five Viewers Discussed an Ad Seen on a Digital Billboard with Other People

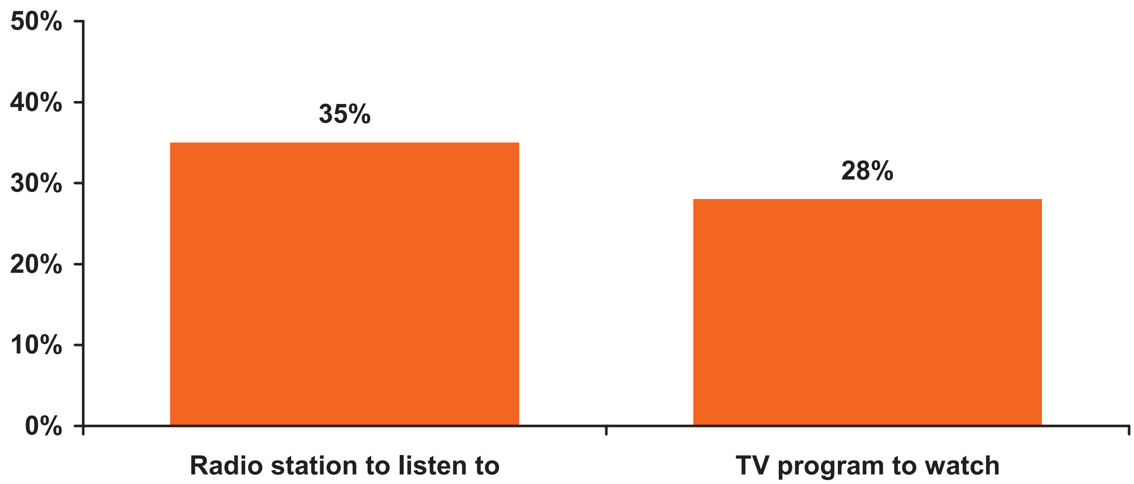
"Now I would like to ask you about some things you learned from seeing digital billboards. Have you ever seen something funny that you talked about with others that day?"

Nineteen percent of travelers who recalled a specific ad on the digital billboards said they talked about the advertising message with their family, friends or coworkers that day.

Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days and recalled at least one ad.

More Than One-Third of Digital Billboard Viewers Learned About a TV Show or Radio Station from the Signs

"Now I would like to ask you about some things you learned from seeing digital billboards. Have you ever noted a…?"

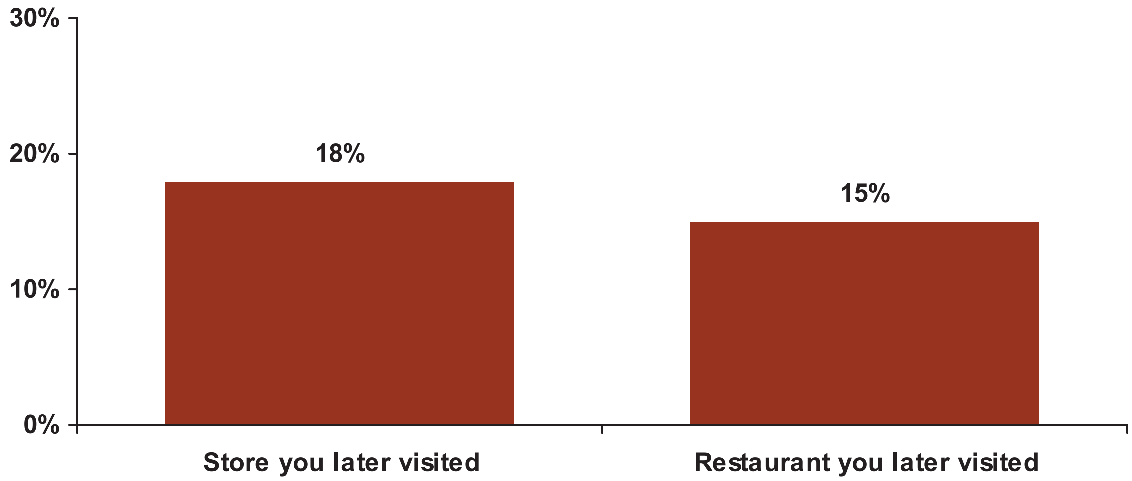


Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days and noticed the digital billboards.

Digital billboards can drive traffic to other media. Thirty-five percent of travelers who noticed digital billboards noted a radio station message they saw on a digital billboard, and 28% of viewers noted a television program to watch.

Digital Billboards Drive Traffic to Local Businesses

"Now I would like to ask you about some things you learned from seeing digital billboards. Have you ever learned about a…?"



Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days and noticed the digital billboards.

Nearly one in five viewers were motivated to visit a store after seeing an advertisement for the store on a digital billboard. Eighteen percent of travelers who noticed the digital billboards learned about a store they later visited, and 15% of viewers learned about a restaurant they later visited.

Getting the Word Out on Special Events

Nearly Two of Five Viewers Learned About an Event They Were Interested in Attending From a Digital Billboard

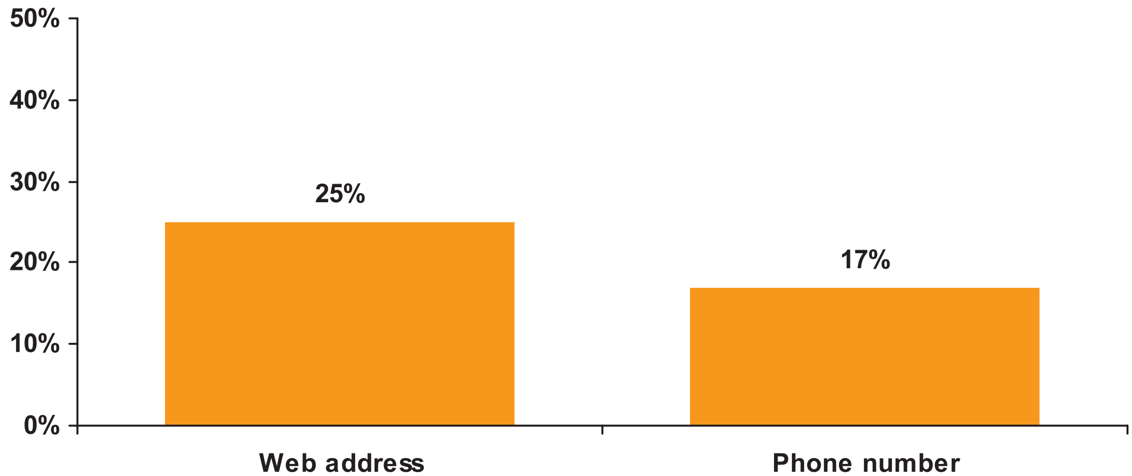
"Now I would like to ask you about some things you learn from seeing digital billboards. Have you ever learned about an event you were interested in?"

Thirty-nine percent of travelers who noticed the digital billboards learned about an event that they were interested in attending.

Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days and noticed the digital billboards.

Digital Billboards Prompt Viewers to Learn More About a Brand Through Phone Numbers and Web Addresses

"Now I would like to ask you about some things you learned from seeing digital billboards. Have you ever noted a…?"



Base: Persons 18 years or older living in the Cleveland, OH, Metro area who traveled on I-77, I-90, I-271 or I-480 in the past 30 days and noticed the digital billboards.

One-quarter of viewers noted an advertiser's Web address displayed on a digital billboard. Twenty-five percent of travelers who noticed digital billboards noted the Web site address of an advertiser, and 17% noted an advertiser's phone number.

Appendix A

Travel Habits of Cleveland Metro Residents

Cleveland highway travelers in the past week

- 87% drove themselves.
- 58% traveled in a car or truck as a passenger.
- 17% carpooled to or from work either as a driver or as a passenger.
- 10% took a bus.
- Average total miles traveled: 200 (median 105).

Cleveland work commuters

- Commuters traveled an average of 16 miles one way.
- Almost half (45%) traveled for 10 to 30 minutes one way, and 36% traveled over a half hour each way.

Appendix B

Demographic Profile of Cleveland Travelers

	Cleveland Residents[1]	Cleveland Highway Travelers	Travelers Who Noticed Digital Billboards
Gender			
Men	48%	49%[2]	50%[2]
Women	52%	51%	50%
Age			
18–24	12%	13%	7%
25–34	16%	16%	18%
35–44	18%	19%	23%
45–54	20%	22%	24%
55–64	15%	14%	19%
65+	19%	16%	9%
Employment Status			
Employed full-time	47%	55%	65%
Employed part-time	18%	13%	11%
Retired	18%	19%	13%
Homemaker	8%	5%	4%
Unemployed	4%	5%	5%
Student	3%	3%	1%
Income			
$50K+	49%	58%	54%
$75K+	28%	33%	32%
Ethnicity			
White	86%	74%	76%
African-American	12%	18%	15%
Hispanic/Latino	3%	3%	3%

[1]*Data in this column are from Scarborough 12-Month Survey (March '06–February '07).*

[2]*How to read: Forty-nine percent (49%) of the Cleveland residents who traveled on Cleveland highways in the past 30 days are male, and 50% of those travelers who noticed digital billboards are male.*

Note: Totals subject to rounding. All sections do not add up to 100% because some respondents declined to answer certain demographic questions.

Appendix C

Demographic Profile of Cleveland Travelers by Miles Traveled in the Past Seven Days

	Cleveland Highway Travelers	Light Travelers (Fewer than 75 Miles) *33% of sample*	Medium Travelers (75-200 Miles) *34% of sample*	Mega-Milers (200+ Miles) *30% of sample*
Gender				
Men	49%[1]	43%[1]	47%	59%
Women	51%	57%	53%	41%
Age				
18–24	13%	16%	11%	13%
25–34	16%	13%	17%	20%
35–44	19%	14%	18%	25%
45–54	22%	17%	26%	22%
55–64	14%	15%	15%	13%
65+	16%	25%	14%	8%
Employment Status				
Employed full-time	55%	34%	60%	77%
Employed part-time	13%	17%	13%	8%
Retired	19%	28%	18%	7%
Homemaker	5%	8%	4%	3%
Unemployed	5%	9%	3%	1%
Student	3%	3%	2%	4%
Income				
$50K+ HHI	58%	46%	60%	70%
$75K+ HHI	33%	20%	33%	48%
Ethnicity				
White	74%	69%	81%	77%
African-American	18%	23%	13%	16%
Hispanic/Latino	3%	4%	2%	2%

[1]*How to read: Forty-nine percent (49%) of the Cleveland residents who traveled on Cleveland highways in the past 30 days are male, and 43% of light travelers are male.*

Note: Totals subject to rounding. All sections do not add up to 100% because some respondents declined to answer certain demographic questions.

About Outdoor Advertising Association of America (OAAA)

The Outdoor Advertising Association of America is the lead trade association representing the outdoor advertising industry. Founded in 1891, OAAA is dedicated to uniting, promoting, protecting and advancing outdoor advertising interests in the U.S. With nearly 1,100 member companies, OAAA represents more than 90% of industry revenues.

**Information supplied by OAAA.*

About Arbitron Inc.

Arbitron Inc. (NYSE: ARB) is an international media and marketing research firm serving the media—radio, television, cable, online radio and out-of-home—as well as advertisers and advertising agencies in the United States and Europe. Arbitron's core businesses are measuring network and local market radio audiences across the United States; surveying the retail, media and product patterns of local market consumers; and providing application software used for analyzing media audience and marketing information data. The Company has developed the Portable People Meter™, a new technology for media and marketing research, which has been selected as one of *Time* magazine's "Best Inventions of 2007."

Arbitron's marketing and business units are supported by a world-renowned research and technology organization located in Columbia, Maryland. Arbitron has approximately 1,900 employees; its executive offices are located in New York City.

Through its Scarborough Research joint venture with The Nielsen Company, Arbitron provides additional media and marketing research services to the broadcast television, newspaper and online industries.

Arbitron's Out-of-Home division provides training, consumer shopping data and audience profiles for out-of-home media. Currently, more than 100 out-of-home plants/place-based media and thousands of media industry clients—agencies, advertisers, stations, marketers and networks—utilize Arbitron and Scarborough consumer behavior information and software.

Credible third-party measurement helps advertisers justify their investment in the medium. The Company's 50+ years of audience measurement experience help sellers focus on selling the value of their advertising rather than justifying the credibility of their measurement. Arbitron research studies about cinema advertising, the outdoor industry and traditional and nontraditional media can be found on the Company's Web site at www.arbitron.com and can be downloaded free of charge.

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Appendix B FHWA Study

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

SEPTEMBER 2012

U.S. Department of Transportation
Federal Highway Administration

FHWA-HEP-

FOREWORD

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

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

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

Nelson Castellanos
Director, Office of Real Estate
Services

TECHNICAL DOCUMENTATION PAGE

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FHWA-HRT-		

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

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

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

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

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

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

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

APPROXIMATE CONVERSIONS FROM SI UNITS

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

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

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LIST OF ACRONYMS AND SYMBOLS

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

EXECUTIVE SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Do drivers look at CEVMS more than at standard billboards?

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

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

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

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

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

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

INTRODUCTION

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

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

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

BACKGROUND

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

Post-Hoc Crash Studies

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

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

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

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

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

Field Investigations

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

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

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

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

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

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

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

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

Laboratory Studies

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

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

Summary

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

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

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

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

STUDY APPROACH

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

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

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

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

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

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

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

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

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

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

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

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

Research Questions

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

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

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

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

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

EXPERIMENTAL APPROACH

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

Figure 1. Eye tracking system camera placement.

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

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

Figure 2. FHWA's field research vehicle.

EXPERIMENTAL DESIGN OVERVIEW

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

Site Selection

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

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

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

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

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

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

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

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

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

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

READING

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

METHOD

Selection of Data Collection Zone Limits

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

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

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

Advertising Conditions

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

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

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

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

Table 2. Inventory of target billboards with relevant parameters.

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

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

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

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

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

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

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

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

Photometric Measurement of Signs

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

Photometric Equipment

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

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

Measurement Methodology

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

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

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

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

Visual Complexity

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

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

Participants

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

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

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

Procedures

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

Pre-Data Collection Activities

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

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

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

Practice

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

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

Data Collection

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

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

Debriefing

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

DATA REDUCTION

Eye Tracking Measures

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

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

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

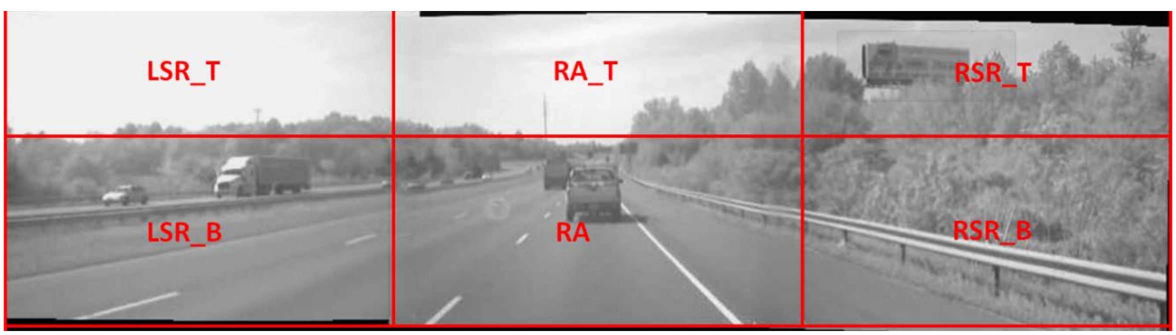

Figure 9. Screen capture showing static ROIs on a scene video output.

The following ROIs were defined with the analysis software:

Static ROIs

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

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

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

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

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

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

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

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

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

Dynamic ROIs

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

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

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

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

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

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

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

Other Measures

Driving Behavior Measures

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

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

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

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

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

Level of Service Estimates

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

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

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

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

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

Vehicle Speed

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

RESULTS

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

Photometric Measurements

Luminance

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

Contrast

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

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

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

Visual Complexity

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

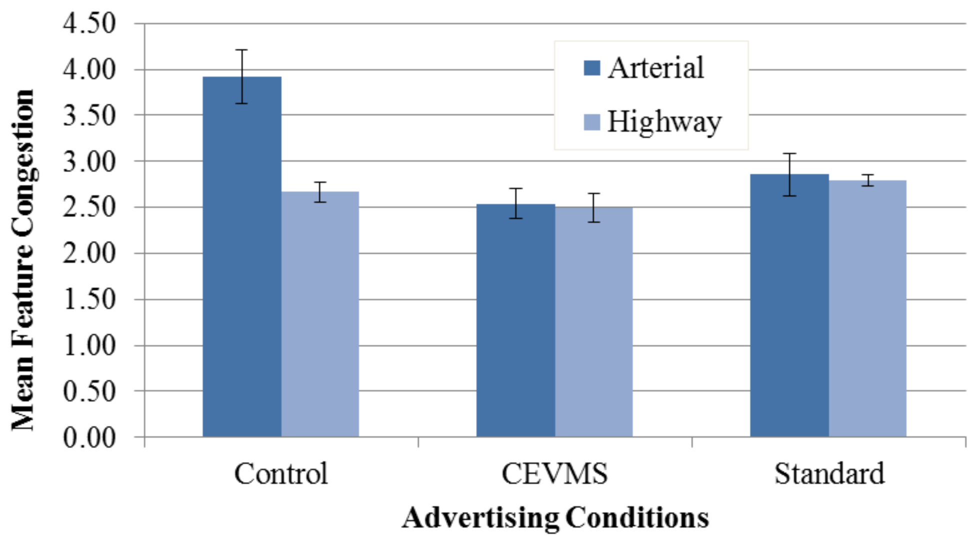

Figure 10. Mean feature congestion as a function of advertising condition and road type (standard errors for the mean are included in the graph).

Effects of Billboards on Gazes to the Road Ahead

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

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

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

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

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

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

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

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

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

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

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

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

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

Fixations to CEVMS and Standard Billboards

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

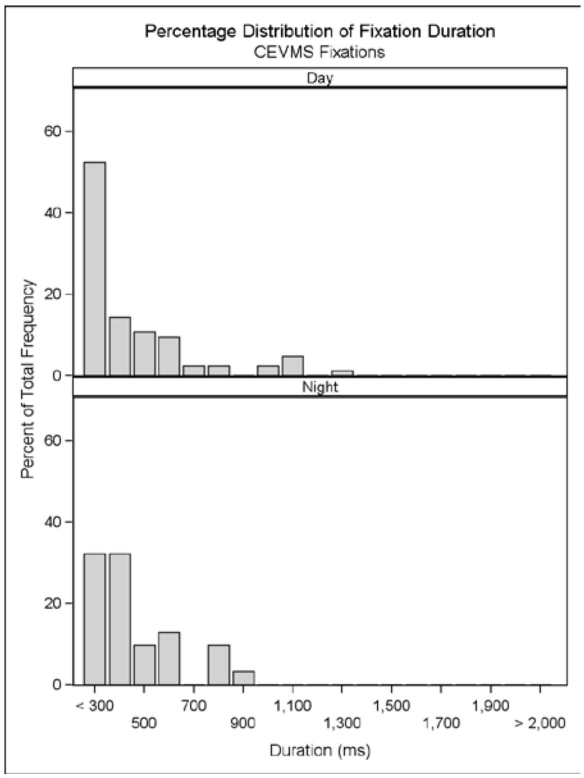

Figure 11. Distribution of fixation duration for CEVMS in the daytime and nighttime.

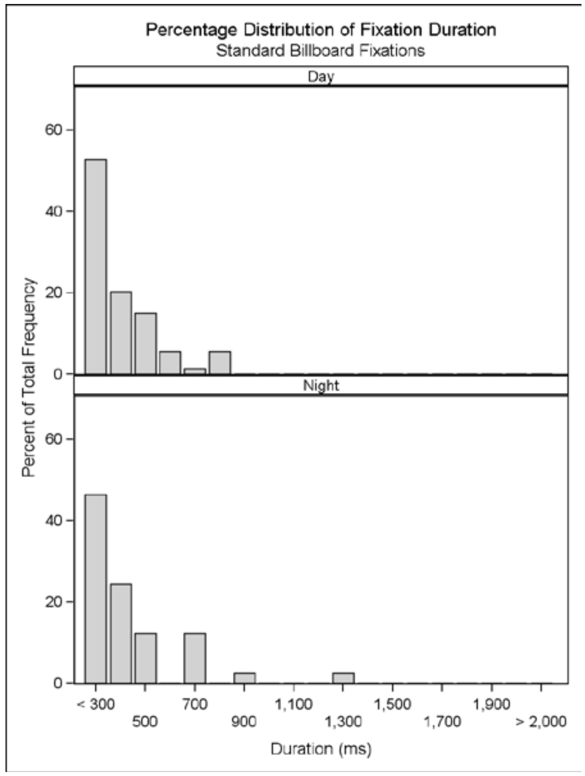

Figure 12. Distribution of fixation duration for standard billboards in the daytime and nighttime.

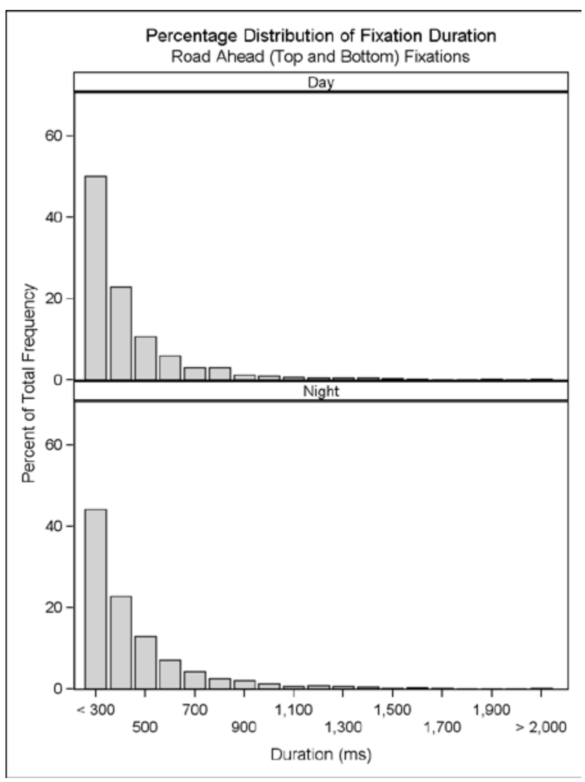

Figure 13. Distribution of fixation duration for road ahead (i.e., top and bottom road ahead ROIs) in the daytime and nighttime.

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

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

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

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

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

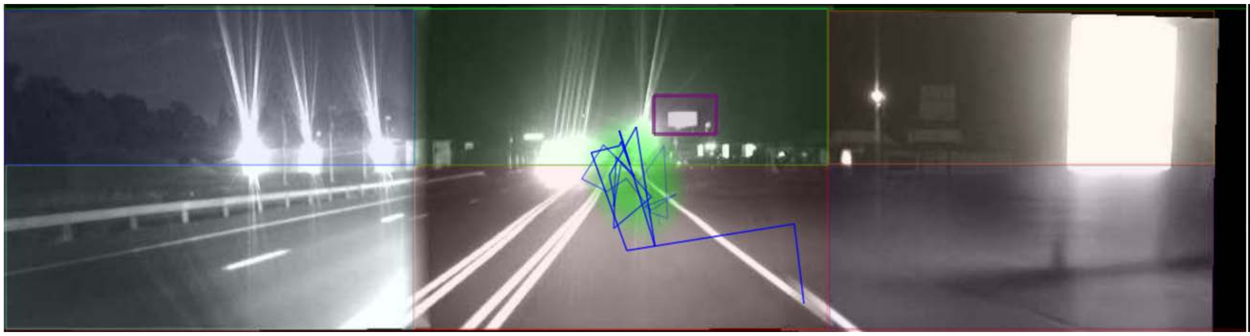

Figure 14. Heat map for the start of a DCZ for a standard billboard at night on an arterial.

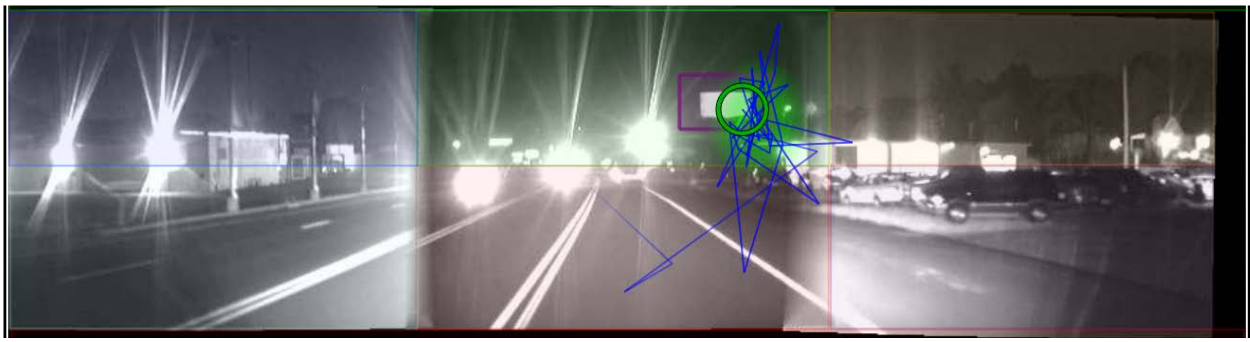

Figure 15. Heat map for the middle of a DCZ for a standard billboard at night on an arterial.

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

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

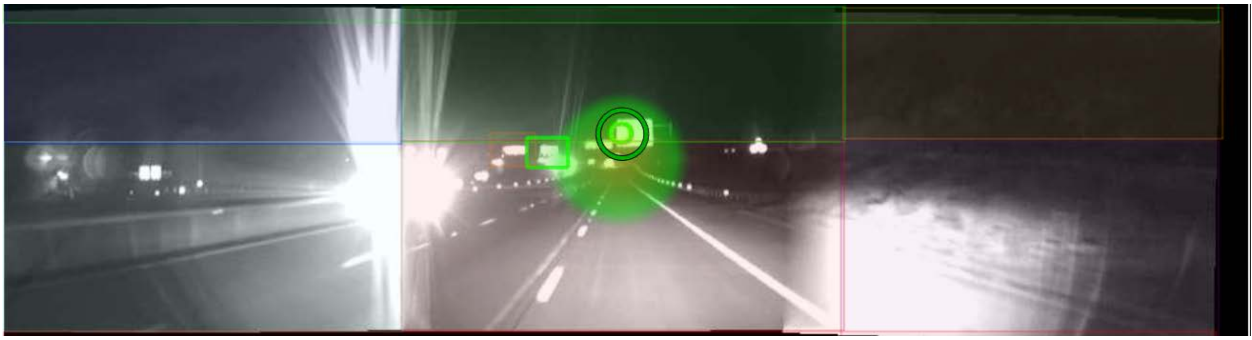

Figure 17. Heat map for start of a DCZ for a standard billboard at night on a freeway.

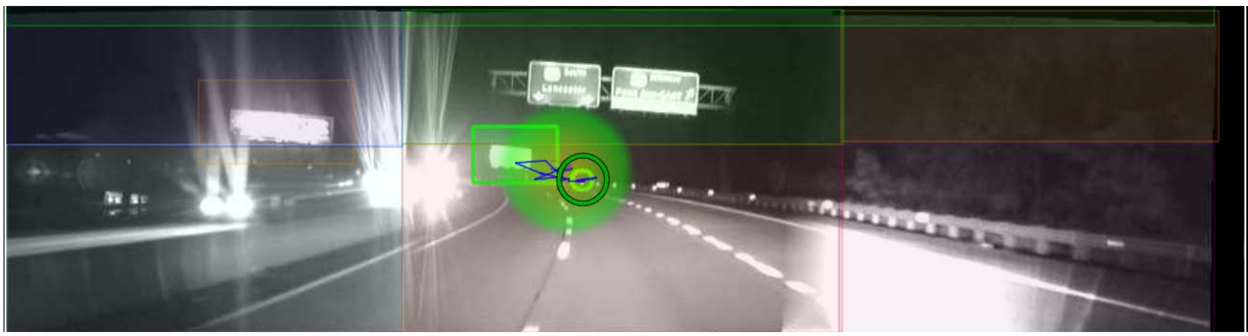

Figure 18. Heat map for middle of a DCZ for a standard billboard at night on a freeway.

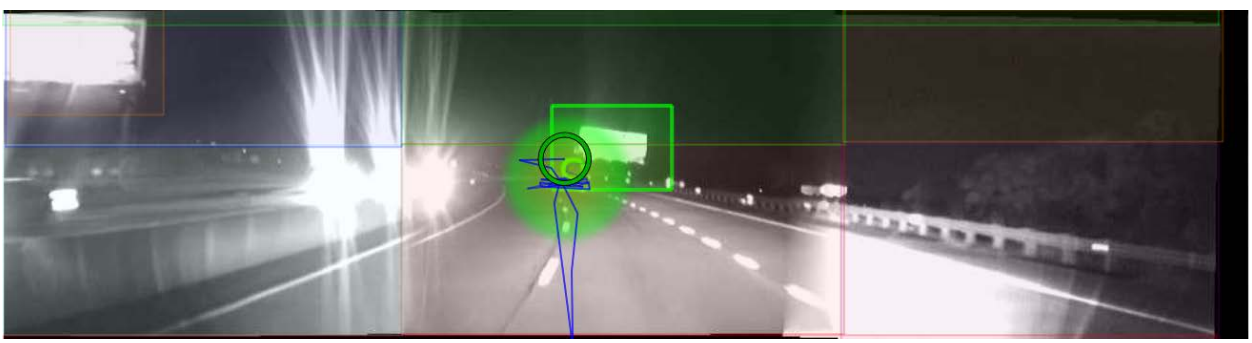

Figure 19. Heat map near the end of a DCZ for a standard billboard at night on a freeway.

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

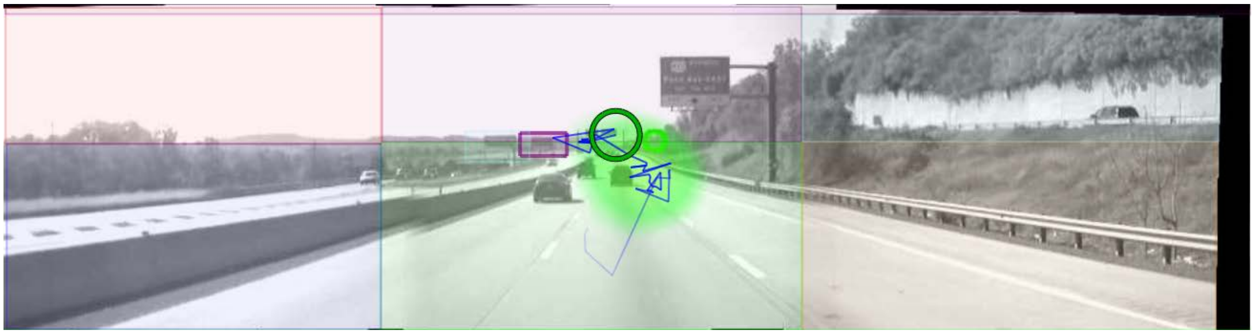

Figure 20. Heat map for the start of a DCZ for a standard billboard in the daytime on a freeway.

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

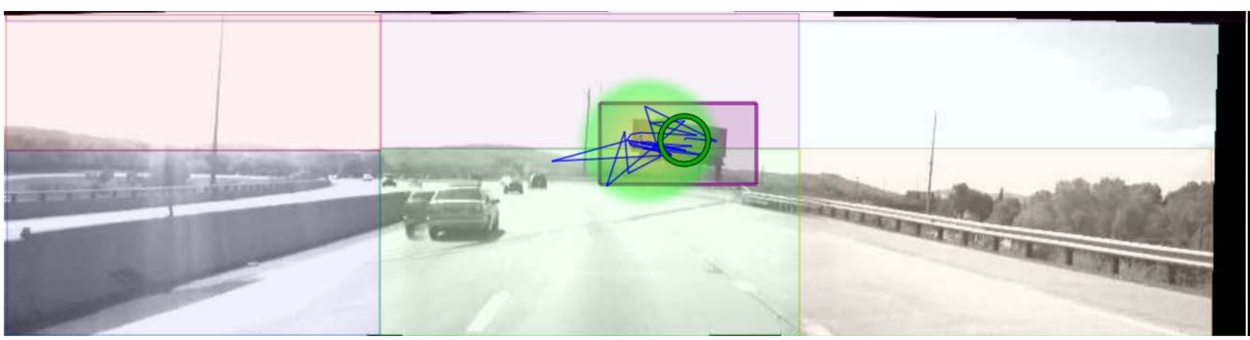

Figure 22. Heat map near the end of DCZ for standard billboard in the daytime on a freeway.

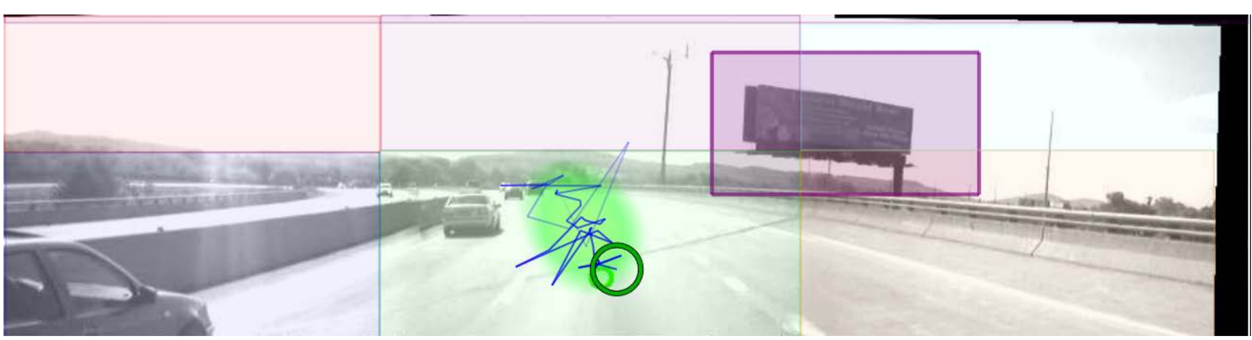

Figure 23. Heat map at the end of DCZ for standard billboard in the daytime on a freeway.

Comparison of Gazes to CEVMS and Standard Billboards

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

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

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

Observation of Driver Behavior

No near misses or driver errors were observed in Reading.

Level of Service

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

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

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

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

DISCUSSION OF READING RESULTS

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

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

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

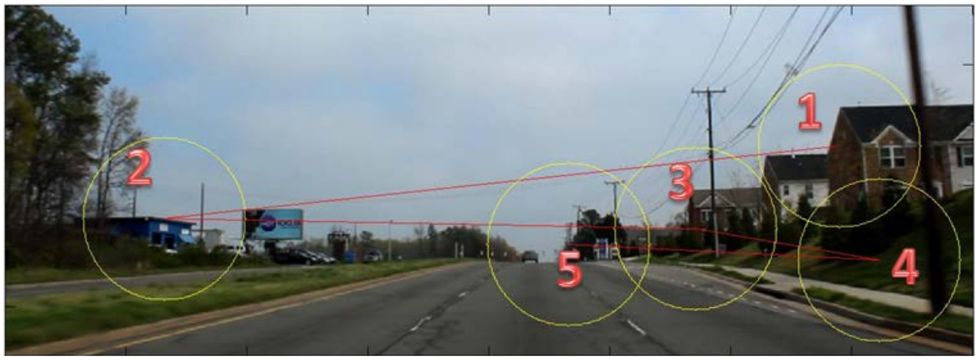

Figure 24. Example of identified salient areas in a road scene based on bottom-up analysis.

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

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

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

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

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

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

RICHMOND

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

METHOD

Selection of DCZ Limits

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

Advertising Type

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

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

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

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

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

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

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

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

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

Figure 26. Example of CEVMS DCZ an arterial.

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

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

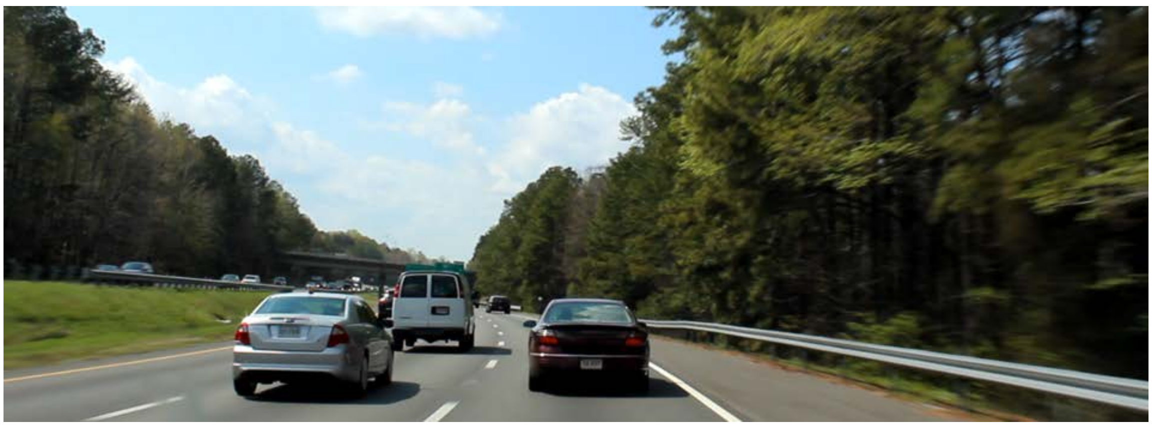

Figure 29. Example of a control DCZ on a freeway.

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

Photometric Measurement of Signs

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

Visual Complexity

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

Participants

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

Procedures

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

Participant Testing

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

Pre-Data Collection Activities

This was the same as in Reading.

Practice Drive

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

Data Collection

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

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

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

Debriefing

This was the same as in Reading.

DATA REDUCTION

Eye Tracking Measures

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

Other Measures

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

RESULTS

Photometric Measurement of Signs

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

Luminance

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

Contrast

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

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

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

Visual Complexity

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

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

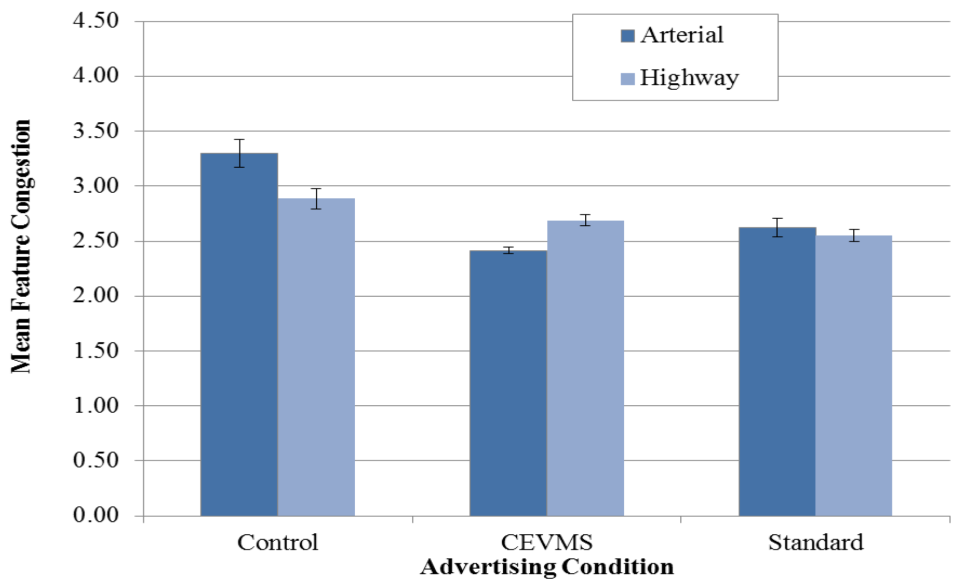

Figure 31. Mean feature congestion as a function of advertising condition and road type.

Effects of Billboards on Gazes to the Road Ahead

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

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

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

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

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

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

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

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

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

Fixations to CEVMS and Standard Billboards

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

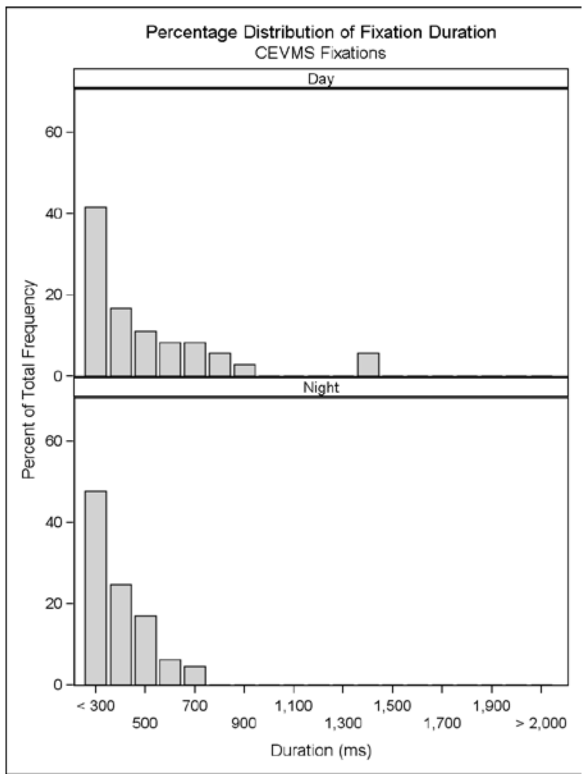

Figure 32. Fixation duration for CEVMS in the day and at night.

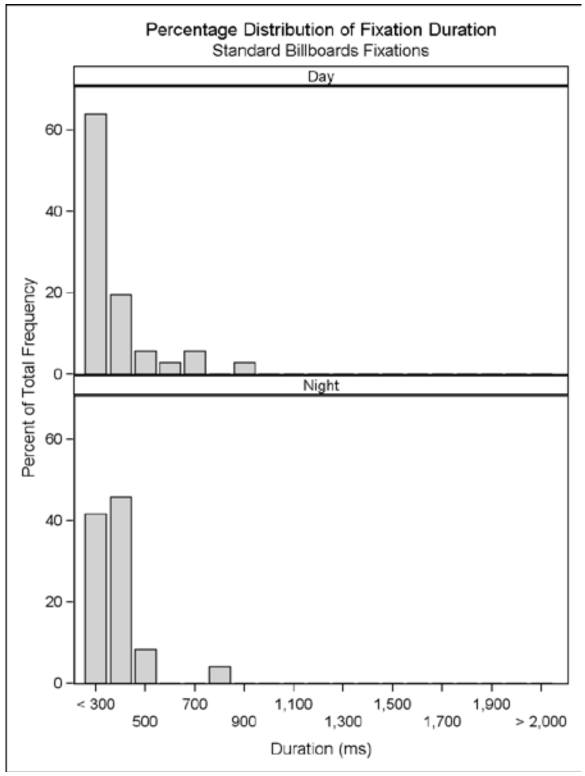

Figure 33. Fixation duration for standard billboards in the day and at night.

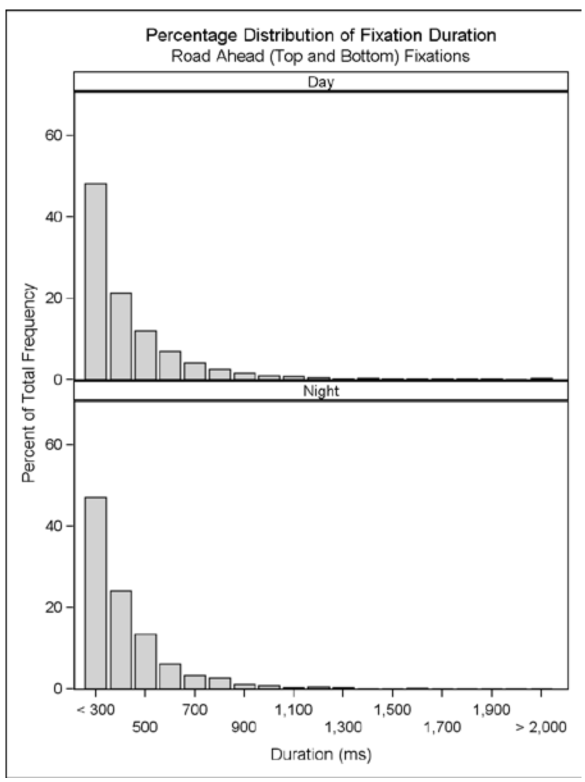

Figure 34. Fixation duration for the road ahead in the day and at night.

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

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

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

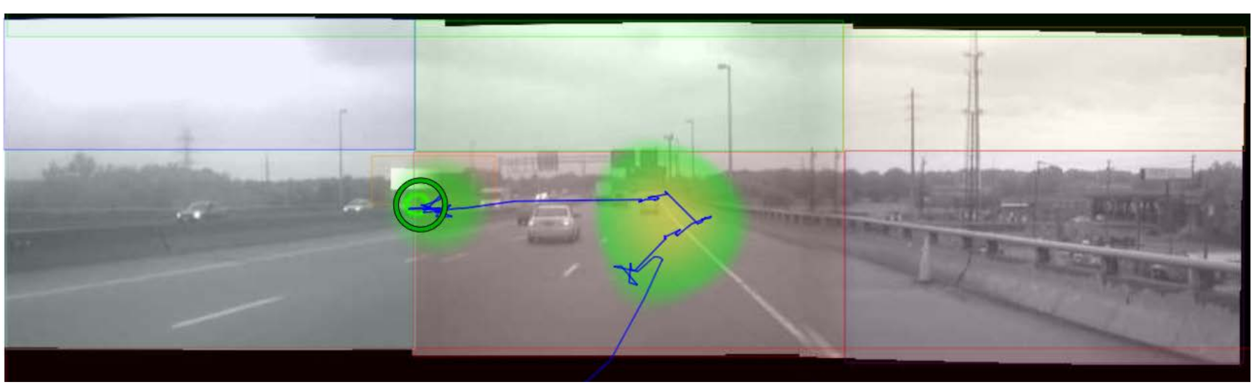

Figure 35. Heat map for first fixation to CEVMS with long dwell time.

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

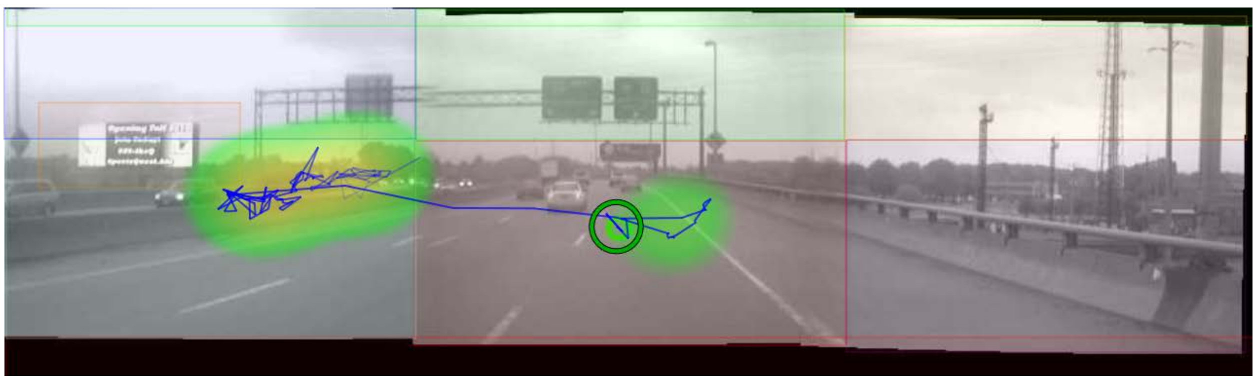

Figure 37. Heat map at end of fixations to CEVMS with long dwell time.

Comparison of Gazes to CEVMS and Standard Billboards

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

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

Observation of Driver Behavior

No near misses or driver errors occurred.

Level of Service

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

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

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

DISCUSSION OF RICHMOND RESULTS

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

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

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

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

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

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

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

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

GENERAL DISCUSSION

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

CONCLUSIONS

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

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

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

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

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

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

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

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

Do drivers look at CEVMS more than at standard billboards?

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

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

SUMMARY

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

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

LIMITATIONS OF THE RESEARCH

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

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

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

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

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

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

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

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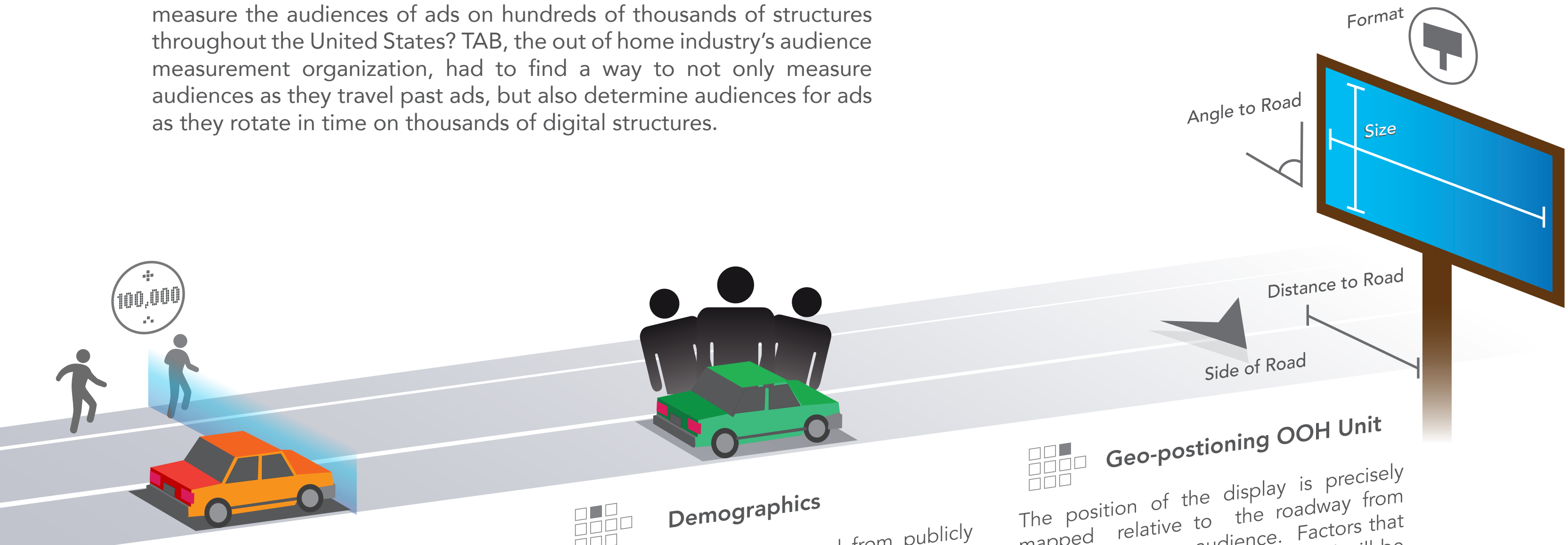
Appendix C Outdoor Advertising Ratings – TAB

CONSTRUCTING AN OUT OF HOME RATING

TAB Out of Home Ratings™

How did digital out of home ads change the needs of our industry to measure the audiences of ads on hundreds of thousands of structures throughout the United States? TAB, the out of home industry's audience measurement organization, had to find a way to not only measure audiences as they travel past ads, but also determine audiences for ads as they rotate in time on thousands of digital structures.



Circulation

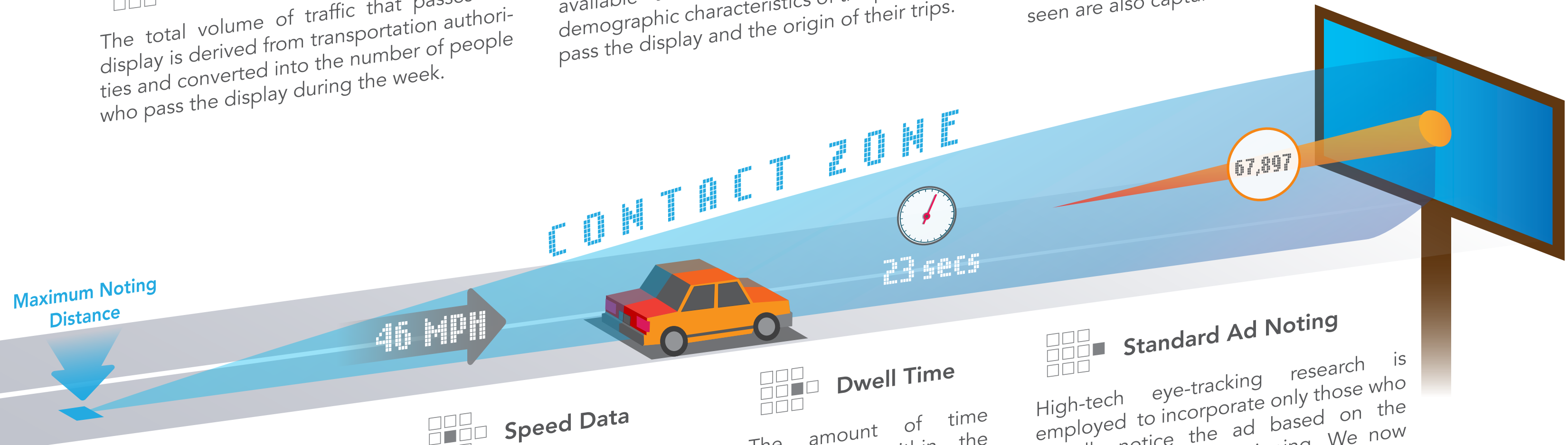
The total volume of traffic that passes the display is derived from transportation authorities and converted into the number of people who pass the display during the week.

Demographics

Millions of trips are generated from publicly available travel surveys. They provide the demographic characteristics of the people who pass the display and the origin of their trips.

Geo-postioning OOH Unit

The position of the display is precisely mapped relative to the roadway from which it derives an audience. Factors that influence the likelihood that the ad will be seen are also captured.



Contact Zone

The road type and size of the display are used to determine the distance from which ads on a display can be seen. This is referred to as the maximum noting distance.

Speed Data

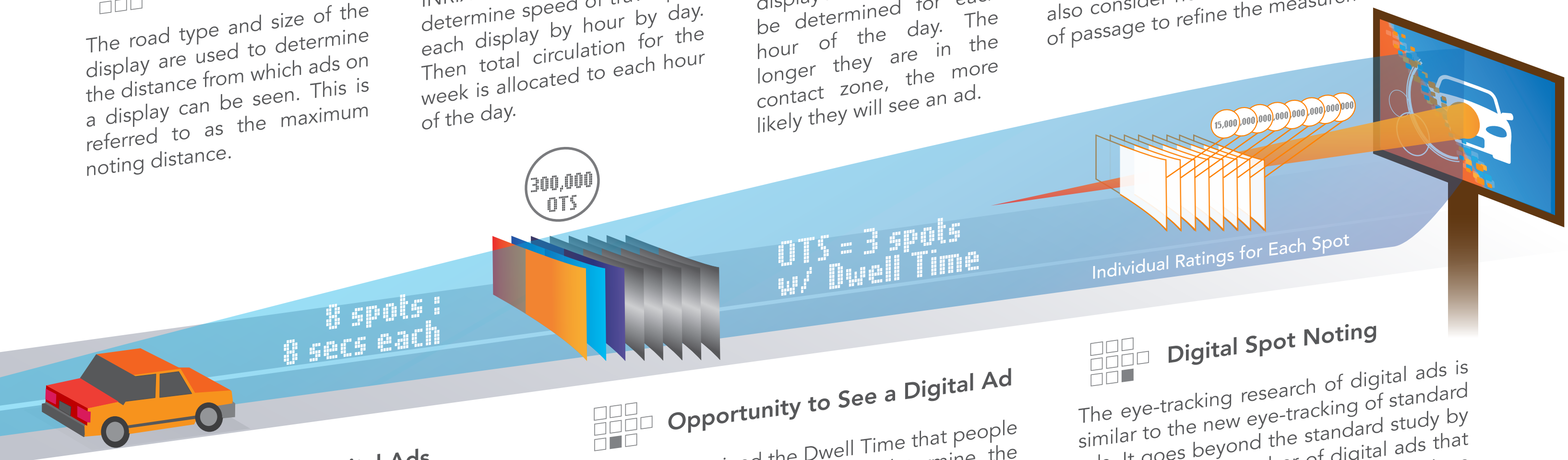
INRIX traffic data are utilized to determine speed of travel past each display by hour by day. Then total circulation for the week is allocated to each hour of the day.

Dwell Time

The amount of time people are within the display's contact zone can be determined for each hour of the day. The longer they are in the contact zone, the more likely they will see an ad.

Standard Ad Noting

High-tech eye-tracking research is employed to incorporate only those who actually notice the ad based on the display's size and positioning. We now also consider noting distance and speed of passage to refine the measurement.



Number of Digital Ads

Now out of home displays can carry one or more ads. For digital displays, the ad length (e.g. 8 or 10 seconds) and the number of ads in the rotation (e.g. 8 ads) are stored.

Opportunity to See a Digital Ad

Having determined the Dwell Time that people are in the Contact Zone, we determine the number of digital ads that can be seen as people pass at various speeds during the day. For example, for a time of day with moderate congestion, people might have an opportunity to see 3 of 8 digital ads in the rotation.

Digital Spot Noting

The eye-tracking research of digital ads is similar to the new eye-tracking of standard ads. It goes beyond the standard study by considering the number of digital ads that can be seen as people pass at various levels of speed throughout all hours of the day. The result is the ability to report the number of people who see each digital spot displayed on the structure.