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16. Abstract

Outdoor advertising signs impact millions of travelers around the world every day. These signs are designed to attract driver attention, thus taking it away from the driving task. Driver inattention and distraction are two critical factors for road safety. Regulation of outdoor advertising signs must deal with changing technologies, including digital billboards, which allow for modifications to sign illumination, motion, and content. Regulations are not keeping pace with changing sign trends and must be updated to address potential impacts on-road user safety.

This research project focused on the degree of driver distraction caused by typical and digital advertising signs and potential safety impacts of that distraction. The project included a comprehensive state-of-the-practice review, crash investigation, and an on-road human factors evaluation. The research team located each of the digital billboards in Texas and used those locations in the crash investigation and human factors site selection process. The research team also evaluated the nighttime lighting levels of digital and standard billboards along the human factors evaluation route. The research team used the study findings to make recommendations and provide guidance to better regulate digital billboards to minimize negative impacts on safety to the traveling public. The research team also recommended additional areas of digital signing where research or regulation may be needed.

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DISCLAIMER

This research was sponsored by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

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LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AOI	Area of Interest
APA	Administrative Procedures Act
CEVMS	Changeable/Commercial Electronic Variable Message Signs
CMS	Changeable message signs
CRIS	Crash Records Information System
DBB	Digital Billboard
DOT	department of transportation
EBB	Electronic Billboard
EMC	Electronic Message Center
EMD	Electronic Message Display
FHWA	Federal Highway Administration
FSA	Federal-State Agreement
HBA	Highway Beautification Act
LED	Light Emitting Diode
MV	multi-vehicle
non-int	non-intersection
OA	outdoor advertising
OAAA	Outdoor Advertising Association of America
OAC	Outdoor advertising control
RE	rearend
Secretary	United States Secretary of Transportation
SS	sideswipe
SV	single-vehicle
USDOT	United States Department of Transportation

CHAPTER 1:
PROJECT OVERVIEW

PROJECT NEED

Outdoor advertising signs impact millions of travelers around the world every day. These signs are designed to attract driver attention, thus taking it away from the driving task. Driver inattention and distraction are two critical factors for road safety. Regulation of outdoor advertising signs must deal with changing technologies, including digital billboards (DBBs), which allow for modifications to sign illumination, motion, and content. Regulations are not keeping pace with changing sign trends and must be updated to address potential impacts on-road user safety.

RESEARCH CONDUCTED

This research project focused on the degree of driver distraction caused by typical and digital advertising signs and potential safety impacts of that distraction. The project included a comprehensive state-of-the-practice review, crash investigation, and an on-road human factors evaluation. The research team located each of the DBBs in Texas and used those locations in the crash investigation and human factors site selection process. The research team also evaluated the nighttime lighting levels of digital and standard billboards along the human factors evaluation route. The research team used the study findings to make recommendations and provide guidance to better regulate DBBs to minimize negative impacts on safety to the traveling public. The research team also recommended additional areas where research or regulation may be needed concerning digital signing.

REPORT OVERVIEW

This report includes chapters describing:

- An examination of existing literature and a detailed review of the legal regulations of DBBs.
- A summary of the locations of current digital sign installations in Texas. These locations were used in the crash investigation and human factors evaluation.
- A before and after crash investigation at DBB locations in Texas.
- A human factors evaluation on the impact of DBBs on drivers' gaze behavior while driving on open roadways. Signs along the human factors evaluation route were also evaluated to measure the brightness of advertising signs at night.
- Guidance and recommendations resulting from the research effort.

CHAPTER 2:
STATE OF THE PRACTICE

This section provides an examination of existing literature related to digital and standard billboards. The study team was interested in collecting information on the influence of advertising signs on driver behavior and distraction as well as the methodologies used to assess these impacts. The state-of-the-practice review includes detailed information on the legal regulations of DBBs.

The state-of-the-practice review covers the following topics:

- Review of literature.
    - On-road studies.
    - Simulator studies.
    - Surveys.
    - Gaps in the literature.
- Legal regulations of DBBs.
    - Highway Beautification Act.
    - Federal-State Agreements (FSAs).
    - U.S. code.
    - Case law.
    - Current guidance.
    - Looking at future topics.

REVIEW OF LITERATURE

On-Road Studies

On-road studies are carried out to analyze the effect of roadside advertising on drivers' distraction. There are many researchers who carried out on-road studies, but each study varies in the form of parameters measured and the level of accuracy with which the data were collected. Various researchers have put in efforts to get results as close to reality as possible. To achieve this, various combinations of driver factors like age, gender, driving experience, and the equipment used to track the data were used. A review of some of the on-road studies carried out since 1991 is presented below.

Beijer et al. conducted an on-road study focused on the glance behavior of 25 drivers at various advertising signs along an expressway in Toronto, Ontario, Canada (*1*). The drivers were exposed to a total of 37 large commercial advertising signs, and the average glance duration on each sign was measured using an EL-MAR 2000 IR eye tracking system. The signs included a

static billboard, roller bar sign, scrolling text sign, and a video sign. The duration of glance for the signs in increasing order was roll, billboard, video, and scroll sign. The average duration was found to be 0.57 second, and there were an average of 35.6 glances per subject. Active signs that had movable displays attracted 69 percent of all glances and 78 percent of long glances. These results suggested that the signs with more active components and signs that are placed in the driver's field of view distract the driver more.

Dukic et al. studied the effects of electronic billboards (EBBs) on driver distraction (*2*). They conducted on-road studies by asking 41 drivers to drive an instrumented vehicle (Volvo V70 fitted with data acquisition unit [VBox] and a camera [MobilEye]) along routes with four EBBs during daytime and nighttime. The experiment did not involve video advertising, but the contents in the EBB changed every 7 seconds. Based on these data they carried out gaze analysis using BeGaze 3.0 software. The drivers that participated in the study had an age of 42 ± 8 years and they had held their driving license for 22 ± 9 years. The message displayed in the EBBs changed every 7 seconds, and thus it resulted in three to four advertisements while passing the billboard. The driving behavior was analyzed in terms of mean speed, standard deviation of lateral position in the lane, and minimum time headway. The driver's visual behavior was analyzed by measuring dwell time, visual time sharing, number of fixations, and maximum fixation duration. The performance of the driver varied during day and night times. This can be clearly seen from the graphs in Figure 1 generated by Dukic et al. (*2*). EBBs attract more dwell times than normal traffic signs. On an average the dwell time for billboards during daytime was 2.23 seconds and nighttime was 2.09 seconds, whereas the same for other signs was 0.87 seconds and 1.16 seconds, respectively. This indicates that billboards distract the drivers and take away the time spent focusing on the road ahead.

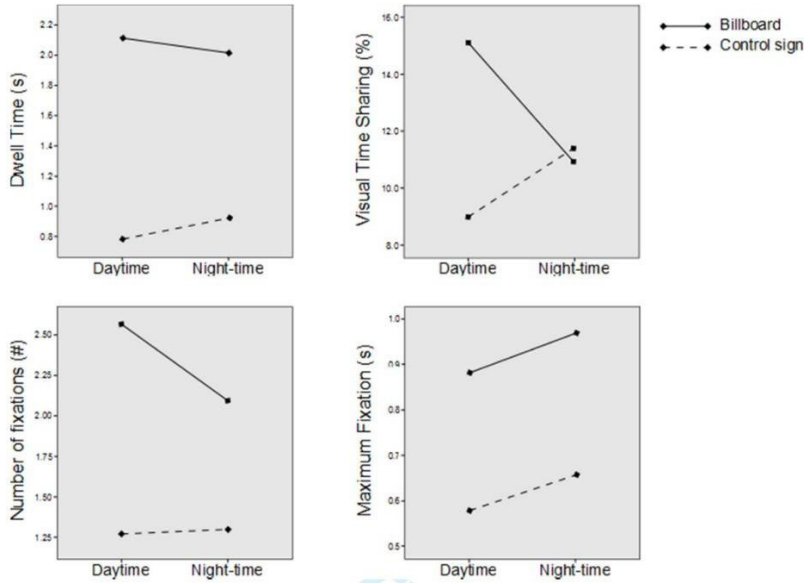

Figure 1. Mean Values across Participants and Signs for Dwell Time, Visual Time Sharing, Number of Fixation, and the Longest Fixations for the Factors Time-of-Day and Sign-Type.

Herrstedt et al. conducted an on-road study to prove that roadside advertising affects driver attention and road safety (*3*). The study focused only on static billboards. The test drive was conducted with 32 different drivers in the range of 23 to 70 years age, and they were asked to drive an instrumented car along a route. The instrumented car had SMART EYE 3-camera system to track eye movements, a scene camera for video detection, GPS for registration of speed, and a laser scanner to measure the distances to other road users. The two critical parameters that were considered were safety buffer and drivers' distraction. Safety buffer was calculated as the time gap to the vehicle ahead subtracted by the glance duration. The driver's distraction was measured as the time spent by the driver looking at anything other than the road and traffic. The experiment resulted in 25 percent of the drivers having a safety buffer of less than 2 seconds, which is unsafe. They also found that 17 out of 109 drive pasts included visual distraction. In conclusion, they found that roadside advertising affects the driver's attention since 69 percent of the drivers glanced at least once at the sign and 18 percent of drivers glanced at it for more than 1 second.

Sisiopiku has studied the relationship between digital advertising billboards and drivers' distraction and crash rates (*4*). This study was conducted by the University of Alabama and Florida International University and focused only on DBBs. They analyzed the crash data at 18 study sites in Alabama and Florida and found that the crash rates were higher in areas where there was billboard influence. This was confirmed by carrying out a regression analysis. They used the data of 377 crashes in Florida and 77 crashes in Alabama. The results suggested that there was a 25 percent increase in crashes in Florida due to the presence of DBBs. In Alabama, it was found to be 29 percent. The study did not focus on the type of crash that occurred. The study also conducted a questionnaire survey with 22 questions to assess several variables. In total there were 231 respondents from Alabama and 285 respondents from Florida. The results suggested that young- to middle-aged drivers and the oldest drivers glance at the signs for a longer time and more than half of the drivers looked at DBBs for a sufficiently long time. Another study that they conducted as a part of this research was to let the drivers drive a simulator, which had billboards along the driving route. Sixty-six drivers were asked to drive 2.84 miles on a STISIM simulator with three 20-inch screens to provide a 135° field of view. The eye movement of drivers was tracked using FaceLab software. The parameters that were considered to assess the driving performance were time spent looking at the billboard, number of road edge excursions, and number of speed exceedances. In conclusion, the segments involving billboards had negative impact on drivers' performance and attention.

Smiley et al. conducted several studies evaluating video advertising signs (*5*, *6*). Five studies were conducted to evaluate the safety of video advertising: eye fixation, conflicts, headways and speeds, crashes, and public survey. To assess distraction, the eye fixation data of 16 drivers were collected at three downtown sites and one urban expressway site. The subjects had to pass four video advertising signs, and the distraction of the driver was measured by using an EL-MAR 2000 IR eye tracking system. All the drivers were in the range of 25–50 years old with low rates

of accidents per kilometer. When the driver was operating the vehicle, the eye movement data were recorded for every 1 minute, and the total data for 10 hr were analyzed. The parameters that were considered to assess the driver distraction were number of glances, glance duration, and the angle of glance. It was found that 45 percent of the drivers on average looked at the signs, and most glances were made when the signs were within a 15° angle to the field of view.

Interestingly, video signs attracted less glances when compared to normal signs. In analyzing the conflicts, the incidents that took place before the installation of the signs and after the installation were compared. In addition, the amount of braking without good cause and the unwarranted displacements that took place were also counted. In comparison, drivers braked without good cause for 19 percent of time in the presence of video signs and 12 percent during normal signs. Moreover, the before and after comparison was also carried out for speed and headway. There was a minor decrease in the speed and a corresponding decrease in headway after the installation of video signs. When crash data were analyzed, there was a 12.9 percent increase in rear-end collisions after the installation of video signs. The crashes were analyzed by dividing them into total crashes, injury crashes, and rear-end crashes. Comparatively, the number of rear-end crashes were more than the injury crashes in the case of video advertising signs. In the last study, 152 persons were surveyed about their opinions on safety of video signs. Overall, 59 percent of drivers said that video signs cause distraction and 49 percent claimed that they have a negative effect on their attention. Moreover, 86 percent of the subjects indicated that there should be restrictions on video advertising in interest of traffic safety.

Luoma conducted road studies to evaluate the recall method and some aspects of the eye movement method (*7*). This study involved standard signs like speed limit signs, game crossing signs, etc. The major problem of the eye movement method is that drivers behave differently when alerted that they are in an experiment. To overcome this, the eye movement of 77 alerted and 311 unalerted drivers was recorded when they came across a road sign. Luoma found that the speed and the variance of speed was greater in unalerted drivers when compared to alerted drivers (*7*). Luoma concluded that alerted drivers behave differently compared to unalerted drivers. The drivers were also asked to recall the sign after they passed it, and the drivers with less recall delay were able to remember the sign better. In total, 94 percent of the drivers were able to recall the signs but only 31 percent of the drivers were able to recall the sign when asked after a longer delay.

Simulator Studies

The aim of simulation studies is to create an environment as close as possible to road conditions, but in a controlled lab environment. To achieve this the simulator setup needs to consider all the factors involved in typical on-road driving. The various factors to consider include the driver's experience, road conditions, traffic characteristics, and the realistic nature of the simulation and simulator used. Various researchers have used complicated equipment to conduct simulator studies from full-size vehicle platforms surrounded by large display screens to tabletop setups

with a steering wheel and computer monitors. Some of the simulation studies that have evaluated driver distraction and roadside advertising are presented below.

Bendak et al. conducted simulation studies to study the role of roadside advertising signs on distracting drivers (*8*). The driving simulator used in the study was an SSI S-2300 Interactive Modular Driving simulator. It has three 1024×768-pixel screens with both automatic and manual transmission modes. Twelve participants were asked to drive the simulator in various conditions like rain, fog, day, night, light and heavy traffic, and on a road without lights. The driving simulator gives data regarding various factors like the number of tailgating occurrences, number of speeding occurrences, and number of times the car drifted from the lane. The driving route was a 5.8-mile stretch of three-lane divided road with six intersections. The average sign density on the actual road was road 79 signs/mile and in simulator it was reduced to 58 signs/mile for a more conservative rate. Driving in lane and not drifting from the lane requires continuous eye-hand steering coordination. The study found that drifting from the lane in the presence of advertising signs is a strong indication of the signs distracting the drivers and affecting their performance. In addition to the simulation study, a questionnaire survey was also carried out, and 80 out of 160 respondents indicated that they were distracted by the advertising signs. The questionnaire survey involved four simple questions about the age of the respondent, if the respondent paid attention to roadside advertising signs, if these signs distracted the respondent's attention, and if such signs had ever put the respondent in a dangerous situation by distraction. In conclusion, the number of tailgating occurrences, speeding, and turning or changing lanes without signaling were increased in the presence of advertising signs compared to when no such signs were present.

Chattington et al. carried out research on investigating driver distraction and the effects of video and static advertising (*9*). Chattington et al. used TRL's CarSim to conduct the simulator study. It has an integrated non-intrusive SmartEye eye tracking system used to analyze the gaze behavior of 55 participants in the study. Using this equipment, a driving environment was created, as shown in Figure 2. The three factors that were considered for the analysis were the advertisement position, advertisement presentation, and advertisement exposure time. The route driven by the drivers was 8.1 miles in length. Data regarding speed, lateral position, number of glances, glance duration, and deceleration rate were captured and used for data analysis using statistical methods. The results suggested that drivers looked at video advertising signs 12 percent longer and 34 percent more than static advertising. Drivers also looked for a longer time at video advertising signs compared to static signs. Signs placed overhead attracted more glances than signs placed on the side of the road.

Figure 2. Example Screenshot of the Simulated Scenario (*9*).

Edquist et al. evaluated the effect of billboards on driver behavior during simulated driving (*10*). The aim of the study was to examine the visual behavior of drivers in the presence and absence of billboards. This was achieved by conducting a simulated study using a 2003 Holden Calais sedan mounted on a motion platform with three projection screens in the front. The simulator was equipped with a Crystal River Audio Reality Accoustetron II audio system to generate the traffic sounds. The study was conducted with 48 participants of three age and experience groups. Each drive was approximately 5.6 miles long, and data were collected from the acceleration pedal, braking pedal, and steering wheel of the simulator. The head and eye movement of the drivers was also tracked using FaceLab head and eye tracking hardware. The parameters that were measured to assess the driver's distraction were the time to change lanes, number of lane change errors, and the proportion of time fixating on the road ahead. The time to change lanes increased, and 50 of the 62 lane change errors happened in the presence of billboards. Drivers only spent 55.9 percent of the time on the approach to a lane change in the presence of an advertising sign fixating on the road ahead. In addition to these results, the drivers' response to all actions was delayed by 1 second in the presence of billboards.

Megías et al. studied the impact on attention and urgent decisions by roadside advertisement in risky driving scenarios (*11*). The main aim of this study was to assess the effect of emotional content in static advertisements on the drivers' ability to make decisions. This was carried out by using a Honda Riding Trainer motorcycle simulator. It included a projector screen in front, and the eye movement of drivers was tracked using the Eyelink II head-mounted eye tracking system. Each drive was a length of 4.4 miles, and 22 undergraduate students participated in this experiment. Pictures of different emotional valence were displayed on the static billboards to act as emotional cues. The parameters that were measured through the simulator were the total fixation time and the brake responses. Billboards with negative valence attracted longer fixation

times and later gaze disengagement when compared to positive and neutral ones. In addition, negative signs resulted in risky brake response.

Tarnowski et al. used an Opel Astra based AS1200-6 simulator to study roadside advertising and the resulting distraction of drivers' attention (*12*). The research included two studies: safety inspection of existing roads and verifying the impact of advertisement contents on the memory of the driver. The first study included 45 drivers driving the simulator for 3.7 miles of the road. The task for drivers was to search for service stations, and the percentage of time spent by the drivers looking at the road, mirrors, and cockpit was calculated using SMI eye tracking glasses. The time was considered as visual attention, and the density of advertising signs affected the visual attention of the drivers. The second study included 31 participants who were shown 38 photos that had traffic signs in them. Some of the photos also contained advertisements with human representation and without representation. The participants were then asked to recall the traffic signs present in the photographs, and the number of errors were high when photos with advertisements were shown. The results of this study in combination with the first study confirmed prior knowledge that roadside advertising is a potential attention and perceptiveness distractor.

Young et al. conducted a simulator study to determine the effects of roadside advertising on driver attention and performance in different road conditions (*13*). They used the Brunel University Driving Simulator, which has a Ford Mondeo frame with Dolby Pro Logic audio and controls connected to a computer running SITSIM Drive software. Forty-eight participants were asked to drive the simulator in both rural and urban conditions. The length of the drive was 3 miles on urban roads, 5.7 miles on freeways, and 2.8 miles on a rural road. After each trial participants were asked to recall the last traffic sign they saw and the advertisements.

Participants were also subjected to a NASA-TLX test to measure their mental workload. The performance data were collected in the form of time spent out of lane, number of lane excursions, average time-to-contact, and minimum time-to-contact. Statistical analysis was carried out on these parameters to know their degree of significance. It was found out that the time spent out of lane and number of lane excursions were comparatively high in the presence of roadside advertising boards, and the participants were able to recall the advertisements clearly in comparison to the traffic signs.

Surveys

Another method to carry out research on the effect of advertising on drivers' attention is to collect the data regarding the perception and opinion of drivers. This can be achieved by carrying out surveys. There are various surveys like questionnaire surveys, road-side interviews, mailing questionnaires to houses, surveys through phone call, etc. Below are some of the studies carried out using a survey method to study the effect of billboards on drivers' attention. The data

collected using a survey method are very useful and can be used in combination with on-road or simulation study data to generate research findings and recommendations.

Benson et al. conducted a survey to study the attitude of motorists toward variable message signs (*14*). The study was carried out in Virginia and collected the opinion of motorists on 60 variable message signs. This research included two studies: one to construct the questionnaire and the other to actually carry out the survey. To create the questions, seven focus groups with 125 participants were formed. The participants included a broad range of commuters and demographic characteristics. The main survey was carried out using computer-assisted telephone interviews. A total of 517 interviews were conducted, and the respondents were selected based on random digit dialing. Other than the information about the signs, the questions also included data about age, gender, income, etc. to know the demographics of the participants. After analyzing the survey data, it was stated by half of the survey respondents (254) that they were negatively affected by the variable message signs and the content displayed in them.

Olejniczak-Serowiec et al. conducted a survey to study the social attitudes towards roadside advertising (*15*). The survey focused on how drivers are distracted due to the type of content in roadside advertising. The study did not consider the type of advertising billboard. The research included two surveys: one to know about the attention of drivers to roadside advertisements and another to verify the impact of emotionally loaded advertisements on attention. The first study involved 1,095 participants who filled out an online form containing questions concerning demographics, driving experience, and eyesight condition. The questions were about seven types of content in advertisements: positive, negative, sexual, humorous, riddles, sales offers, and signs that resemble traffic signs. After conducting a frequency analysis on the data, it was found that 42.8 percent of drivers declared they were distracted by roadside advertisements. The second study was carried out on 50 Polish drivers. They were presented with 30 slides each lasting 2 seconds. The slides consisted of three numbers and one picture with or without advertisements. After each slide, the drivers were asked questions about the numbers, and the amount of correct answers served as the performance measure. The study found that the drivers were distracted by advertisements and that positively loaded advertisements attracted more attention than negatively loaded advertisements.

Gaps in Literature

Many of the studies reviewed were not conducted in the United States, were conducted more than a decade ago when vehicles had fewer features and in-vehicle distractions were less, and many of the studies did not consider DBBs. Some specific gaps in the literature and considerations for a human factors study are described below.

Human Factors

Human factors play a key role in the selection of participants. It is very important to select the sample of participants since the results are expected to represent the whole population. This was mentioned by Sisiopiku in his study, which did not include many novice drivers, making it difficult to generalize the results to a younger group of drivers (*4*). On the other hand, the study conducted by Edquist et al. only included novice drivers and hence the number of errors in responding to the signs were relatively high (*10*). Smiley et al. also mentioned in their study that the group of drivers selected for the study were in the safest range possible for the study and did not involve all the age groups (*5*). This can be overcome by carefully considering demographic characteristics like age, gender, driving experience, and vision in the area in which the results of the study are used.

Statistical Evidence

Although there have been numerous studies that implied roadside advertising negatively affects the driver's attention, very few studies have been able to provide statistical evidence. Smiley et al. felt that the evidence from their experiments was by no means clear cut in one direction or the other but concluded that it was intuitively obvious that distraction causes crashes and is unsafe for the driver (*6*). An adequate sample size, proper performance metrics, and advanced statistical analysis techniques can help achieve statistical confidence. This is true for both crash analysis and driving performance analysis.

Sign Characteristics

In the study conducted by Beijer et al., one of the major limitations was that drivers were prone to look at a certain sign because of the closer proximity to the visual field (*1*). Bendak et al. also mentioned that the signs should cause minimum interference with driving tasks and more research should be done to find out their reasonable position (***Error! Bookmark not defined.***). T he type of sign (standard billboard, DBB, traffic sign, changeable message sign, etc.), size and content of the sign, and relative position to the roadway need to be considered when developing an on-road study. For nighttime evaluations, the visual performance of the signs (retroreflectivity, brightness, etc.) need to be considered to not bias the results of one sign type against another.

LEGAL REGULATIONS OF DIGITAL BILLBOARDS

The statutory and regulatory framework of the Highway Beautification Act (HBA) of 1965 controls the regulation of standard (non-digital) billboards, including DBBs/EBBs, or changeable/commercial electronic variable message signs (CEVMS). CEVMS are self-luminous advertising signs, which depict any kind of light, color, or message change, which ranges from static images to image sequences to full-motion video (*16*). The CEVMS may also be referred to as an EBB or a DBB.

The determination of statutory or regulatory language that controls lighting standards or settings is not grounded in any specific scientific analysis or rigorous testing, such as tests that have been historically conducted by groups such as the American Association of State Highway and Transportation Officials (AASHTO) or the Transportation Research Board. Industry-led efforts by The Illuminating Engineering Society of North America (*17*) and The Outdoor Advertising Association of America (OAAA) (*18*) have recommended acceptable sign luminance limits, contrast ratios, maximum brightness levels, and guidelines for dimming; however, these vary and are not necessarily mandatory. As TxDOT Project 0-7085 noted (*19*):

> Sometimes, the statute or regulation may call for a standard, yet the resources are lacking to implement or enforce the program. For example, some states have brightness requirements (for traffic safety) in the law for digital signs but lack the device or training to actually measure said brightness.

TxDOT Project 0-7085 also noted:

> Also, FHWA has not conducted recent safety or privacy research on these bright digital signs that could include the technological advances such as personalized and smart billboards, vehicle detection technology, data aggregation from mobile phones and the issues inherent in the encryption of license plate data. In the 2007 memo, digital signs are called "changeable electronic variable message signs" (CEVMS), and the Guidance provides that states should request from FHWA Division offices a determination as to whether the State should allow for off-premises CEVMS on routes subject to the Highway Beautification Act. In providing considerations for review, it includes "duration of message, transition time, brightness, spacing, and location," and it requires states to show that their policies are "reasonable and safe." Although this 2007 memo allows for CEVMS, it still refers to the criteria in the 70s era FSAs prohibiting "intermittent" or "flashing" or "moving" lights—which were surely a different type of light. FHWA guidance on digital billboards or has been sparse since 2007,[1] yet the safety of brighter, newer LED signs remains an issue, and some states are tackling the proliferation and regulation of these signs with skill.

[1] Highway Beautification Act of 1965, 23 USC 131; also 23 CFR 750.705(h); Establishing a statewide unform program to control the use of advertising devices in areas adjacent to the State Highway System is a government goal. Many state statutes and regulations state that the intent of these rules is to protect and promote the health, safety, and welfare of the traveling public. The state laws and rules often take HBA language in codifying the HBA, with goals to promote the "reasonable, orderly and effective display of outdoor advertising, while preserving and enhancing the natural and scenic beauty" of the state. This is uniquely implemented by the federal-state agreements.

Background—Highway Beautification Act of 1965

Under the HBA,[2] the federal government created a gradual method to "sunset away" billboards and control the proliferation of outdoor advertising (OA).[3] The federal and state governments cooperate in regulating OA. This cooperation began with the federal Bonus Act of 1958, which amended the Federal-Aid Highway Act of 1956 to provide a 0.5 percent bonus in federal highway aid to states that voluntarily controlled OA along interstate highways (*20*). Regulations promulgated under the Bonus Act prohibited, inter alia, signs with "any flashing, intermittent, or moving light or lights."[4] This language was later kept in the HBA related regulations of 23 CFR 750.108(c).

Effective Control

States achieve effective control in part by prohibiting the erection of new signs, displays, and devices adjacent to the interstate and primary highways except for the following:

- Directional and official signs and notices, which must conform to certain standards.
- Signs that advertise the sale or lease of property upon which they are located.
- Signs that advertise activities conducted "on the property" upon which they are located.
- Landmark signs lawfully in existence on October 22, 1965.
- Signs by nonprofit organizations advertising free coffee.[5]

However, each state may allow new signs, displays, and devices to be erected and maintained within 660 feet of the interstate and primary system if such signs conform to standards outlined in the state's FSA.

States also must submit proposed regulations and OA enforcement procedures to the Federal Highway Administration (FHWA). FHWA's local offices, or Division Offices, then review whether the proposals comply with the applicable FSA and FHWA's own regulations implementing the HBA.[6] If a state fails to exercise "effective control" of its OA, the United States Department of Transportation (USDOT) may reduce the state's federal highway funding by 10 percent.[7] HBA specifies the process that USDOT must follow before "making a final determination to withhold funds from a State" and allows a state to obtain judicial review of an adverse determination.[8]

[2] Transcript of *Reagan*, City of Austin argument, at 52 (the gradual "phasing out those off-premise signs" is a goal that government sign regulation, such as the Austin ordinance, may accomplish).
[3] Pub. L. No. 85-381, § 122, 72 Stat. 89, 95.
[4] 23 C.F.R. § 750.705(j).
[5] 23 U.S.C. § 131
[6] 23 U.S.C. § 131(*l*).
[7] 23 U.S.C. § 131(b).
[8] 23 CFR § 750.101 Purpose (a)(1).

Congress enacted the HBA in order to "protect public investment," "promote safety," "preserve natural beauty," and "promote the reasonable, orderly, and effective display of outdoor advertising" across all 50 states.[9] Decades of case law have supported the idea that "billboards are traffic hazards" and "can be perceived as an 'esthetic harm'" and governments thus have an interest in supporting sign regulation.[10] More recently, in the landmark billboard case, *Reagan*, the Supreme Court analyzed the idea that "digital billboards pose a risk to public safety" and undermine community aesthetics.[11]

The HBA requires states to maintain effective control of off-premise OA signs, displays, and devices within 660 feet and visible from the main traveled way of the interstate and primary systems.[12] The HBA empowers the United States Secretary of Transportation (Secretary) to withhold 10 percent of a state's federal-aid highway apportionment from states that do not maintain effective control.[13] States may impose stricter limitations than those established by the HBA. FHWA is charged with effectuating and enforcing the HBA, but state and local governments are part of this regulatory framework, and their statutes reflect government interests in natural scenic beauty and safety.[14]

On- versus Off-Premise Signs

In clarifying "effective control," the HBA distinguishes between on-premise and off-premise signs. On-premise signs, such as signs at restaurants, hotels, or gas stations, advertise "activities conducted on the property on which they are located."[15] Those signs, including ones "which may be changed at reasonable intervals by electronic process or by remote control," are consistent with "effective control" and are therefore permitted by the HBA without restriction.[16]

Off-premise signs, on the other hand, are consistent with effective control when (a) they are located in commercial or industrial areas, whether zoned or unzoned, and (b) their "size, lighting, and spacing" accords with the terms of the applicable FSA.[17] States retain "full authority under

[9] 23 USC § 131(d)
[10] Metromedia v. San Diego, 453 U.S. at 509–10, (This landmark sign case found that a ban on off-premises commercial billboards would advance San Diego's interests in promoting traffic safety and aesthetics).
[11] National League of Cities, et al, Brief in *Reagan* case, at 30-42; See also, *Reagan*, 142 S. Ct. 1464 (April 21, 2022); Various Amicus briefs in the *Reagan* case informed the final decision of the court, such as the American Planning Association ("APA") Amicus Curiae Brief, Case No. 20-1029, (Aug. 19, 2021), which argued that digital billboards "make it difficult for drivers to find driveways, businesses, and other locations," and that, "[a]s more signs utilize electronic lighting technologies, bright signs may temporarily blind drivers to objects in or adjacent to roadways." See APA Br. 13-14 and fig. 6.
[12] 23 USC § 131(d).
[13] 23 U.S.C. § 131(b) and 23 U.S.C. § 104.
[14] For example, see New York Consolidated Laws, Public Authorities Law PBA § 361-a(3) (stating these two government purposes).
[15] 23 U.S.C. § 131(c)(3).
[16] Surface Transportation Assistance Act of 1978, Pub. L. No. 95-599, 92 Stat. 2689, 2701 (amending the HBA to add the quoted language).
[17] 23 U.S.C. § 131(d); *see* 23 C.F.R. § 750.704(a)(4), (5), (b).

their own zoning laws to zone areas for commercial or industrial purposes," and their determinations "will be accepted."[18]

Customary Use

Whenever a state or a local zoning authority has determined that the size, lighting, and spacing of signs in commercial or industrial areas is "consistent with customary use," the Secretary must defer to that determination "in lieu of controls by" the FSA. Thus, the determination of "customary use" has been ceded to the states or appropriate "local jurisdiction."[19]

Sign Removal under the HBA

States are required to provide just compensation[20] to owners of signs that were initially lawfully erected but became nonconforming after the passage of the HBA.[21] The federal government is responsible for providing 75 percent of just compensation funds. A state may not remove a nonconforming sign unless the federal share of just compensation is available.[22] States may not circumvent the federal just compensation requirement through amortization. The just compensation requirement does not apply to the removal of nonconforming signs built after the passage of the HBA.

Other HBA Requirements

In addition to requiring effective control of OA, states are responsible for establishing criteria to determine which OA falls under the HBA.[23] States may effectuate a successful program by maintaining a sign inventory with sign locations, zoning, size, permit information, and sign classification. States must also establish laws, regulations, and procedures to accomplish effective control of OA.[24] States must also establish enforcement procedures to discover illegal signs and ensure their prompt removal. States must also submit regulations and enforcement procedures to FHWA for approval.[25]

FSAs: Size, Lighting, and Spacing

FSAs are mandatory agreements entered into in the 1960-70s era by the states and FHWA to "promote the reasonable, orderly, and effective display of OA while remaining consistent with the purposes" of the HBA. Each FSA details size, lighting, and spacing requirements consistent with customary use and authorizes signs that meet these requirements to be erected and

[18] 23 U.S.C. § 131(d).
[19] Conf. Rep. No. 1799, 90th Cong., 2d Sess. 26 (1968).
[20] 23 C.F.R. § 750.707(e).
[21] 23 U.S.C. § 131(g).
[22] 23 U.S.C. § 131 (n).
[23] 23 C.F.R. § 50.705(g).
[24] 23 C.F.R. § 750.705(h).
[25] 23 C.F.R. § 750.705(i), (j).

maintained in areas zoned as commercial or industrial under authority of state law.[26] Within these FSAs, certain crucial terms of art, such as "size, lighting, and spacing" and "customary use" are used to create specific statutes and regulations to further this regulatory framework.[27] Nearly all of the FSAs contain a prohibition against "flashing," "intermittent," and "moving" lights.[28]

Signs consistent with FSA requirements may also be erected and maintained in unzoned commercial or industrial areas as determined by agreement between the state and the Secretary.[29]

FSAs also define terms and provide state control details for OA oversight and the role of certified cities.[30] Since the FSAs were executed independently with each state, FHWA interprets and supervises the applicable state law and FSAs on an individual basis, taking into account past practice in the state and state certification of local controls in lieu of those in the agreement. In certain states' FSAs, states may authorize a political subdivision, such as a certified city,[31] to exercise control over commercial signs in their jurisdictions. If the political subdivision receives approval under a statutory provision, it will be listed as a certified city and a permit issued by that political subdivision will be acceptable instead of a permit issued by the department within the approved area (*21*). Sometimes, when a city fails in its regulatory duty to effectively control OA, FHWA will inform the state that the city is not in compliance, in which case the state will normally decertify the city to avoid endangering the state's federal highway funds.[32]

DBBs and 2007 Federal Guidance Memo on CEVMS

The U.S. Code does not, per se, expressly govern the type of media format used for OA. Most of the FSAs that uphold the HBA's tenets require that "no sign may be permitted which contains, includes, or is illuminated by any flashing, intermittent, or moving light or lights."[33] These standards were created in the 1960–70s, before the type of light-emitting diode (LED) technology that exists today. This means the unanticipated technology and brightness of today's LEDs were not part of the original assumptions during the federal-state negotiations in the 1970s. States are required to seek permission from FHWA Division Offices before they permit the use of DBBs (*22*).

In response to multiple requests by different states to modify their FSAs to provide for the use of digital OA signs, and to provide clarification to the multiple FHWA Division Offices reviewing

[26] 23 C.F.R. §750.703 (j).
[27] 23 USC § 131(d).
[28] See an example, Texas Federal/State Agreement, May 2, 1972, https://www.scenic.org/sign-control/highway-beautification-act/federal-state-agreements/
[29] See Highway Beautification Act, 23 U.S.C. § 131(d).
[30] 23 U.S.C. §131(d); For example, see also Texas Federal/State Agreement, May 2, 1972, https://www.scenic.org/sign-control/highway-beautification-act/federal-state-agreements/ For example, this is a 2023 list of Texas Certified Cities, https://ftp.txdot.gov/pub/txdot- info/row/certified_cities.pdf
[31] For example, in Texas, 43 TAC §21.200(a) provides for this unique process of delegation from the State to a city.
[32] 23 CFR § 750.108(c).
[33] 23 CFR § 750.705(j).

these agreements, FHWA issued a memorandum in 2007 entitled, "Guidance on Off-Premise CEVMS" (FHWA Memo) (*22*).

In the FHWA Memo, FHWA concluded that because these DBBs (also termed as "off-premise changeable electronic variable message signs") display "stationary messages for a reasonably fixed time," they do not violate the prohibition against intermittent, flashing, or moving signs (*22*). In issuing the memo to its Division Offices, FHWA stated:[34]

> Proposed laws, regulations, and procedures that would allow permitting CEVMS subject to acceptable criteria…do not violate a prohibition against "intermittent" or "flashing" or "moving" lights as those terms are used in the various FSAs that have been entered into during the 1960s and 1970s.

FHWA then clarified "acceptable criteria" based on "certain ranges of acceptability that have been adopted in those States that do allow CEVMS" (*22*).

The FHWA Memo provides specific recommendations regarding the duration of message, transition time, brightness, spacing, and location of DBBs. These recommendations were based on consultations with other FHWA Division Offices and surveys of other states that had allowed DBBs. The FHWA Memo gave guidance on brightness: "Adjust brightness in response to changes in light levels so that the signs are not unreasonably bright for the safety of the motoring public." Also, it provided the following guidance on other sign standards:

> A default designed to freeze a display in one still position if a malfunction occurs; a process for modifying displays and lighting levels where directed by the State [department of transportation] to assure safety of the motoring public; and requirements that a display contain static messages without movement such as animation, flashing, scrolling, intermittent or full-motion video (*22*).

Scenic America Sues USDOT

On January 23, 2013, Scenic America,[35] a nonprofit that promotes scenic highway goals, filed a lawsuit asking the court to invalidate FHWA's Memo guidance, claiming that it was a "legislative" not "interpretive" rule, violating § 553 of the Administrative Procedures Act (APA)[36] and § 706 because it created a new lighting standard that was not "consistent with

[34] Supra Note 25 (recommending, among other things, that each display generally remain static for between 4 and 10 seconds, and transition to a new display in 1 to 4 seconds).
[35] Scenic Am., Inc. v. United States DOT, 49 F. Supp. 3d 53, 2014 U.S. Dist. LEXIS 84129, (United States District Court for the District of Columbia, June 20, 2014, Filed), See also Complaint against Federal Highway Administration, Ray Lahood, Victor Mendez, United States Department of Transportation, Scenic America Inc. v. Dept. of Transportation et al, No. 1:13-cv- 00093 (D.D.C. Jan 23, 2013).
[36] Administrative Procedure Act, 5 U.S.C. §553 (2006).

customary use" as required by the HBA.[37] However, Scenic America lost on both counts, with the court claiming that it must defer to the agency's interpretation of its governing statute and "accord some measure of flexibility" to an "agency as it encounters new and unforeseen problems over time." Scenic America seemed to want FHWA to issue a regulation that defined "flashing, intermittent, or moving light or lights" in a manner consistent with the agency's historical position prior to 2007, and consistent with the policies of the HBA, to promote highway safety and preserve scenic beauty.[38] The court viewed FHWA's Memo as exempt from the notice-and-comment requirements of the APA because it was interpretive (i.e., it interpreted the common FSA lighting standards, and was not a new or amended legislative rule).[39]

FHWA's Memo helped clarify criteria for those promoting DBBs, but it also allowed states to step back from regulating EBBs so broadly. The FHWA Memo (*22*), with its broad ranges on criteria, excluded commercial, changeable, or CEVMS from FHWA's definition of "intermittent or flashing or moving" so long as these DBBs do not change messages more frequently than once every 4 seconds (*23*).

Although FHWA in 2014 outlined a process by which a state may amend the terms of the FSAs, updating them to reflect modern times,[40] it appears no state has fully completed this complex process to date. Scenic America also argued that the FHWA Memo violates the HBA because it does not conform to the procedures for establishing lighting standards under the HBA and because it creates lighting standards that are not "consistent with customary use," as required under HBA. HBA mandates that billboard "size, lighting, and spacing" standards "be determined by agreement between the several States and the Secretary."[41] The court disagreed, stating that FHWA's Memo did not create new lighting standards without state agreement and did not violate HBA.

Lighting

The state DOTs are authorized to promulgate rules pursuant to their own statutes and to federal law (HBA) 23 USC 131[42] and federal sign regulations 23 CFR 750.701 et seq. Some states are

[37] Petition for rulemaking from Scenic America requesting FHWA to issue a definition of "flashing, moving, or intermittent light or lights." (Feb. 23, 2010).
[38] Administrative Procedure Act, 5 U.S.C. §553 (b)(A).
[39] Supra Note 25.
[40] HBA, 23 USC § 131(d).
[41] Highway Beautification Act of 1965, 23 USC 131; also 23 CFR 750.705(h); Establishing a statewide unform program to control the use of advertising devices in areas adjacent to the State Highway System is a government goal. Many state statutes and regulations state that the intent of these Rules is to protect and promote the health, safety, and welfare of the traveling public. The state laws and rules often take HBA language in codifying the HBA, with goals to promote the "reasonable, orderly and effective display of outdoor advertising, while preserving and enhancing the natural and scenic beauty" of the state. This is uniquely implemented by the FSAs.
[42] For example, TN Code § 54-21-119 (2019) (h)(1) "All changeable message signs installed on or after July 1, 2014, shall come equipped with a light sensing device that automatically adjusts the brightness in direct correlation with ambient light conditions; (h)(2) The brightness of light emitted from a changeable message sign shall not

regulating specific brightness of digital signs with post-2007 lighting standards[43] in an attempt to keep up with changing technology and reduce glare.[44] States that allow CEVMS employ three methods to regulate the technology:

- Statutory changes.
- Administrative rule/regulations.
- Interpretation of the individual state's FSA.

After the FHWA Memo, many states had to re-evaluate how and what digital signs would be regulated at the state and local levels. In accordance with the FSAs, localities have powers to pass ordinances to control light pollution and regulate signs, since the FSAs and state law permits control by local zoning authorities, and these controls may govern in lieu of the size, lighting, and spacing controls set forth in the agreement. For local government to regulate billboards, certain conditions must be met:

- The local zoning authority's controls must include the regulation of size, of lighting, and of spacing of OA signs in all commercial and industrial zones.
- The regulations established by the local zoning authority may be either more restrictive or less restrictive than the criteria contained in the agreement, unless state law or regulations require equivalent or more restrictive local controls.
- If the zoning authority has been delegated extraterritorial jurisdiction under state law, and exercises control of OA in commercial and industrial zones within this extraterritorial jurisdiction, control by the zoning authority may be accepted in lieu of agreement controls in such areas.
- The state shall notify FHWA in writing of those zoning jurisdictions wherein local control applies. It will not be necessary to furnish a copy of the zoning ordinance. The state shall periodically assure itself that the size, lighting, and spacing control provisions of zoning ordinances accepted under this section are actually being enforced by the local authorities.
- Nothing contained herein shall relieve the state of the responsibility of limiting signs within controlled areas to commercial and industrial zones.[45]

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exceed 0.3 foot candles over ambient light levels measured at a distance of one hundred fifty feet (150′) for those sign faces less than or equal to three hundred square feet (300 sq. ft.)…"

[43] For example, WV Code § 17-22-4 (5) "No advertising sign shall contain lighting which is not shielded and any lighting shall be of such low intensity as not to cause *glare* or impair the vision of the operator of any motor vehicle…"

[44] 23 CFR 750.706 (c)(1-5).

[45] For example, Montana has ARM 18.6.202(9) for CEVMS: "Commercial variable message signs (CVMS)" means signs *other than electronic billboards* which contain, include, or are illuminated by any flashing, intermittent, or moving light or lights, producing the illusion of movement by means of electrical or electro-mechanical input and/or the characteristics of one or more of the following classifications…"

Sometimes a state will differentiate between DBB/EBBs and CEVMS.[46] Whereas other, often local, governments merge both categories together in defining them legally as the same item.[47] Some states and cities also call digital signs electronic signs,[48] electronic message centers (EMCs), or electronic message displays (EMDs). However, EMCs are mostly considered on-premise signs and are not regulated by the HBA. DBBs are off-premise or OA EMCs.[49]

At least 18 states have opted to use statutes to regulate these signs.[50] The more recent states to amend how they regulate digital signs are Kentucky (2021) and Tennessee (2020) due to Sixth Circuit litigation.[51] At least 15 states use administrative regulations to regulate digital control OA

[46] City of Lone Oak Texas, § 4-07-121 Definitions—changeable electronic variable message sign (CEVMS). A sign which permits light to be turned on or off intermittently or which is operated in a way whereby light is turned on or off intermittently, including any illuminated sign on which such illumination is not kept stationary or constant in intensity and color at all times when such sign is in use, including an LED (light emitting diode) or digital sign, and which varies in intensity or color. A CEVMS does not include a sign located within a right-of-way that functions as a traffic-control device and/or that is described and identified in the Manual on Uniform Traffic Control Devices (MUTCD) approved by the Federal Highway Administrator as the national standard. (Ordinance 110-2008, § 2, adopted 6/9/08; Ordinance adopting Code).

[47] 43 TX Admin Code § 21.142 (5) Electronic sign—A commercial sign that changes its message or copy by programmable electronic or mechanical processes., https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=43&pt=1&ch=21&rl=142

[48] Arizona (A.R.S. §§ 28-7902(E)-(L)); California (CAL. BUS & PROF. CODE § 5405(d)(1)); Colorado (COLO. REV STAT. § 43-1-404(1)(f)(I))(amended in 2021); Connecticut (CONN. GEN. STAT. §13a-123(f)); Delaware (DEL. CODE ANN. tit. 17 § 1110(b)(3)(e)); Georgia (GA. CODE ANN. § 32-6-75(c)(1)); Indiana (IND. CODE § 8-23-20-25.5); (105 IND. ADMIN. CODE § 7-3-1.5); Kansas (KAN. STAT. ANN. § 68.2234 (3)(e)); Michigan (MICH. COMP. LAWS § 252.318(f)); Minnesota (MINN. STAT.173.155); Missouri (MO. REV. STAT. § 226.540(1)(a))(2022); New York (N.Y. HIGH. LAW § 88 (2)(g)); Oklahoma (OKLA. STAT. tit. 69 §1275(d)(4)); Oregon (OR. REV. STAT. §§ 377.710(6) and 377.720(3)(d)); South Dakota (S.D. CODIFIED LAWS § 31-29-66(4)); Tennessee (TENN. CODE ANN. § 54-21-122); Utah (UTAH CODE ANN. § 72-7-505(1)(d)); Virginia (VA. CODE ANN. § 33.1-369).

[49] For more on the differences between DBBs and EMCs, see chart from ISA (shows differences between EMCs and Billboards, providing a side-by-side comparison and contrast between on-premise and off-premise signs. Each type of sign has very distinct capabilities and purposes; each targets a specific audience and each has traditionally been treated under separate legal and regulatory regimes), https://signs.org/codes-regulations/signcodehelp/emcs/

[50] L.D. Management Company v. Gray, 2021 WL 567817 (Feb. 16, 2021); Auspro Enterprises, LP v. Texas Dep't of Transportation, 506 S.W.3d 688 (Tex. App. 2016), review granted, judgment vacated (Apr. 6, 2018); and Thomas v. Bright, 937 F.3rd 721 (6th Cir. 2019). The United States Court of Appeals for the Sixth Circuit has jurisdiction over federal appeals arising from the states of Kentucky, Michigan, Ohio, and Tennessee.

[51] Alabama (ALA. ADMIN. CODE § 450-3-1-.13); Arkansas (ARK. CODE RULE § 001.00.07-001); Florida (FLA. ADMIN. CODE r.14-10.004); Idaho (IDAHO ADMIN. CODE § 39.03.60.300.05); Illinois (ILL. ADMIN. CODE tit. 92, §§ 522.20 and 522.150); Iowa (IOWA ADMIN CODE r.716-117.3(1)); Kentucky (603 KAR 10:021); Louisiana (LA. ADMIN. CODE tit. 70 § 132); Massachusetts (700 C.M.R. 3.17); Mississippi (tit. 7501-09002 MISS. CODE R. § 1000(5)); Montana (ARM 18.6.237); Nebraska (NEB. ADMIN. CODE § 410-3-002.05(D)); Nevada (NEV. ADMIN. CODE § 410.350); New Mexico (NMAC 18.21.5.13 and 18.21.5.14); 33. New Jersey (N.J. ADMIN CODE § 16:41C-8.8); North Carolina (tit. 19A N.C. ADMIN. CODE 2E.0203(4)); Ohio (OHIO ADMIN CODE 5501:2-2-02(B) and Informal AG Opinion); Rhode Island (RI CODE R. § VI); South Carolina (S.C. REG. § 63-354); Texas (tit. 43 TEX. ADMIN. CODE § 21.206); West Virginia (W. VA. CODE R. § 157-6-7.8); Wisconsin (WIS. ADMIN. CODE TRANS. § 201.15); Wyoming (tit. 2349 ch.16 WYO. CODE R. § 4).

and several are currently considering how to change regulations.[52] Other states rely on an interpretation of the state's FSA to allow CEVMS in that state (*24*).

When states regulate brightness, they typically use two commonly accepted metrics:

- Foot-candles, which measure illuminance, the amount of light coming from a lit object and striking an unlit object at a given distance.
- Nits, a measure of luminance, the density of light emitted from a lit object.[53]

Many state laws that regulate brightness are precisely similar to Tennessee's code:[54]

> (2) The brightness of light emitted from a changeable message sign shall not exceed 0.3 foot-candles over ambient light levels measured at a distance of one hundred fifty feet (150′) for those sign faces less than or equal to three hundred square feet (300 sq. ft.).

Localities may require stricter standards and often seek to ensure that OA light sources are deflected, shaded, and focused away from drivers and adjacent properties and do not create a spot glare nuisance. As brighter LED bulbs appear in OA, any overspill of lighting onto adjacent properties may exceed local standards and become a nuisance to the public. Resources to enforce rules may be scarce for states, but states create a job for themselves if they decide to ensure that display brightness will be adjusted as ambient light levels change and that the ambient light conditions associated with standard-size DBBs are monitored by a light-sensing devices.

Spacing Defined

Spacing is one of the key terms in the original FSAs that states have interpreted in creative ways to reduce digital off-premise billboard proliferation.[55] For example, in Montana:[56]

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[52] Maryland, New Hampshire, North Dakota and Pennsylvania (See Publication 581, April 2023, Highway Beatification Manual in Section 5.04 covers Changeable Message Signs, https://www.dot.state.pa.us/public/pubsforms/Publications/pub%20581.pdf)

[53] For example, TN Code § 54-21-119 (2019)(h)(2). Montana, Massachusetts, Michigan, New Mexico, Oregon, Puerto Rico, Tennessee, and Wyoming have adopted the standard to limit brightness to 0.3 foot candles above the surrounding light level.

[54] See Montana ADS 18.6.237; Colorado, CO Code § 43-1-404 (f)(I) (2022) (1000 feet apart for two digital signs, see § 43-1-404(1)(f)(I, C.R.S.)); Florida 479.07 Fla. Stat. (2015) Highway spacing of 1500 feet, but 1000 feet spacing in jurisdictions which adopt policies for voluntary sign removal in historic or sensitive districts); Massachusetts 700 CMR 3:17(5)(h) (500 feet for static billboards, but 1000 feet for digital); Mississippi Code R. § 1-7501-09002-1000 (3)(d) (1000 feet spacing for digital signs); Nebraska Neb. Admin. Code Ch. 3 § 410-3-002.05D2 (no 2 Changeable Message signs (CMS) may be less than 5000 feet apart); New Mexico NMAC 18.21.5.13 (1000 feet apart for electronic /CEVMS); New York Comp. Codes and Regs. Tit. 17 § 150.7 (2500 feet apart).

[55] Mont. Admin. R. 18.6.237 (2)(h) and (i).

[56] Metromedia v. San Diego, 453 US at 509-10.

> (h) an EBB must not be located within 1000 feet of the beginning or ending of the pavement widening, for each entrance or exit roadway, to the main-traveled way on interchanges, and within 500 feet of an intersection;
>
> (i) an EBB must not be placed within 2000 feet of another permitted sign measured along the nearest edge of the pavement between points directly opposite the signs on the same side of the roadway;

This means to get a permit or convert a regular sign to a digital sign in commercially zoned areas, a permit holder would have to reduce probably two or three adjacent signs, if they own them. If they do not own adjacent signs, the holder may have to buy them from whoever does own the signs. Regular signs have a 300-ft spacing, but digital signs have a 1000-ft spacing under the Montana regulation. Such rules provide a great financial disincentive to put up DBBs.

Aesthetic Interests of Government and the Public

In decades of case law, courts have recognized that state interests in traffic safety and esthetics may justify zoning regulations for advertising (*25*). Although this Montana sign reduction is accomplished by regulation and not statute, it seems to be an effective way to maintain the original federal goals of the HBA and government interests' states have in protecting natural aesthetics and traffic safety. Montana is known for its "Dark Skies" and has two designated Dark Sky sanctuaries (Lost Trail National Wildlife Refuge and Medicine Rocks State Park) as well as two international Dark Sky Parks (Waterton and Glacier National Parks).[57] Montana requires that EBBs approved as off-premise signs must be in a zoned commercial area within an incorporated town.[58] Their administrative regulation sets a brightness standard at 0.3 foot-candles over ambient light as measured by the distance to the EBB.[59] In Montana, an EBB must use automatic dimming technology to adjust to ambient light to avoid exceeding this brightness level.

Traffic Safety

For traffic safety interests, the Montana rule, like many other states, requires that EBB illumination may not interfere with the effectiveness of or obscure an official traffic sign, device, or signal.[60] An EBB must not cause beams, rays, or light to be directed at the traveled way if the light is of unreasonable intensity or brilliance or is likely to be mistaken for a warning or danger signal or cause glare or impair the vision of any driver, or to interfere with the driver's operation of a motor vehicle.[61]

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[57] MT ADC 18.6.237 (2)(d).
[58] MT ADC 18.6.237(1).
[59] MT ADC 18.6.237(2)(b).
[60] MT ADC 18.6.237 (2)(e).
[61] Id., at 166.

Case Law Concerning Digital Billboards

Outdoor advertising control (OAC) regulations must be evaluated with a consideration of extensive federal, state, and local authorities and a 50-year history of case law. OAC case law has primarily focused on freedom of speech, whether legal restrictions on signs were content-based or content-neutral, and the constitutionality of OAC rules. After the enactment of the HBA in 1965, on- and off-premises distinctions in advertising regulation proliferated among states and municipalities to support the goal of limiting off-premises signs within the HBA.

Municipal sign ordinances that distinguish between on-premises and off-premises signs, regulating the latter more heavily to protect public safety and preserve aesthetic value, have proliferated. These sign codes often ban the construction of new off-premises signs but grandfathered preexisting ones are subject to strict restrictions, including a prohibition of digitized messages. Courts are examining the on-/off-premises distinction to see if they are content-based regulatory classifications.

The role of the federal courts in interpreting federal/state statutes, federal/state regulations, and the U.S. Constitution affects how the digital sign/advertising/billboard industry conducts its business. A review of case law helps stakeholders to understand this complex legal framework and how governmental interests in traffic safety and aesthetics are balanced with restrictions on various types of speech and the duty of states to effectively control OA.

Standards of Judicial Review

In TxDOT Project 0-7085, the researchers described how different levels of judicial review are applied in case law.

> A review of the different levels of judicial review is useful before discussing the facts. Courts employ three forms of judicial review to determine whether a sign regulation is constitutional. The forms of judicial review are rational basis, intermediate scrutiny, and strict scrutiny. Rational basis review is the most lenient level of constitutional scrutiny. Under rational basis review, a regulation is constitutional if it is rationally related to a government purpose. The second standard, intermediate scrutiny, applies to regulations that affect constitutional rights but are either content-neutral or only applicable to commercial speech. Content-neutral regulations of noncommercial speech need only survive intermediate scrutiny.[62] Although laws that restrict only commercial speech are content based, such restrictions need only withstand intermediate scrutiny.[63]

[62] Central Hudson Gas & Elec. Corp. v. Public Serv. Comm'n of N.Y., 447 U.S. 557, 564, 100 S. Ct. 2343, 65 L. Ed. 2d 341 (1980).
[63] McCullen v. Coakley, 134 S. Ct. 2518, 2534 (2014), (citing Ward v. Rock Against Racism, 491 U.S. 781, 796 (1989)).

> Although deciding whether a particular regulation is content-based or content-neutral appears to be difficult to determine. To survive intermediate scrutiny review, a sign regulation should be content neutral and "narrowly tailored to serve a significant government interest."[64] Finally, strict scrutiny review applies to regulations that affect fundamental constitutional rights, particularly free speech rights protected by the First Amendment. Strict scrutiny requires that a regulation be "narrowly tailored to further a compelling government interest" (*19*). Because strict scrutiny requires the regulation to be the least restrictive means necessary to achieve the purported purpose of the regulation, it is an almost insurmountable standard that often results in the determination of the regulation as unconstitutional.[65]

Procedural History and Chronology of Cases on Sign Regulation

Table 1 provides a list of relevant case law. These will be discussed in the following subsections.

[64] Reed, 576 U.S. at 172.
[65] Reed v. Gilbert, 576 U.S. 155, 171 (2015).

Table 1. Simplified Case Law Chronology: Sign Regulation (Freedom of Speech, Content Based Regulation, and Standard of Scrutiny).

Year	Case	Issue
1981	*Metromedia* (S.Ct.)(1981)	Off-premise commercial billboards: regulation of off-premises signs advances government interests in "traffic safety and esthetics." Those interests are "substantial governmental goals."
2015	*Reed* (S.Ct.)(2015)	Town's sign code, which imposed more stringent restrictions on *noncommercial* directional signs than it did on other signs, was content-based regulations because the restrictions depended entirely on the communicative content of the sign; provisions failed strict scrutiny; safety and aesthetics were government interests.
2020	*Reagan* (5th Cir.) (8/25/2020 filed)	City sign code that did not allow the digitization of off-premises signs violated the First Amendment because its on-premises/off-premises distinction was content-based; did not pass the *strict* scrutiny test.
2022	*Reagan* (S.Ct.) (4/21/2022)	City's ordinance, which distinguished between on-premises and off-premises signs and specially regulated the latter, was facially content-neutral; *not* subject to strict scrutiny under the First Amendment absent a content-based *purpose or justification*. Provisions did not single out any *topic* or subject matter for differential treatment, and the message on the sign mattered only to the extent that it informed the sign's relative *location*. (Told 5th Cir. that intermediate scrutiny was appropriate on remand as the standard unless an improper purpose for the code is identified.)
2023	Adams Outdoor Advertising Ltd. P'ship v City of Madison (7th Cir.) (1/4/2023)	Challenge to a city's sign-control ordinance ban on digital displays; the on-/off-premises distinction in the city's sign code was content-neutral (not triggering strict scrutiny), so intermediate scrutiny applied. Ban on digital-image signs upheld. The Seventh Circuit had the benefit of using the April 21, 2022 decided *Reagan* court reasoning in this case.
2023	*Reagan* (5th Cir. Remand) (3/30/2023)	Austin's code distinction between on-premises and off-premises signs survived intermediate scrutiny (First Amendment) because the sign code did not allow *content* discrimination. (Noncommercial and commercial off-premises signs were treated similarly, based on location.)

Reed v Gilbert (2015)

In 2015, the U.S. Supreme Court's decision in *Reed v. Town of Gilbert*[66] caused a reevaluation of the constitutionality of most sign regulations. The court held that the Town of Gilbert's sign code violated the First Amendment because it regulated speech based on its "communicative content."[67] By subjecting content-based regulations of non-commercial speech (political and ideological signs) to the most exacting level of judicial review, strict scrutiny, the court narrowed the scope of constitutionally enforceable sign regulations and found the speech restrictions in this case to be unjustified by safety concerns and not narrowly tailored to government interests.

The court also held that the sign code's provisions could not survive First Amendment strict scrutiny because the town could not claim that placing strict limits on temporary directional signs was necessary to beautify the town while it simultaneously allowed unlimited numbers of other types of signs to proliferate and create the same problem. The town failed to show that limiting temporary directional signs was necessary to eliminate threats to traffic safety, but that limiting other types of signs was not.

The Gilbert Sign Code identified various categories of signs based on the types of information they convey, then subjected each category to different restrictions. One of the categories was "Temporary Directional Signs Relating to a Qualifying Event," loosely defined as signs directing the public to a meeting of a nonprofit group.[68] The code imposed more stringent restrictions on these signs than it did on signs conveying other messages. The court thus held that these provisions were content-based regulations of speech that could not survive strict scrutiny.[69]

This case provided steps to determine if a speech restriction was content-based before the court applied a level of scrutiny. Commercial speech is treated differently than noncommercial speech under the law. Under the First Amendment,[70] a government has no power to restrict expression because of its message, ideas, subject matter, or its content.[71]

Commercial Speech Generally

Commercial speech is entitled to a lesser degree of constitutional protection than non-commercial speech. Commercial speech is speech that "does no more than propose a commercial transaction."[72] In *Central Hudson Gas & Elect. Corp. v. Pub. Serv. Comm'n of New York*

[66] Reed 576 US at 163 (2015).
[67] Reed, 576 U.S. 155, 159 (2015).
[68] §4.402(P).
[69] U.S. Const., First Amendment. (The First Amendment applies to the states through the U.S. Constitution, Fourteenth Amendment.)
[70] Police Dep't of Chicago v. Mosley, 408 U. S. 92, 95, 92 S. Ct. 2286, 33 L. Ed. 2d 212 (1972).
[71] R. A. V. v. St. Paul, 505 U. S. 377, 395, 112 S. Ct. 2538, 120 L. Ed. 2d 305 (1992); Simon & Schuster, Inc. v. Members of N. Y. State Crime Victims Bd., 502 U. S. 105, 115, 118, 112 S. Ct. 501, 116 L. Ed. 2d 476 (1991).
[72] Cent. Hudson Gas & Elec. Corp. v. Pub. Serv. Comm'n of New York, 447 U.S. 557 (1980).

(Hudson), the U.S. Supreme Court held that restrictions on commercial speech are constitutional if:

- The speech concerns a lawful activity and is not misleading.
- A substantial state interest is furthered by that restriction.
- The restriction directly advances the state interest.
- The restriction is narrowly drawn to serve the state's interest.[73]

Intermediate Scrutiny and Narrowly Tailored

Content based laws (i.e., those that target speech based upon the communicative content of the speaker) are presumptively unconstitutional and may be justified only if the government proves that they are "narrowly tailored" to serve a compelling state interest.[74] When a law imposes content-based restrictions on speech, those legal provisions can stand only if they survive strict scrutiny, "which requires the Government to prove that the restriction furthers a compelling interest and is narrowly tailored to achieve that interest,"[75] thus the question of which level of scrutiny matters, since strict scrutiny tends to strike down invalid laws.

In free speech cases, it is the government's burden to demonstrate that the code's differentiation between temporary directional signs and other types of signs, such as political signs and ideological signs, furthers a compelling governmental interest and is narrowly tailored to that end.[76]

Content-Based Regulations of Non-Commercial Signs and Strict Scrutiny

The sign ordinance reviewed in *Reed* applied different size, location, number, and duration restrictions on temporary directional signs, ideological signs, and political signs. The sign code defined the categories of temporary, political, and ideological signs on the basis of their messages and then subjected each category to different restrictions.[77] "Temporary Directional Signs" were defined as signs directing the public to a church or other "qualifying event," yet they had even greater legal restrictions than "ideological signs" and "political signs." The court determined the ordinance to be content-based because it required a town enforcement officer to read the communicative content of a sign in order to determine which regulations applied.[78] The

[73] See Rodriguez de Quijas v. Shearson/Am. Exp., Inc., 490 U.S. 477, 484 (1989). ("If a precedent of [the] Court has direct application in a case, yet appears to rest on reasons rejected in some other line of decisions, the [lower courts] should follow the case which directly controls, leaving to [the Supreme] Court the prerogative of overruling its own decisions.")
[74] Reed v. Town of Gilbert, 576 U.S. 155, 171, (June 18, 2015), 135 S. Ct. 2218, 2231, citing to Arizona Free Enterprise Club's Freedom Club PAC v. Bennett, 564 U. S. 721, 734, 131 S. Ct. 2806, 2817, 180 L. Ed. 2d 664, 675 (2011)) (quoting Citizens United, 558 U. S., at 340, 130 S. Ct. 876, 175 L. Ed. 2d 753).
[75] Reed v. Town of Gilbert, 576 U.S. 155, 171 (2015).
[76] Id at 171.
[77] Id at 64.
[78] Id at 156.

court further held that regulations that are facially content-based are "subject to strict scrutiny regardless of the government's benign motive, content-neutral justification, or lack of 'animus toward the ideas contained' in the regulated speech."[79] The court held that content-based restrictions on non-commercial speech are only upheld when the government can show the restriction is narrowly tailored to meet a compelling government interest. Here the ordinance allowed other categories of signs to be placed for longer periods of time, and the court determined the ordinance to be under-inclusive in light of the town's stated interests of aesthetic preservation and promotion of traffic safety.[80] *Reed* established that content-based restrictions on non-commercial speech are presumptively unconstitutional and do not survive strict scrutiny.[81]

After *Reed*, at least two state highway beautification acts have been held to be unconstitutional because they contained content-based regulations of non-commercial speech. In *Thomas v Schroer*, the Tennessee Billboard Act was determined by federal district court to be content-based because its distinctions between on-premise and off-premise signs drew "distinctions based on the message a speaker conveys."[82] The Sixth Circuit later affirmed the unconstitutionality of the act as applied to non-commercial speech and held that the act was not narrowly tailored to advance the law's purported interests in aesthetics and traffic safety (Auspro case).[83] In Texas, an appeals court ruled that an exemption for political signs from a general ban on highway advertising signs was content-based.[84] The Texas Court of Appeals invalidated the Texas HBA as unconstitutional because it was unable to survive strict scrutiny under *Reed*. However, in 2018, the Texas Supreme Court vacated the judgments of the Court of Appeals and trial court and dismissed the case as moot. While the appeal was pending, the Texas Legislature amended the HBA in 2017. The newly amended Texas HBA then essentially solved the act's First Amendment problems from a judicial standpoint such that the dismissal may have legally nullified the precedential value of Auspro.

Reagan and Noncommercial Signs

The remanded *Reagan* case did not truly address the broader issues in the distinction between noncommercial and commercial signs specifically due to the fact that the Supreme Court found the regulation facially content neutral and thus probably not subject to strict scrutiny. However, the Supreme Court left to the lower court any decision on whether there was an impermissible purpose or justification underpinning the content neutral restriction.

[79] Id at 171.
[80] Id at 159. (J. Thomas).
[81] Thomas v. Schroer, 248 F. Supp. 3d 868 (W.D. Tenn. 2017).
[82] Thomas v. Bright, 937 F.3d 721 (6th Cir. 2019); As a result of this case, Tennessee passed a law on June 25, 2020 (HB 2255, The Outdoor Advertising Control Act of 2020) which defines "on premises" signs and is modeled after the Texas compensation-based legal scheme for commercial signs.
[83]Auspro Enterprises, LP v. Texas Dep't of Transp., 506 S.W.3d 688 (Tex. App.—Austin- 2016, judgment vacated as moot).
[84] Reagan 2022 at 1468.

This court's determination that the city's on-/off-premises distinction is facially content neutral does not end the First Amendment inquiry. Evidence that an impermissible purpose or justification underpins a facially content-neutral restriction may mean that the restriction is nevertheless content-based. Moreover, to survive intermediate scrutiny, a restriction on speech or expression must be "narrowly tailored to serve a significant governmental interest."[85] Because the Court of Appeals did not address these issues, the court leaves them for remand and expresses no view on the matters.[86]

The "purpose" step comes after the "facially content neutral" step. "That does not mean that any classification that considers function or purpose is *always* content based. Reagan's reading of *Reed* would contravene numerous precedents and cast doubt on the Nation's history of regulating off-premises signs."[87]

Reagan (2021) Fifth Circuit

After *Reed*, the 2021 *Reagan* case was heard in the Fifth Court of Appeals, in which the Fifth Circuit found the on- versus off-premises distinction to be "facially content based" because the official had to read a sign's message to determine whether the sign was off-premises. The sign company appealed. This *Reagan* case then made its way to the Supreme Court.

Reagan (2022) at the Supreme Court

The Supreme Court[88] found that the Fifth Circuit decision in *Reagan* was "too extreme,"[89] and the court then refined its *Reed* holding, saying that the City of Austin's on-/off-premises distinction was facially content neutral or not facially content-based.[90] This set the precedent for all federal courts nationwide. This validated statutes, regulations, and ordinances created to support the HBA goals—if they are "location based" on their faces they will not be found as content based. The regulatory distinction must be based upon location and not "communicative content." Here, the U.S. Supreme Court held that, absent an impermissible purpose, the code

[85] Ward v. Rock Against Racism, 491 U. S. 781, 791, 109 S. Ct. 2746, 105 L. Ed. 2d 661.
[86] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1468, (2022)
[87] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464 (April 21, 2022) (Breyer, J., filed a concurring opinion. Alito, J., filed an opinion concurring in the judgment in part and dissenting in part. Thomas, J., filed a dissenting opinion, in which Gorsuch and Barrett, JJ., joined.) ; See also Brief for National League of Cities et al. as *Amici Curiae* In Support Of Petitioner, City Of Austin V. Reagan Nat'l Advertising Of Austin, Inc., 2021.S. S. Ct. Briefs Lexis 2194 (Supreme Court Of The United States August 20, 2021), available at https://advance- lexis-com.ezproxy.lib.utexas.edu/api/document?collection=briefs-pleadings- motions&id=urn:contentItem:63G3-77W1-JSXV-G265-00000-00&context=1516831. (saying local communities regulate digital billboards to promote safety and to preserve aesthetics and that digital billboards pose a risk to public safety.)
[88] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1467, (U.S. April 21, 2022), ("The Court of Appeals' interpretation of Reed—to mean that a regulation cannot be content neutral if its application requires reading the sign at issue—is too extreme an interpretation of this Court's precedent.").
[89] Reagan (2022) at 1474.
[90] Adams Outdoor Adver. Ltd. P'ship v. City of Madison, 56 F.4th 1111, 1119 (7th Cir. Decided Jan. 4, 2023).

would be subject to intermediate scrutiny. The court left it to the Fifth Circuit to assess the constitutionality of the regulation on remand.

Reagan: Topic or Subject Matter versus Function or Purpose

In *Reagan* (2022), "unlike the sign code in *Reed*, the City's sign ordinances here did not single out any topic or subject matter for differential treatment: A sign's message matters only to the extent that it informs the sign's relative location. Thus, the City's on-/off-premises distinction is more like ordinary time, place, or manner restrictions, which do not require the application of strict scrutiny. Cf. *Frisby* v. *Schultz*, 487 U. S. 474, 482. Pp. 6-8, 108 S. Ct. 2495, 101 L. Ed. 2d 420."[91]

In rejecting the official "must read the sign" first rule of Reed, the Reagan court applied subject matter content-based precedents to reach the "common sense" result that a "location-based and content-agnostic on-/off-premises distinction does not, on its face, 'singl[e] out specific subject matter for differential treatment.'"[92]

Since subject matter here is not the issue, the court looked at "function or purpose." Respondent Reagan argued that the city's sign code defines off-premises signs on the basis of function or purpose and is therefore content-based and subject to strict scrutiny.[93]

The argument stretches *Reed*'s "function or purpose" language too far. The principle the *Reed* court articulated is more straightforward. While overt subject-matter discrimination is facially content-based (for example, "Ideological Sign[s]," defined as those "communicating a message or ideas for noncommercial purposes"), so, too, are subtler forms of discrimination that achieve identical results based on function or purpose (for example, "Political Sign[s]," defined as those "designed to influence the outcome of an election").[94] In other words, a regulation of speech cannot escape classification as facially content-based simply by swapping an obvious subject-matter distinction for a "function or purpose" proxy that achieves the same result. That does not mean that any classification that considers function or purpose is always content based. Such a reading of "function or purpose" would contravene numerous precedents, including many of those discussed above. Reed did not purport to cast doubt on these cases.[95]

The court concluded that, "absent a content-based purpose or justification, the City's distinction is content neutral and does not warrant the application of strict scrutiny."[96]

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[91] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1467, (2022).
[92] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1475, (2022) (citing to Reed 576 US at163).
[93] Reagan (2022) at 1457-8.
[94] *Id.*, at 159, 160, 163-164, 135 S. Ct. 2218, 192 L. Ed. 2d 236 (alterations in original).
[95] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1474, (2022).
[96] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1471, (2022).

Adams v. Madison (Jan. 2023) Seventh Circuit

The Seventh Circuit applied the *Reagan* reasoning in narrowing *Reed* here. The court found the distinction between on- and off-premises signs were used to "draw a regulatory line based on location," not "communicative content."[97] Notable here was the court's recognition that the government justified its restrictions based upon its interest in "promoting traffic safety and preserving visual aesthetics."[98] This case has a good discussion of this topic and on how it found the prohibition on converting signs to digital ones was valid based upon *Metromedia*.[99]

Reagan (2023) Fifth Circuit Remand

On remand, the Fifth Circuit Court examined Austin's Ch. 25-10, which included the off-premise sign "digitization ban" that Reagan sought to invalidate. Although the appeal focused on the on- versus off-premise sign distinction, it also examined the city's ban on converting grandfathered off-premise billboard faces to digital face billboards. Thus the 2023 *Reagan* case[100] reexamined the digitization of signs issue within the larger government interests, intermediate scrutiny, and freedom of speech context.

Of note in this case, was its citation to the Seventh Circuit *Madison* sign case[101] a few months before it. The court noted that although Reagan says "the city must provide empirical evidence linking DBBs to aesthetic or safety-related harms. Not so [t]he connection between billboards and traffic safety is too obvious to require empirical proof."[102] The court here defers to the city in its "legislative judgment." The city's sign code is supported by the same logic. The city is entitled to use its legislative judgment to conclude that off-premises advertising undermines its interests in safety and aesthetics more than on-premises advertising does.[103]

When the standard of scrutiny changes from strict to intermediate, the burden of proof for evidence from the city to justify its interests lowers:

> The City also argues, though it provides no evidence we can find, that off-premises signs are larger than those on-premises, and thus the former cause more

[97] Id at 1120.
[98] Id.
[99] Reagan Natl. Advertising of Austin, Inc. and Lamar Advantage Outdoor Co. L.P. v City of Austin, 64 F.4th 287 (2023).
[100] Adams Outdoor Adver. Ltd. P'ship v. City of Madison, 56 F.4th 1111 (7th Cir. Decided Jan. 4, 2023). (Note that the Seventh Circuit had the benefit of using the April 21, 2022, decided *Reagan* Court reasoning in this case.)
[101] Adams Outdoor Adver. Ltd. P'ship v. City of Madison, 56 F.4th 1111, 1120 (7th Cir. Decided Jan. 4, 2023)
[102] Reagan Nat'l Adver. of Austin, Inc. v. City of Austin, 64 F.4th 287, 294 (5th Cir. 2023); but see J. Walker Elrod's dissent in this case, at 299: "In short, the substantial deference applied by the majority opinion has no place in the intermediate-scrutiny analysis of non-commercial speech restrictions."
[103] Reagan Nat'l Adver. of Austin, Inc. v. City of Austin, 64 F.4th 287, 296-297, (5th Cir. 2023).

> visual clutter. More generally, Austin provided little empirical evidence supporting its restrictions.[104]
>
> Nonetheless, intermediate scrutiny has "never required" a municipality to "demonstrate, not merely by appeal to common sense, but also with empirical data, that its ordinance will successfully" achieve the desired end.[105] "[M]unicipalities must be given a reasonable opportunity to experiment with solutions to address the secondary effects of protected speech."[106] As a result, "[t]he quantum of empirical evidence needed to satisfy heightened judicial scrutiny [19] of legislative judgments will vary up or down with the novelty and plausibility of the justification raised." Nixon v. Shrink Missouri Gov't PAC, 528 U.S. 377, 391, 120 S. Ct. 897, 145 L. Ed. 2d 886 (2000).[107]

Although the *Reagan* court cited light and safety studies on billboards listed in amici briefs, many of these are now outdated considering the rapid changes in LED bulb and other digital sign technology since 2007.[108]

Scrutiny Questions

In *Adams*,[109] the Seventh Circuit Court applied the new U.S. Supreme Court *Reagan* rules and declared the on/off-premises distinction subject to intermediate scrutiny, observing that prohibiting digital signs advanced the city's significant interests in aesthetics and traffic safety. This led to the court upholding the ban.

While Adams helped the Fifth Circuit decide on Reagan remand, the dissent was strong. The dissent concluded that Austin did not carry its burden to survive intermediate scrutiny. The Fifth Circuit dissent in *Reagan (2023)* on remand pointed out some lingering problems in the majority's common sense:[110]

> The City offers no studies, surveys or statistics to suggest digitizing the limited number of grandfathered off-premises signs would be either more dangerous or less attractive than digitizing on-premises signs. Neither does common sense support the distinction because off-premises digital signs employ the exact same

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[104] Id.
[105] City of Los Angeles v. Alameda Books, Inc., 535 U.S. 425, 439, 122 S. Ct. 1728, 152 L. Ed. 2d 670 (2002).
[106] Id. (quotation marks and citations omitted).
[107] See Amici brief by NLC; There were 28 briefs in the Reagan 2022 case, most of which were amici briefs rich with research and statistics on safety.
[108] Reagan Nat'l Adver. of Austin, Inc. v. City of Austin, 64 F.4th 287, 289 (5th Cir. 2023), (Citing Metromedia 453 US at 512).
[109] Adams Outdoor Advert. Ltd. P'ship v. City of Madison, Wisconsin, 20-1670, 2023 WL 33962 (7th Cir. Jan. 4, 2023).
[110] Reagan, 64 F.4th 287, 298 (2023) (on remand).

> technology as their on-premises counterparts.... When put under the appropriate quantum of scrutiny, the City's justification do not hold up.

The dissent also addressed the majority's reliance on *Metromedia*. The dissent noted that in *Metromedia*, the Supreme Court limited its deference to legislative judgment "to purely commercial speech restrictions"[111] and explained that non-commercial speech requires more protection. The dissent disagreed with the majority that *Metromedia's* commercial versus non-commercial distinction was "not legally relevant," stating that the majority "invents a logical rule that does not exist in *Metromedia*."[112]

Although the Fifth Circuit majority used *Adams* to support its decision, the dissent disagreed. The dissent pointed out that *Adams* only applied to commercial messages, unlike the Austin ordinance, "which appl[ied] to both commercial and non-commercial messages." The dissent concluded, "In short, the substantial deference applied by the majority opinion has no place in the intermediate-scrutiny analysis of non-commercial speech restrictions."[113]

Although the dissent did not win, questions remain from Justice Alito's concurrence in *Reagan*: What happens with noncommercial speech? Regulators should be aware of the pitfalls when drafting a regulatory framework. Must a sign ordinance define noncommercial and commercial Speech? Not always.[114] Can on-premise signs be limited to commercial speech? The short answer is no.[115]

Content-Based Regulations of Commercial Signs and Intermediate Scrutiny

In *Reagan 2023*, the court reiterated that a commercial enterprise "has a stronger interest in identifying its place of business and advertising the products or services available there than it has in using or leasing its available space for the purpose of advertising commercial enterprises located elsewhere."[116] However, any concern with Austin's different treatment of commercial and noncommercial speech was not addressed as the ordinance distinguished signs by location and not type of business, restricting commercial off-premise signs equally with noncommercial off-premise signs:[117]

> By "communicative interests," the Court was referencing the fact that San Diego's regulations discriminated on the basis of content, allowing some noncommercial messages but not others. Id. at 494, 514-16. The Court was

[111] Id. At 299.
[112] Id. At 299.
[113] Reagan, 64 F.4th 287, 299; 2023 US App. LEXIS 7583, 25.
[114] Major Media of Southeast, Inc. v. Raleigh, 792 F.2d 1269, 1272 (4th Cir. 1986).
[115] Metromedia, Inc. v. City of San Diego, 453 U.S. 490, 513 (1981).
[116] Reagan Nat'l Adver. of Austin, Inc. v. City of Austin, 64 F.4th 287, 296, (5th Cir. 2023).
[117] Reagan Nat'l Adver. of Austin, Inc. v. City of Austin, 64 F.4th 287, 296, 2023 U.S. App. LEXIS 7583, *17, 2023 WL 2702582 (5th Cir. Tex. March 30, 2023).

concerned about government control of "the appropriate subjects for public discourse." Id. at 515. That concern is absent here. As the Supreme Court determined, Austin's Sign Code does not allow content discrimination.

Commercial Speech in Reed (2015)

Because the court in *Reed* only addressed the constitutionality of content-based restrictions on non-commercial speech, the constitutionality of content-based restrictions of commercial speech still remains in flux. A factor supporting the constitutionality of such regulations is the principle that the Supreme Court does not overrule itself by implication.[118] The majority opinion in *Reed* did not address the potential impact of the decision on the commercial speech doctrine. However, a circuit split on the issue exists.[119]

Reed's Impact Across Circuits Prior to Reagan

In 2019, *Thomas v Bright* held that the Tennessee Billboard Act, Tenn. Code Ann. § 54-21-103(3), violated the First Amendment because it had a content-based restriction that did not survive strict scrutiny. In applying *Reed*, the court determined that the act had a content-based restriction because, to determine whether the on-premises exception applied, a state official must read the message written on the sign to determine its meaning, function, or purpose. The act did not survive strict scrutiny because the state did not show that the restriction was narrowly tailored to serve a compelling interest since the act discriminated against non-commercial speech on, but unrelated to the premises, while allowing on-premises commercial speech.

In 2020, in *International Outdoor, Inc. v. City of Troy*, the Sixth Circuit rejected the traditionally used Hudson standard, used by other circuits, which would apply intermediate scrutiny to commercial speech.[120] Here, the court held that the City of Troy's sign ordinance should be subject to strict scrutiny because it contained content-based restrictions.[121] The ordinance, which regulated commercial and non-commercial speech differently, required the city to consider the content of the message before deciding which treatment to apply.[122] The ordinance exempted

[118] The D.C. Circuit has interpreted Reed differently. See Act Now to Stop War and End Racism Coal. & Muslim Am. Soc'y Freedom Found. v. District of Columbia, 846 F.3d 391, 404, 427 U.S. App. D.C. 296 (D.C. Cir. 2017), cert. denied, 138 S. Ct. 334 (2017).
[119] Troy rejected the Hudson standard of intermediate scrutiny for commercial speech, and in doing so, also rejected the reasoning used by the Tenth, Third, Second and Ninth Circuits. This contributes to the Circuit split."
[120] Int'l Outdoor, Inc. v. Troy, 974 F.3d 690 (6th Cir. 2020).
[121] Id. At 706.
[122] During the course of litigation, Troy amended its sign code possibly to address the content-based constitutional challenges to its code. Id. At 695. Despite the procedural issues, the Court examined whether a sign regulation of commercial speech should be evaluated under the "intermediate scrutiny" of Central Hudson Gas & Electric vs Public Service Comm., or the "strict scrutiny" test of Reed. In choosing "strict scrutiny", the 6th Circuit Court relied on Thomas vs Bright, 937 F.3d 721 (6th Cir. 2019) and applied Reed, at 166: ""[b]ecause strict scrutiny applies either when a law is content based on its face or when the purpose and justification for the law are content based, a court must evaluate each question before it concludes that the law is content neutral and thus subject to a lower level of scrutiny."

certain types of signs, such as temporary signs and garage sale signs, from permitting requirements. The court reasoned that intermediate scrutiny only applies to commercial speech regulations that are content-neutral on their face and that *Reed's* strict scrutiny is triggered when the commercial speech regulations are not content-neutral.[123]

Relying on the Sixth Circuit's decision in *Thomas v. Bright*,[124] the Fifth Circuit, in *Reagan Nat'l Advertising of Austin, Inc. v. Austin*,[125] invalidated an Austin sign ordinance that distinguished between on-premise and off-premise signs.[126] The court said the distinction was content-based because it required a government official to read the sign's content in order to determine whether the sign met the ordinance's off-premise definition.[127] The ordinance included a substitution clause which permitted a non-commercial message to replace any commercial message. However, the court concluded that clause could not save the ordinance because the content-based distinction applied with "equal force to commercial and non-commercial messages."[128] Here, the content-based regulation was held to not be subject to the commercial speech exception, so strict scrutiny applied.[129] However, the Fifth Circuit later had to correct this and apply intermediate scrutiny in the *Reagan* remand of 2023.

Despite the increasing application of strict scrutiny to noncommercial signs after *Reed*, that case was silent on commercial speech. For certain circuits, the intermediate scrutiny standard applicable to commercial speech (*Hudson*) applies only to a speech regulation that is content-neutral on its face.[130] Certain cases show a regulation of commercial speech that is not content-neutral is subject to strict scrutiny. However, several other circuits have continued to apply intermediate scrutiny to content-based regulations of commercial speech.[131] In July 2021, the Supreme Court issued certiorari[132] for *Reagan*, which narrowed the *Reed* holding.

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[123] Thomas v. Bright, 937 F.3d 721 (6th Cir. 2019).
[124] Reagan Nat'l Advertising of Austin, Inc. v. Austin, 972 F.3d 696 (2020), 2020 WL 5015455 (5th Cir. August 25, 2020), cert. granted
[125] 972 F.3d 696 (2020), 2020 WL 5015455 (5th Cir. August 25, 2020).
[126] Id. At 701. "Because an off-premises sign is determined by its communicative content, we hold that the Sign Code's distinction between on-premises and off-premises signs is content based."
[127] Id. at 708 (The regulation applied to any noncommercial message "off-premises").
[128] Id. At 701.
[129]The Fifth, Sixth and Eighth Circuits appear to differ on the application and reasoning of Reed strict scrutiny compared to the standards and reasoning used in the Tenth, Third, Second and Ninth Circuits. This disagreement contributes to the Circuit split which may get clarification in 2022 by the US Supreme Court.
[130] Troy rejected the Hudson standard of intermediate scrutiny for commercial speech, and in doing so, also rejected the reasoning used by the Tenth, Third, Second and Ninth Circuits. This contributes to the Circuit split.
[131] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 212 L. Ed. 2d 418, 2022 (Supreme Court of the United States April 21, 2022, Decided). The Court remanded the case back to the Fifth Circuit to revisit remaining questions. In a 5-4 decision, The Court provided one concurrence, one concurrence in the judgment in part and dissent in part; and one dissent.
[132] Certiorari simply defined is a "writ" by which a higher court (such as an appellate court) reviews some lower court's decision (such as a district court). See Legal Information Institute. https://www.law.cornell.edu/wex/certiorari and Merriam Webster Dictionary. https://www.merriam-webster.com/dictionary/certiorari

Reagan Case at the Supreme Court

The City of Austin's OA ordinance, which distinguished between on-premises and off-premises signs and which specifically regulated off-premise signs, was held facially content-neutral and was not subject to strict scrutiny review under the First Amendment. The city had denied permits to the advertising company (Reagan)[133] seeking permits to digitize some of its billboards. Reagan National Advertising alleged that the city's prohibition against digitizing off-premise signs, but not on-premise signs, violated the First Amendment's Free Speech Clause. The Supreme Court's application of intermediate—and not strict—scrutiny here was significant because the lower courts in this case had applied the *Reed* case in determining if the on/off-premise distinction was content-based or content-neutral.

Even if a city's ordinance is facially content neutral, a court must still determine if there is evidence that an impermissible purpose or justification underpins a facially content-neutral restriction. If so, that restriction may be still found to be content-based.[134] Here, the ordinance's provisions did not single out any topic or subject matter for differential treatment, and the message on the sign mattered only to the extent that it revealed the sign's location.[135] This means a given sign is treated differently based solely on whether it is located on the same premises as the thing being discussed or not. The on/off-premises distinction is therefore similar to ordinary time, place, or manner restrictions. *Reed* does not require the application of strict scrutiny to this kind of location-based regulation, the court said. Most importantly, the court, in clarifying the scope of its holding in *Reed*, cautioned against "stretch[ing] Reed's 'function or purpose' language too far."[136] *Reed* does not, the court explained, stand for the proposition that "any classification that considers function or purpose is always content based." Only "regulations that discriminate based on 'the topic discussed or the idea or message expressed' are content based."[137] Because the city's sign code did not discriminate on those bases, the court concluded that it was not facially content based.[138]

The court found that, to survive intermediate scrutiny, a restriction on speech or expression must be narrowly tailored to serve a significant governmental interest.[139] Ordinarily the level of judicial scrutiny a regulation must withstand will lead to the regulation being upheld or held invalid. The Supreme Court reversed the Fifth Circuit on the judicial scrutiny question, narrowing the scope of *Reed*, and advised the Fifth Circuit to apply intermediate scrutiny on remand.

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[133] Reed, 576 US at 164.
[134] Reed, 576 US at 163.
[135] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 596 U.S. 61, 71-72, 142 S. Ct. 1464, 1474.).
[136] Id. Citing Reed 576 at 171.
[137] Id. At 1474.
[138] Reed, 576 at 1475-6, Citing Ward v. Rock Against Racism, 491 U. S. 781, 791, 109 S. Ct. 2746, 105 L. Ed. 2d 661 (1989).
[139] Reagan at 1473.

Post Reagan

After *City of Austin v Reagan*[140] was decided on April 21, 2022, the various circuits have been following the precedent on Freedom of Speech within *Reagan*.[141]

In fact, the Fourth,[142] Fifth,[143] Sixth,[144] Seventh,[145] Tenth,[146] and D.C. Circuits[147] have all followed *Reagan* since its decision.

[140] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464 (2022); 212 L. Ed. 2d 418, 2022 U.S. LEXIS 2098, (April 21, 2022, Decided).

[141] In shepherdzing the *Reagan* case, we found that the Fourth Circuit, Fifth, Sixth Seventh and DC Circuit have all followed the Supreme Court's First Amendment analysis in *Reagan*. https://advance-lexis-com.ezproxy.lib.utexas.edu/api/permalink/17b1b05f-b3c2-4685-862f-b9d05a2a2513/?context=1519360&identityprofileid=3NGKCP51903

[142] For example, in the Fourth Circuit Courts, Adams Outdoor Adver. Ltd. P'ship v. Town of Mount Pleasant, 2023 U.S. Dist. LEXIS 120536, 2023 WL 4491197 (United States District Court for the District of South Carolina, Charleston Division July 12, 2023, Filed). https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a68P9-YVV1-DXPM-S003-00000-00&context=1519360&identityprofileid=3NGKCP51903.

[143] For example, in the Fifth Circuit, cases include, i.a.: Nat'l Press Photographers Ass'n v. McCraw, 90 F.4th 770, 2024 U.S. App. LEXIS 683 (United States Court of Appeals for the Fifth Circuit January 10, 2024, Filed), available at https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a6B2Y-0J83-RSGF-X502-00000-00&context=1519360&identityprofileid=3NGKCP51903 ; Nat'l Fed'n of the Blind of Tex. Inc. v. City of Arlington, 2022 U.S. Dist. LEXIS 162768, 2022 WL 4125094 (United States District Court for the Northern District of Texas, Dallas Division September 9, 2022, Filed), available at https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a66BV-K191-JKPJ-G010-00000-00&context=1519360&identityprofileid=3NGKCP51903

[144] Sixth Circuit cases include, i.a. , Spring House Commercial, LLC v. City of Richmond, 2022 U.S. Dist. LEXIS 217430, 2022 WL 17406310 (United States District Court for the Eastern District of Kentucky, Central Division December 2, 2022, Filed), available at https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a670S-9CC1-F1H1-24T3-00000-00&context=1519360&identityprofileid=3NGKCP51903.

[145] Seventh Circuit cases include, i.a., Adams Outdoor Adver. Ltd. P'ship v. City of Madison, 56 F.4th 1111, 2023 U.S. App. LEXIS 125, 2023 WL 33962 (United States Court of Appeals for the Seventh Circuit January 4, 2023, Decided), available at https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a677T-MN31-FH4C-X4CN-00000-00&context=1519360&identityprofileid=3NGKCP51903.;

[146] Tenth circuit cases include, i.a. Streetmediagroup, LLC v. Stockinger, 79 F.4th 1243, 2023 U.S. App. LEXIS 22000 (United States Court of Appeals for the Tenth Circuit August 22, 2023, Filed), available at https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a690R-3T21-JJ6S-60NB-00000-00&context=1519360&identityprofileid=3NGKCP51903.

[147] DC Circuit cases include, i.a. Green v. United States DOJ, 54 F.4th 738, 459 U.S. App. D.C. 302, 2022 U.S. App. LEXIS 33559, 2022 U.S.P.Q.2D (BNA) 1177 (United States Court of Appeals for the District of Columbia Circuit December 6, 2022, Decided). https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a671H-FW91-F4GK-M54N-00000-00&context=1519360&identityprofileid=3NGKCP51903.

The Seventh Circuit has held that sign ordinances that prohibited off-premise signs[148] and that banned off-premise digital signs are not content-based.[149] In the Eighth Circuit, courts have held that a location-based distinction between off-premises signs and on-premises signs was not content based.[150]

With the *Reagan* case framework, courts are equipped to examine a sign regulation of speech and determine if it is facially content based under the First Amendment if it targets speech based on its communicative content—that is, if it applies to particular speech because of the topic discussed or the idea or message expressed.[151]

Reagan's Holding on the Fourteenth Amendment: Aesthetics and Traffic Safety

Reagan recognized anew the government interests and authority to regulate signage in the interests of traffic safety and aesthetics:[152]

> At the same time, the City has asserted a legitimate interest in maintaining the regulation. As I have said, the public has an interest in ensuring traffic safety and preserving an esthetically pleasing environment, supra this page, and the City here has reasonably explained how its regulation of off-premises signs in general, and digitization in particular, serves those interests. Amici us that billboards, especially digital ones, can distract drivers and cause accidents. See, e.g., Brief for United States as Amicus Curiae 21 (citing a study of 450 crashes in Alabama and Florida that "revealed that the presence of digital billboards increased the overall crash rates in areas of billboard influence"); Brief for National League of Cities et al. as Amici Curiae 22 ("The Wisconsin Department of Transport found a 35% increase in collisions near a variable message sign" (alteration omitted)). They add that on-premises signs are less likely to cause accidents. Id., at 23 ("[A] 2014 study found no evidence that on premises digital signs led to an increase in crashes"). The City further says that billboards cause more visual clutter than on-premises signs because the latter are "typically 'small in size' and integrated into the premises." Reply Brief 19. I would leave for the

[148] Geft Outdoor, LLC v. City of Westfield, 39 F.4th 821, 824 (7th Cir. 2022) (applying rule that speech is content based only if it "target[s] speech based on its communicative content," or "applies to particular speech because of the topic discussed or the idea or message" and rejecting need to read rule).
[149] Norton Outdoor Advert., Inc. v. Vill. of St. Bernard, No. 1:20-CV-350, 2022 WL 2176339, at *4 (S.D. Ohio June 16, 2022) (holding ban on off-premises variable message billboards content neutral).
[150] Outfront Media, LLC v. City of Grand Rapids, No. 357319, 2022 WL 3329484, at *11 (Mich. Ct. App. Aug. 11, 2022) (holding a location-based distinction between off-premises signs and on-premises signs does not amount to a content-based restriction).
[151] See City of Austin v. Reagan Nat. Advertising of Austin, LLC, 596 U. S. 61, 69, 142 S. Ct. 1464, 212 L. Ed. 2d 418 (2022).
[152] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 596 U.S. 61, 82-83, 142 S. Ct. 1464, 1479, 212 L. Ed. 2d 418, 434-435, 2022 U.S. LEXIS 2098, *30-31, 29 Fla. L. Weekly Fed. S 221, 2022 WL 1177494 (U.S. April 21, 2022)

> courts below to weigh these harms and interests, and any alternatives, in the first instance, without a strong presumption of unconstitutionality.

After *Reagan*, lower courts will follow suit with subsequent cases, often recognizing the precedents setting out governmental interests in traffic safety and aesthetics:[153]

> Courts have uniformly found that both on-/off-premises distinctions and digital-sign bans promote traffic safety and preserve visual aesthetics. See Metromedia, Inc. v. City of San Diego, 453 U.S. 490, 507-08, 101 S. Ct. 2882, 69 L. Ed. 2d 800 (1981) (expressing "little controversy" that the "twin goals" of "traffic safety and the appearance of the city are substantial governmental goals"); City of Madison II, 56 F.4th at 1120 ("Prohibiting digital signs serves Madison's stated interests in promoting traffic safety and preserving visual aesthetics.").

General Guidelines That Emerged Post-Reed for OA Regulation

Post-*Reed*, regulations of non-commercial speech that impose time, manner, and placement restrictions remain enforceable.[154]

Under First Amendment principles, the government has no power to restrict expression because of the message, ideas, subject matter, or content of a sign after *Reed*. Content-based laws and regulations that focus on the "communicative content" of a noncommercial sign will be presumed unconstitutional under the *Reed* criteria.[155]

Examples of enforceable, non-content-based restrictions upon signs include those on location, size, height, type of structure, building materials, lighting, moving parts, portability, spacing, total maximum number, and temporal[156] regulations applicable to all categories of signs.

Commercial versus Noncommercial Speech— Questions After Reagan

After years of jurisprudence, the Supreme Court has held that regulating noncommercial speech requires a higher standard of judicial review than that of commercial speech.[157] Courts do not

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[153] Adams Outdoor Adver. Ltd. P'ship v. Town of Mount Pleasant, 2023 U.S. Dist. LEXIS 120536, 2023 WL 4491197, at 39. (United States District Court for the District of South Carolina, Charleston Division, July 12, 2023, Filed). https://advance-lexis-com.ezproxy.lib.utexas.edu/api/document?collection=cases&id=urn%3acontentItem%3a68P9-YVV1-DXPM-S003-00000-00&context=1519360&identityprofileid=3NGKCP51903.

[154] Reagan at 163.

[155] Reed, at 174. (See "rules" regulating signs that Justice Alito set out as enforceable regulations that would not be content based, in his concurring opinion in Reed).

[156] See Reed at 175, "Time restrictions" on one-time event signs are listed by J. Alito as permissible, but such restrictions could be viewed as counter to Reed's generalized rule that if an enforcement officer has to read the sign to determine which provisions of the Code apply to it, that Code may be impermissibly content-based. (See Reed, at 170 discussing noncommercial, political signs).

[157] See infra and Ohralik v. Ohio State Bar Ass'n, 436 U.S. 447, 456 (1978).

allow sign ordinances to treat commercial speech more favorably than noncommercial speech.[158] For example, a sign ordinance that includes more restrictive requirements for the display of noncommercial signs than it does for commercial signs, such as a smaller size requirement, would probably be invalid. Sometimes courts struggle to determine whether a sign ordinance regulates commercial or noncommercial speech.[159] Ordinance drafters should consider whether ordinances making the commercial/noncommercial distinction raise a content neutrality problem. According to the Supreme Court speech is commercial even though it contains "discussions of important public issues"[160] and does not lose its commercial character just because it "links a product to a current public debate."[161] The test for commercial speech most often applied by the court is the "'common sense' distinction between speech proposing a commercial transaction, which occurs in an area traditionally subject to government regulation, and other varieties of speech."[162]

The Supreme Court has also defined commercial speech as "expression related solely to the economic interests of the speaker and its audience"[163]

Exemptions for Noncommercial Speech in Sign Ordinances

Most sign ordinances exempt a number of signs from the ordinance, such as government signs, traffic and regulatory signs, and those of religious and charitable organizations.[164]

Differential treatment of noncommercial signs is unconstitutional. As shown in *Metromedia*[165] the Supreme Court held 12 exemptions in the sign ordinance invalid because they made impermissible distinctions among different types of noncommercial speech,[166] some of which was content-based.

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[158] *KH Outdoor, LLC v. City of Trussville, 458 F.3d 1261 (11th Cir. 2006)*.
[159] Metromedia, Inc. v. City of San Diego, 453 U.S. 490, 538, 539 (1981) (Justice Blackmun, concurring).
[160] Bolger v. Youngs Drug Prods. Corp., 463 U.S. 60, 67, 68 (1983).
[161] Central Hudson Gas & Elec. Corp. v. Public Serv. Comm'n, 447 U.S. 557, 563 n.5 (1980).
[162] Ohralik v. Ohio State Bar Ass'n, 436 U.S. 447, 456 (1978). This test was first proposed in Pittsburgh Press Co. v. Pittsburgh Com. on Human Relations, 413 U.S. 376, 385 (1973), and Lorillard Tobacco Co. v. Reilly, 533 U.S. 525, 554 (2001).
[163] Central Hudson, 447 U.S. at 561. Later cases have not applied this definition, however. City of Cincinnati v. Discovery Network, Inc., 507 U.S. 410, 422 (1993).
[164] An example, City of Pflugerville, Texas § 154.004 Signs Exempt from Regulation Under This Chapter, https://ecode360.com/39359007#39359049, (government signs, political signs, traffic control signs , site addressing, internal signs in concert venues)
[165] Metromedia, 453 U.S. at 513 (although the plurality opinion is now recognized by the Court as a majority opinion, this doesn't apply to the part of the opinion that decided the noncommercial speech issue. City of Austin, Texas v. Reagan Nat'l Advert. of Austin, LLC, 142 S. Ct. 1464, 1474 n.5 (2022) (explaining that Parts I-IV, "the relevant portion of the opinion was also joined by a fifth").
[166] Id at 496. ("Although the city may distinguish between the relative value of different categories of commercial speech, the city does not have the same range of choice in the area of noncommercial speech to evaluate the strength of or distinguish between various communicative interests.").

Findings on Current Guidance for DBBs

As already noted, HBA, 23 U.S.C.S. § 131, required FHWA and each state to develop and implement FSAs, detailing, among other things, size, lighting, and spacing standards for the billboards. One of those adopted standards, included in most states' FSAs, prohibits those states from erecting any billboard with flashing, intermittent, or moving lights. FHWA regulations, promulgated under the HBA, require that states "[d]evelop laws, regulations, and procedures" that implement the standards contained in each state's FSA.[167] Within a state's FSA umbrella criteria three major areas allow local jurisdictions—subject to case law findings and the FHWA Memo—to develop more restrictive requirements and detailed criteria for billboards and DBBs. The researchers identified ranges adopted by states that authorize DBBs along with CEVMS that may be useful to jurisdictions around lighting, spacing, height, and transition/duration of messages. Table 2 shows a summary of a review of almost 3000 local ordinances.

Table 2. Sources of Guidelines for DBBs.

Source	Criteria	Seen in Practice	Regulatory
FSA	Size	Height, Size sq. feet	
FSA	Spacing	Between DBBs, cap and replace conversions/swap outs	New trend—highest end of range: 1500 ft between DBBs; cap and replace is reducing DBBs
FSA	Lighting	Brightness, illuminance/foot-candles or luminance/nits, OAAA has guidelines, older studies completed with mixed tech and results	Trend: 0.3 fc found in legal text, but no federally mandated national standard, so industry standard has been de facto adopted
CEVMS MEMO	Message duration	Falls under lighting	8 seconds recommended, seen in most ordinances/legal text
CEVMS MEMO	Transition time	Falls under lighting	1–2 seconds recommended, seen in legal text
CEVMS MEMO	Location	HBA, FSA, and CEVMS MEMO	"except such locations where determined inappropriate to ensure safety of the motoring public"- CEVMS Memo
Case Law	Freedom of speech, content, location, safety, and aesthetics, state and local rules litigated, *Reagan* etc.	DBB companies sue cities over ordinances on various criteria; seek variances for DBBs; seek design board process over zoning process for leniency	Safety and aesthetics are justified in government interest in regulating DBBs, Reagan does not require studies or evidence of safety to regulated DBBs

[167] 23 C.F.R. § 750.705(h).

Targeted Regulation of Various Sign Criteria

The FHWA guidance includes four key DBB criteria that are federally recommended and may be state regulated for billboards:

1. Duration of Message (8 seconds recommended).
2. Transition Time—Transition between messages (1–2 seconds is recommended).
3. Brightness—Adjust brightness for ambient light–reasonable.
4. Spacing—Spacing between DBBs not less than minimum spacing requirements for signs under the FSA, or greater if determined appropriate to ensure the safety of the motoring public.

State and local government have responded in kind over the past 20 years to amend law, regulations, and ordinances to reflect federal criteria relevant to the safety and aesthetic government concerns. Of these four, brightness and spacing are the most flexible criteria and where states and cities have innovatively pursued government interests in reducing billboards—in the absence of more specific standards from FHWA. The federal government has provided no uniform national numerical standards on DBB brightness (nits or foot-candles) nor on spacing between DBBs.

For certified cities that entered into an agreement of certification with the state DOT, the local rules control. Typically, a certified city's local zoning authority has legal requirements in place concerning the control of billboards that are at least as restrictive as the state rules as to size, lighting, spacing, use, and maintenance.

Spacing After Reagan

Locations were allowed for signs under the FSA except such locations that were determined inappropriate to ensure safety of the motoring public. Spacing between such signs is not less than minimum spacing requirements for signs under the FSA, or greater if determined appropriate to ensure the safety of the motoring public.

Post *Reagan*, local jurisdictions are also developing spacing requirements, often using the trade-off of authorizing DBBs with larger spaces between signs, while requiring traditional billboard retirements.

Spacing has been a way for state and local government to restrict the proliferation of DBBs. As the 2007 guidance states: "Guidance does not prohibit States from adopting more restrictive requirements for permitting CEVMS to the extent those requirements are not inconsistent with the HBA, Federal regulations, and existing FSAs."(*22*) The regulation of sign spacing inside a certified city is controlled by a municipality on behalf of the department. A certified city may establish electronic sign spacing requirements that are more or less restrictive than state regulations.

With the new rulemaking by TxDOT this year, more practical and time-efficient methods have been implemented in the rule updates. New TAC §21.160, Commercial Sign Location Requirements, contains the substance of existing §21.166 and clarifies an existing rule regarding the denial of new permits or amendments surrounding the environmental clearance for new projects. The rule was originally written to prevent the issuance of a permit, and subsequent erection of a sign, while right-of-way acquisition was underway for a transportation project. The revised language specifies that the department may refuse to issue a new or amended permit when the location is within a parcel identified for acquisition. This narrows the department's discretion to minimize impact on regulated persons. The new rule also provides for a large spacing between another electronic sign.[168]

Nationwide, billboard companies are pushing to change spacing rules between DBBs because the current state and federal push has used this criterion to effectively and indirectly limit the number of billboards. For example, in Colorado, innovative state law requires spacing between CEVMS to be 1000 ft.[169] Centennial Colorado also uses a land development code to regulate intensity of DBBs (§ 12-6-307).[170] Florida also has created large spacing between signs: 1500 ft from any other permitted sign on the same side for interstate highways, and 1000 ft for federal-aid primary highways, although there is no mention of EBBs in the statute.[171] Various states have more recently been focused on sizeable digital sign spacing, including Mississippi (1000 ft),[172] Nebraska (5000 ft),[173] and Massachusetts (1000 ft).[174]

Douglasville, Georgia, for example under its municipal codes at § 7.08 1. D. authorizes DBBs under a series of criteria including distance to single family residences and commercial/industrially zoned property within 500 ft of Interstate Highway 20. The billboards cannot be erected within 5,000 ft of another DBB on same side of the road. Dallas, Texas, which overhauled its sign code for digital signs in August 2023 and amended again in July 2024, requires that for support structures with two digital display signs, signs must be located a minimum of 2000 ft from any other digital display on the same side along the same expressway measured linearly (*26*).

In Meridien, Connecticut (*27*), for example, OutFront Media LLC recently pushed to have the city amend its zoning regulations to remove language that currently limits the spacing between DBBs to 1,500 ft between each of those billboards.[175] The effort failed. The current allowed

[168] TAC §21.160
[169] 2 Colo. Code Regs. § 601-3-12.00
[170] Centennial CO, § 12-6-307
[171] § 479.07 Fla. Stat. 9(a)
[172] Sub-part 7501 – Maintenance, Chapter 09002, Section 900.
[173] Title 410-Nebraska Department of Roads- Right of Way Division Chapter 3- Sign Permits.
[174] 700 CMR 3.00.
[175] Connecticut, Meriden Code of Ordinances, § 213-56 Signs , http://meriden-ct.elaws.us/code/coor_ptii_ch213_artviii_sec213-56

spacing between traditional billboards under current regulations are 750 ft.[176,177] According to city zoning regulations, the Billboard Overlay District limits the placement of billboards to limited access highways and to a limited stretch along I-91. According to a staff report prepared by city planning officials, DBBs are already permitted within this zone, with 13 billboards either already built or approved in the overlay zone. The proposed 2021 amendment appeared to be consistent with the city's Plan of Conservation and Development.

During that hearing, committee members, fellow city councilors, and the mayor asked questions regarding the benefits the amendment would provide to the city and raised concerns about the possible proliferation of DBBs and increased light pollution in residential areas. Officials and OutFront representatives stated the proposal would not lead to a proliferation of billboards and suggested the number of billboards likely would not increase.[178] Billboard companies often tout the benefit to cities that they will give some free ad time of local government to meet its needs in exchange for getting the permission for the DBB. Here, committee member Fontanilla asked OutFront's representatives what the benefit would be to the city. OutFront responded that the digital platform would provide more social utility—enabling civic organizations to advertise campaigns for which they would not have the budgets for on a traditional platform. OutFront also described the ability to quickly program emergency notifications, such as amber alerts, which can be programmed onto a DBB, which would not be available on the traditional platform.

Lighting and Brightness

Of the five important federal criteria for DBBs (size, spacing, lighting, message duration, and transition time), lighting is key. In the FSAs, the term "Lighting" is broad. Tucked under the umbrella criteria of lighting and related safety standards at the state and local levels should be brightness, [179] message duration, and transition time.[180]

Cities are able to get more specific than state laws about brightness of digital signs, using foot-candles as a unit of measure. Lighting sections of a municipal ordinance may sometimes cover both on- and off-premise signs. For example, in El Paso, the light intensity rules (§ 20.18.280 Lighting) are under Billboard regulation (Art. II) and are found in the Sign Regulations Chapter 20.18. This all falls under the zoning ordinance umbrella of Title 20.

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[176] These are also called "conventional" or "static" billboards.
[177] Connecticut, Meriden Code of Ordinances, § 213-56 Signs , http://meriden-ct.elaws.us/code/coor_ptii_ch213_artviii_sec213-56 (Spacing:[1] Conventional billboards shall be spaced at a horizontal distance of not less than 750 feet from other conventional or digital billboards on the same side of the limited access highway. [2] Digital billboards shall be spaced at a horizontal distance of not less than 1,500 feet from any other digital billboard on the same side of the limited access highway.)
[178] Supra Gagne, Note 173.
[179] *Brightness* refers to the adjustment of brightness in comparison to ambient light conditions so that "signs are not unreasonably bright for the safety of the motoring public". CEVMS Memo 2007.
[180] Message Duration is one of five criteria spelled out in the FSA's and the 2007 CEVMS Memo: Size, lighting/Brightness, Spacing.

Some suggestions have also been made that regulations should make regulatory distinctions between technology, brightness, and "changeable copy." To control DBBs, brightness levels on signs are equipped with light sensors, which measure the amount of light available in the surrounding environment. In the bright sun, the billboard might be at its brightest to provide the necessary contrast to make the billboard legible. At night, the billboard should be much dimmer to adjust to surrounding light conditions. OAAA says that the DBBs use the minimum amount of light necessary to provide legible copy, a practice which meets federal criteria and the lighting industry's standards.[181]

Model Sign Ordinances on Foot-Candles and Illuminance

As the technology progresses, FHWA may not have created updated guidance on newer lighting technology. However, OAAA has created guidance (*28*). OAAA recommended brightness criteria for DBBs as follows:

> Light produced by a digital billboard should not exceed 0.3 footcandles over ambient light levels. Measurement should be taken utilizing a footcandle meter from the following distances (perpendicular to the face of the digital billboard): Posters: 150 feet; 10'6x36 Bulletins: 200 feet 14x48 Bulletins: 250 feet; 20x60 Bulletins: 350 feet. The measurement distances are based on the average minimum viewing distances for each type of billboard. Digital billboards must have automatic dimming capability.

Other organizations have created model ordinances (*29, 30, 31*) on regulating the brightness and use of dimming technology in regulatory frameworks for the increasing concentrated light in LED billboards. OAAA says that technology is improving the energy efficiency of billboard lighting, while reducing light "spillage." Innovative reflector and prism designs reduce energy use and reduce the amount of light leaking into the night sky (*32*).

OAAA claims that DBBs are equipped with light sensors that adjust billboard brightness to surrounding light conditions and requires industry practices conform to guidelines issued by FHWA for DBBs. Yet the researchers found unusually bright billboards that perhaps were not installed or operated properly for ambient light and night visibility concerns. These overly bright signs were often on-premise but were also among those off-premise.

Local sign codes typically should contain:

- A statement of the purposes to be achieved.[182]

[181] Id.

[182] For example, Ordinance for the City of Pflugerville, Texas, includes i.a. in § 154.000 Purpose : (A) "Freedom of Speech," (D) "Maintain and enhance the aesthetic environment," (G) "Promote public safety and protect persons and

- Definitions.
- Standards for measuring sign areas.
- Regulations governing sign placement, height, and area.
- Enforcement.
- Regulations for temporary signs.
- Prohibited signs.
- Regulations for non-conforming signs.
- Administrative provisions, variances,[183] and appeals.[184]

Within the definitions are often brightness related terms such as "illuminated sign" and "illuminance/foot-candle" (i.e., "foot-candle means a unit of light density which falls onto an object or plane [assumed to be horizontal plane unless otherwise specified], and measurable with an illuminance meter, or otherwise known as a light meter.").[185]

Although restrictions on brightness in ordinances may apply to street lighting, they also often apply to both on- and off-premise signs.[186]

With more recent recognition of light pollution, light trespass, environmental impacts upon wildlife (*33*), and Dark Sky initiatives (*34*), cities are often seeking more modern approaches to restrict brightness of all signs, and light pollution, regardless of sign location.[187] Over time more cities have added provisions on premise EMC brightness, with requirements on automatic dimming technology to adjust the brightness to the ambient light; however, EMCs are mostly on-premise signs. These on-premises digital signs, if unusually bright, may contribute to drivers' visual complexity when combined with off-premise signs for high-density, inner-city drivers.

The 2007 CEVMS memo from FHWA required this adjusting: "Brightness: Adjust brightness in response to changes in light levels so that the signs are not unreasonably bright for the safety of the motoring public" (*22*). Many cities separate the zoning chapter of a municipal code from the sign regulations chapter within the municipal code. An example is Cedar Park, Texas, Municipal Code. For billboard or sign brightness rules, one may search under the "Design and

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property by ensuring that signs do not create a hazard by:…(2) Confusing or distracting motorists; or (3) Impairing drivers' ability by obstructing the awareness or visibility of pedestrians, obstacles, or other vehicles, or to read traffic-control devices or signs, and (H) Control the number, size, height, location, lighting, and design characteristics of signs to avoid visual clutter which leads to the decline in the community's appearance and property values, and reduces the effectiveness of the signs; (I) and the city's ability to attract sources of economic development and growth." https://ecode360.com/39359007#39359009

[183] Id. § 154.800 Variances and Appeals, https://ecode360.com/39359007#39359413

[184] Sign Research Foundation (SRF), Model Sign Code (2019), at 5.

[185] Id. § 154.005 Definitions

[186] Amarillo Municipal Code, § 4-2-9. - Sign standards. https://library.municode.com/tx/amarillo/codes/code_of_ordinances?nodeId=CO_TITIVBUCODEZO_CH4-2SI_S4-2-9SIST

[187]Dripping Springs, TX has passed an Outdoor Lighting ordinance and has declared itself a Dark Sky community, https://www.cityofdrippingsprings.com/Lighting

Maintenance" Article 13.02[188] under the Sign Regulations Chapter 13[189] inside the municipal code. Here, one typically finds the (a) light design standards,[190] (b) operational standards, (c) illumination standards,[191] and (d) maintenance standards.[192]

In addition to industry, organizations that fight light pollution have moved to create "best management practices to decrease or eliminate negative impacts on the environment,[193] reduce visual clutter, and improve safety for drivers and pedestrians."[194]

Message Duration

The International Sign Association (ISA), the trade group representing on-premises signs, has advocated for a minimum message duration of 8 seconds, while other groups like Scenic America or cities may support longer intervals (*35*). A 2006 analysis by the National Highway Traffic Safety Administration found that due to the brightness of digital signs, they can often be seen by drivers more than ½ mile away, potentially causing a distraction before the message even becomes legible. If a changeable copy sign were visible from ½ mile away, a driver going 40 mph would witness the message change more than 10 times if each message were only displayed for 8 seconds.[195] Eight seconds is federally recommended in the CEVMS memo and appears in some state laws (Tennessee for example) for duration. The Texas current regulations require:[196]

[188] For example, Article 13.02 Design and Maintenance, City of Cedar Park, Texas, falls under Chapter 13 Sign Regulations. https://ecode360.com/38619752
[189] City of Cedar Park, Chapter 13, Sign Regulations, https://ecode360.com/38619752
[190] Id, § 13.02.001.
[191] Id, § 13.02.002.
[192] Id, § 13.02.005.
[193] Dark Sky claims that EMCs are "harmful to the nighttime environment" as "EMC light emissions at this time cannot be shielded "which means that some of the light is "necessarily emitted laterally into adjacent environments and upward into the night sky." Dark Sky International, Electronic billboards, electronic message centers, July 23, 2023, https://darksky.org/resources/guides-and-how-tos/electronic-billboards/
[194] Supra Note 187. "Dark Sky has developed minimum requirements and a set of best practices for EMCs in order to minimize the environmental hazard that often results from carelessly installed and operated signs. These recommendations are intended to be integrated by planners into existing sign ordinances and zoning codes and adopted by lighting practitioners."
[195] U. S. Department of Transportation, 2006.; Model Sign Ordinance Part 8, xx
[196] TAC § 21.196, https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=43&pt=1&ch=21&rl=196#:~:text=Each%20message%20on%20an%20electronic%20sign%20must,accomplished%20within%20two%20seconds%20and%20must%20occur; TXDOT Rulemaking, July 2024, https://www.sos.state.tx.us/texreg/archive/August162024/Adopted%20Rules/43.TRANSPORTATION.html#:~:text=message%20on%20an%20electronic%20sign%20must%20be%20displayed%20for%20at%20least%20eight&text=accomplished%20within%20two%20seconds%20and%20must%20occur%20simultaneously%20on%20the%20entire%20sign%20face.

§21.196.Requirements For an Electronic Sign.

(a) Each message on an electronic sign must be displayed for at least eight seconds. A change of message must be accomplished within two seconds and must occur simultaneously on the entire sign face.

(b) An electronic sign must:

(1) contain a default mechanism that freezes the sign in one position if a malfunction occurs; and

(2) automatically adjust the intensity of its display according to natural ambient light conditions.

Douglasville, Georgia, for example, requires that signs cannot change more frequently than once in every 10 seconds. Reno Township, for example, sets for DBBs a rate of change between static messages at one change per 8 seconds.[197] Multiple jurisdictions also require that DBBs are configured to either a static display or to go completely black in the case of mechanical failure.

The size of signs, physical conditions of the road, and topography, as well as the posted speed limit, all impact how many different messages a driver might see on any given changeable sign. There are mathematical formulas that calculate this measure. The majority of cities adopted the 8 seconds federal guidance. Cities should look at local conditions/intersections when determining how quickly messages of electronic signs can change. Hours of illumination and nighttime brightness limits are other areas that cities commonly regulate.[198]

Transition Time

The federal recommendation for transition time is 1–2 seconds (*22*).

In looking at multiple local ordinances, transition between messages is generally 1–4 seconds, with 1–2 seconds recommended. Reno Township, for example, requires each change to be completed in one second or less.[199]

Texas has reflected this in its regulation:

RULE §21.196 Requirements For an Electronic Sign

[197] Link to Reno Code
[198] Model Sign Ordinance Part 8. xx
[199] Link to Reno Code

> Each message on an electronic sign must be displayed for at least eight seconds. A change of message must be accomplished within two seconds and must occur simultaneously on the entire sign face.

The Sign Research Foundation Model Sign Code recommends that communities create sign regulations that make regulatory distinctions between electronic changeable copy and the older mechanical or manual changeable copy signs.[200] This ties into transition time between messages and the duration of messages.

Duration of each display is generally 4–10 seconds, with 8 seconds recommended. Other standards that states have found helpful to ensure driver safety include a default designed to freeze a display in one still position if a malfunction occurs, or to go completely black; a process for modifying displays and lighting levels where directed by the state DOT to assure safety of the motoring public; and requirements that a display static messages without movement such as animation, flashing, scrolling, intermittent, or full-motion video (*36, 31*).

Size and Height

Size is one of the three main FSA federal criteria, with height having a pivotal role. In Texas, Senate Bill No. 312, 85th Legislature, Regular Session, 2017 amended §391.038 to legalize the height of all signs as they existed on March 1, 2017, but not to exceed 85 ft, and allowed those signs to be maintained at that height without the need of an amended permit from the department; however, city ordinances may still require formal amendment of a city permit. This change to the height restriction required the department to look at the current maximum height requirement to determine how to address the discrepancy between signs erected in violation of the current rules, those that had complied with the maximum height, and those that will be built in the future (*37*).

> §21.189, Sign Height Restrictions, provides that the maximum height of an OAS is 42.5 feet and is measured from the grade level of the centerline of the main-traveled way closest to the sign at a point perpendicular to the sign location. A roof sign with a solid face surface may not exceed 24 feet above the roof level. A roof sign with an open sign face in which the open area between individual letter or shapes is not less than 40 percent of the total gross area of the sign face may not at any point exceed 40 feet above the roof level. The lowest point of a projecting roof sign must be at least 14 feet above grade. This includes a clarification that the frontage road is not the main traveled way of a controlled access highway.

Scenic America has criticized the height rules that Texas has implemented (*38*).

[200] Sign Research Foundation (SRF) Model Sign Code, (2019), p 39.

Sign Types

Built into state and municipal codes are definitions for sign types.[201] In investigating driver distraction, the study data included all types of signs the drivers encountered while on the road. The researchers used the newest technology to track driver distraction. Not all states define all signs the exact same way but there are commonalities.

There are several types of LED technology and electronic signs. Changeable message signs (CMS) are primarily used by governments to give operators traffic safety information about active or planned events that impact traffic situations on the highway system. These signs are regulated differently from commercial signs. These are the typical roadway signs with text about speed limits, warnings, directions, incident management, events, or other traffic-related information. These signs are often programmed by governments to change messages as needed for safety, and they may be portable or permanent (*39*, *40*).

Additional Topics

Novelty, Human Nature, and Advertising

The rapidly changeable nature of DBBs combines with human evolutionary and neurological processes to create a situation whereby the human eye seeks out novel, attention-grabbing stimuli, like bright light and colors on the road. Advertisers understand this, but so does anyone with common sense. Stimulus characteristics that attract attention include intensity, novelty, movement, contrast, and repetition. Advertisers use these properties in their ads (*41*). The purpose of billboards is to distract the human eye away from the road to the well-lit, colorful ad on the side of the road. Courts seem to use common sense in analyzing how this affects safety. Although the LED signs have new dimming technology—which is sometimes required by regulations and statutes—the human brain has probably not evolved as much as researchers think. The human brain is wired to enjoy bright lights and colors; campfires, fireworks, cell phone screens, movies, TV, theater stages, and holiday light shows all highlight something colorful, bright, and entertaining.

Cap and Replace: The Conversion of Standard Billboard To DBB

As various cities struggle with how to regulate newer DBBs, they implement regulations on the conversion of static billboards to digital ones in the hopes of reducing total numbers of billboards. For some this had been successful as a strategy.[202] For example, San Antonio on June 1, 2023, considered a proposal to issue one DBB permit only if billboard owners would

[201] There may be thousands of municipal ordinances with digital billboard regulations, but the researchers gathered an many as possible in an excel spreadsheet.
[202] See Andrea Drusch. March 21, 2023. San Antonio considers billboard swap to reduce visual clutter https://sanantonioreport.org/san-antonio-digital-billboard-proposal-hill-country-corridor/, (There now are 863 billboards in San Antonio, according to city data.).

remove four static billboards.[203,204] The city also moved from an earlier 2015 stance on prohibiting new billboards from the Hill Country corridor to allowing digital signs in the corridor up to 25 percent of the total signage.[205] Starting in 2024, each year the city will allow eight conventional, or static, billboards to be converted to digital with one caveat: The billboard operator must remove at least four of its existing traditional billboards within the city (*42*).

In 2011, the Texas Transportation Commission unanimously voted to let individual communities decide whether to allow DBBs (electronic signs) within their jurisdictions (*43*). This effectively made the municipal government the gatekeepers on the proliferation of off-premise DBBs in Texas. In 2011, the new §21.256, Modification to Electronic Sign, provided that a sign may be modified to be an electronic sign if a new permit for the new electronic sign is obtained from both the municipality in whose jurisdiction the sign is located and the department. However, lighting may not be added to or used to illuminate a nonconforming sign. When the state asked for comments on this rulemaking in 2011, 419 people sent letters against DBBs, mostly citing safety and aesthetic reasons (*44*). In response, several cities implemented caps on total billboard numbers in the city limits or a conversion plan whereby billboard companies could reduce a number of standard billboards in exchange for allowing one electronic sign/DBB. For example, El Paso's Conversion Provision provides:[206]

> C.1.a. For every one square foot of CEVM billboard display area converted from a static billboard, at least five square feet of static display area must be permanently and completely removed. Of the signs removed to fund this conversion exchange, at least one billboard shall be of a like size as the CEVM display installed or erected.

This study's data may have uncovered some brightness reduction effects from local standards in Amarillo. The results show that participants in Arlington and Killeen looked at the signs more often than in Amarillo—while San Antonio participants were not significantly different from Amarillo. The Amarillo sign ordinance (§ 4-2-14)[207] prohibits conversion of off-premise signs to

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[203] Id.
[204] Id.
[205] Id.
[206] El Paso Ordinance, § 20.18.200 Zoning Districts, https://library.municode.com/tx/el_paso/codes/code_of_ordinances?nodeId=TIT20ZO_CH20.18SIRE_ARTIIIBIRE_20.18.200ZODI
[207] § 4-2-14. - Nonconforming Off-premise signs. B. Upgrading. A Nonconforming off-premise Sign shall not be upgraded. For purposes of this section, "upgrade" means making any change to a Nonconforming off-premise Sign, other than repairs and maintenance operations permitted pursuant to section [Section] 4-2-14(A.). All other alterations of any nature whatsoever in connection with Nonconforming off-premise Signs are prohibited. If any such alteration or upgrade is performed, the owner shall remove the Sign immediately or bring it into compliance with the Zoning Ordinance and all other applicable ordinances as soon as practicable, but in not more than thirty (30) calendar days from the date of the violative alteration. Examples of actions that are upgrades and not maintenance operations and are therefore prohibited, include without limitations: … (10) Converting a Nonconforming off-premise Sign to utilize EMC technology.

utilize EMC (digital) technology.[208] San Antonio implemented a cap-and-replace policy years ago in ordinance and continues to reduce billboards this way.[209]

In addition to basic cap-and-replace policies, some cities add even more prescriptive conditions and restrictions (with size and spacing) to reduce DBB numbers.[210] The billboard industry is well aware of these proliferating cap-and-replace efforts by municipalities and are actively addressing how it affects them (*45*).

Cities Negotiate to Get More from Billboard Companies

Even as municipalities have created rules to manage billboard proliferation and conversion of static billboards to digital ones, there is an increase in visual clutter and DBBs in some places. Although officials often claim that DBBs are smaller than standard billboards,[211] they omit the fact that they may be brighter. There is currently no federal government established, national, uniform standard for brightness (foot-candles or nits) for DBBs. EBBs can be up to 10 times brighter at night than traditionally lit billboards (*46*).

Municipal officials and city councils are under pressure to allow more DBBs and on-premise EMCs from their constituents. Even when ordinances are strict, DBB companies seek variances (*47*) or special agreements to keep DBBs in lucrative locations. Cities seeking compromises with DBB companies often seek concessions in negotiating digital conversions with large national companies. For example, the New Braunfels, Texas, City Council approved the conversion of a non-conforming static billboard along I-35 to a two-sided digital Lamar billboard (*48*). The city's 2006 sign ordinance had prohibited the construction of new billboards or the improvements of non-conforming sign.[212] Under the agreement, the city is guaranteed free advertising space on the DBB to promote local events and run safety messages, and the DBB will be available for emergency messages like amber alerts, missing person notices, and disaster information. The agreement results in fewer billboards in New Braunfels because Lamar will remove four existing billboard structures with eight faces in exchange for digital conversion.[213]

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[208] Amarillo, Texas Municipal Code, § 4-2-14. (B)(10), https://library.municode.com/tx/amarillo/codes/code_of_ordinances?nodeId=CO_TITIVBUCODEZO_CH4-2SI_S4-2-14NOOEMSI

[209] Supra Note 213.

[210] City of Garland, Texas, § 4.73, D.2., https://ecode360.com/40084253 (D.2. The new digital billboard sign face may be no larger than the preexisting conventional billboard sign face, but in no case larger than 700 square feet.)

[211] Molly Smith, San Antonio pushes digital billboard swap to reduce highway clutter, June 1, 2023, https://www.expressnews.com/news/article/digital-billboard-rule-change-18130185.php , ("Since 2015, "on-premise" signs could only be static in this corridor. These signs are far smaller than a traditional billboard.")

[212] New Braunfels, Texas Ordinance, § 106-11 Prohibited Signs., https://library.municode.com/tx/new_braunfels/codes/code_of_ordinances?nodeId=PTIICOOR_CH106SI_S106-11PRSI; City of New Braunfels , https://www.newbraunfels.gov/3442/Development-Planning.

[213] Billboard Insider, Win,Win,Win in New Braunfels, Nov. 20, 2024, https://billboardinsider.com/win-win-win-in-new-braunfels/ ("*The community will benefit from the development agreement as it will result in the reduction of*

DBBs are the most common type of digital out-of-home advertising. According to OAAA, the number of DBBs in the United States reached 9,600 in H1 2020. In 2016, there were just 6,700 DBBs in the United States. That is a 43.3 percent increase over a handful of years (*49*). As outdoor ads are becoming more digitized and data-driven, with multiple message exposures possible within short times, the motivation for billboard companies to convert static billboards into digital ones increases. Digital out-of-home, which accounted for 34 percent of quarterly sales, increased 7.5 percent from a year ago (*50*).

Safety and Jurisprudence

Even if there is no definitive research showing increased crashes due to the presence of billboards or DBBs, courts seem to understand that there may be an increased crash risk based on research on the effects of billboards on driver attention and the effects of driver distraction on safety. Driver distractions by visual fixation on objects outside the vehicle play a role in crashes (*51*). Various studies have examined a driver's visual behavior by measuring dwell time, visual time sharing, number of fixations, and maximum fixation duration.[214] Research shows that the performance of the driver varies during day and night times (*2*). EBBs attract more dwell times than normal traffic signs. Various older studies have examined effects on eye movements and fixations, driver speed, lateral control, mental workload, and ability to follow road signs.[215] Certain groups with higher insurance rates seem more distractable than others.

Even if there is no definitive research showing increased crashes due to the presence of billboards or DBBs, courts seem to understand that there may be an increased crash risk based on research on the effects of billboards on driver attention and the effects of driver distraction on safety. Billboards can have a significant effect on eye movements and fixations, driver speed, lateral control, mental workload, ability to follow road signs, and eye movements and fixations. As an example, older drivers have impaired adaptation to light changes, slower glare recovery, and difficulty with night driving (*52*), so they are especially affected by overly bright LED billboards at night. Courts understand the effects of visual clutter on driving performance, and they seem to understand that DBBs attract more attention than regular billboards, with a larger number of glances and longer glances. The data show the odds of a digital sign being viewed are 31.6 percent higher than those of a standard sign. Courts and regulators seem to understand that DBBs are more likely to be looked at compared to standard billboards.

signage clutter and night sky pollution with the removal of the 4 existing signs. The sign will also be utilized to display emergency notification messages to inform the public of important emergency news. It will also provide an opportunity for local advertisers to utilize the sign for their businesses as static billboard ad space is more expensive and usually is limited to 1 ad per sign face for an extended period of time. And, the City will have the opportunity for free advertising for events, hiring campaigns, weather updates, etc.")

[214] See analysis of previous safety and driver distraction studies, infra.

[215] See analysis of previous safety and driver distraction studies, infra.

Lingering Issues with Digital Signs

Changes in the zoning arena such as mixed use and recreational zoning are new and were uncontemplated as commercial areas when the FSAs were using the term "customary use" for zoning controls when FSAs were signed in the 1970s.[216] Certain states are addressing these newer zoning types directly in regulation changes, for example, Texas in 2024 amended its rules in TAC §21.161, Zoned Commercial or Industrial Area.[217] That determination of "customary use" "rest[s] entirely in the hands of the States or the appropriate local jurisdiction."[218] States must contend with the outdated FSAs, which contain a prohibition on the use of "flashing, intermittent, or moving lights."[219]

As on-premise signs become digitized, the line between on-premise and off-premise may be getting more blurred due to digital signs and the light trespass they present. Also, the temptations for on-premise owners to make money from illegally advertising off-premise business on their signs may increase as off-premise billboards sunset away. Indeed, a justice considered this in Reagan.

In the *Reagan* 2022 dissent, Justice Alito discusses the restriction that off-premise signs may not be digitized unlike on-premise signs. In so doing, he mentions problems that may occur with on-premise digital signs.

As the court notes, under the provisions in effect when the petitioner's applications were denied, a sign was considered to be off-premises if it "advertis[ed]," among other things, a "person, activity, or servic[e] not located on the site where the sign is installed" or if it "direct[ed] persons to any location not on that site."[220] Consider what this definition would mean as applied to signs posted in the front window of a commercial establishment, for example, a little coffee shop. If the owner put up a sign advertising a new coffee drink, the sign would be classified as on-premises, but suppose the owner instead mounted a sign in the same location saying: "Contribute to X's legal defense fund" or "Free COVID tests available at Y pharmacy" or "Attend City Council meeting to speak up about Z." All those signs would appear to fall within the definition of an off-premise sign and would thus be disallowed. Providing disparate treatment for the sign about a new drink and the signs about social and political matters constitutes discrimination on

[216] Off-premise signs are regulated by the HBA: consistent with "effective control" when (1) they are located in commercial or industrial areas, whether zoned or unzoned, and (2) their "size, lighting and spacing" accords with the terms of the applicable federal-state agreement (FSA). 23 U.S.C. § 131(d); see 23 C.F.R. § 750.704(a)(4); 23 C.F.R. § 750.704 (5), (b). States retain "full authority under their own zoning laws to zone areas for commercial or industrial purposes," and their determinations "will be accepted." 23 U.S.C. § 131(d).
[217] TAC §21.161. Zoned Commercial or Industrial Area **(**b) An area that is zoned for mixed use, regardless of the specific label, is not considered to be a zoned commercial or industrial area if the land use of the area is predominantly residential.
[218] Conf. Rep. No. 1799, 90th Cong., 2d Sess. 26 (1968).
[219] 23 C.F.R. §§ 750.106(b)(7), 750.154(c)(1).
[220] Austin, Tex., City Code §25-10- 3(11).

the basis of topic or subject matter. The code provisions adopted in 2017 are worded differently, but the new wording may not rule out similar results.[221]

Brightness, Safety, and Aesthetics

Of note in these cases is the government interest in "public safety and aesthetic values" and how much burden of proof is on the government to support their purpose behind regulating billboards. In the Seventh Circuit case, *Madison* justified the restrictions on off-premise signs in its sign code by asserting that its limitations on off-premise signs advance traffic safety and improve the city's aesthetic environment.

Adams Outdoor questions the degree of fit between Madison's means and its ends. It contends that the city must provide empirical evidence linking DBBs to aesthetic or safety-related harms. Not so. "[B]illboards by their very nature...can be perceived as an esthetic harm," and the city "need not try to prove that [its] aesthetic judgments are right."[222] Likewise, the connection between billboards and traffic safety is too obvious to require empirical proof. "It does not take a double-blind empirical study, or a linear regression analysis, to know that the presence of overhead signs and banners is bound to cause some drivers to slow down in order to read the sign before passing it."[223,224]

The above cases show that the government does not need much to substantiate its regulation of billboards.

Looking to the Future

Based upon the regulatory framework now, increases in digital sign brightness and light trespass may be an ongoing safety and aesthetic problem, even if off-premise signs are regulated more than on-premise signs in the context of digital conversions. Local jurisdictions vary by state on how they regulate aesthetics,[225] but the *Reagan* case did not change the industry status quo very much. State and local authorities still have power to regulate brightness, despite the large range of criteria given to them in 2007 by the FHWA Memo. Statutes, ordinances, and regulations across the country are not uniform, and billboard companies have many lawyers and a potentially dwindling supply of profitable off-premise billboards to defend.

After the *Reagan* Supreme Court decision, not much will really change in the manner that billboard regulations are tested under the First Amendment. Although the City of Austin eliminated the belief that OA control regulations are content-based and thus subject to strict

[221] City of Austin v. Reagan Nat'l Adver. of Austin, LLC, 142 S. Ct. 1464, 1480-1481, 212 L.
[222] Leibundguth Storage & Van Serv., Inc. v. Village of Downers Grove, 939 F.3d 859, 862 (7th Cir. 2019).
[223] Luce v. Town of Campbell, 872 F.3d 512, 517 (7th Cir. 2017).
[224] Adams Outdoor Adver. Ltd. P'ship v. City of Madison, 56 F.4th 1111, 1120 (7th Cir. 2023).
[225] Lorillard Tobacco Co. v. Reilly, 533 U.S. 525, 551 (2001) ("We have recognized that state interests in traffic safety and esthetics may justify zoning regulations for advertising.").

scrutiny, the court left open the question of whether these types of regulations are valid under the more lenient intermediate scrutiny. The various *Reagan* dissents may leave doors open for billboard companies to bring creative legal arguments.

Reagan Dissent and Scrutiny

The billboard industry may seek to use a dissent argument in the future. In the Fifth Circuit's reexamination of Austin's code, in Jennifer Walker Elrod's dissent, she opens the door to more "scrutiny" debate, saying that the city failed to satisfy the "narrowly tailored" part of intermediate scrutiny. The City of Austin's Sign Code prohibits digitization of certain grandfathered off-premise signs yet allows unlimited digitization of on-premise signs. She dissents from the majority opinion's conclusion that this selective prohibition survives intermediate scrutiny.[226] Under that standard, the city bears the burden to show that the ban is "narrowly tailored" to further an important governmental interest.[227] She disagrees with the majority opinion giving substantial deference to the city's "legislative judgment." She says that such deference is inappropriate when applying intermediate scrutiny.[228] She points out that Metromedia was limited to purely commercial speech restrictions and that noncommercial speech restrictions were to have "significantly less deference."[229] She would opine that the city's ban violates the First Amendment because, under a proper application of intermediate scrutiny, "the City fails to carry its burden to establish that the provisions were narrowly tailored to further its stated interests. Here, the City contends that the ban is necessary to further important safety and aesthetic interests. In this regard, the issues presented here closely resemble those presented in City of Cincinnati v. Discovery Network."[230]

Texas Certified Cities and Non-Certified Cities—Ordinances and Digital Signs After Reagan

In Texas, a home-rule city may control billboards by ordinance:[231]

> § 216.901. REGULATION OF SIGNS BY HOME-RULE MUNICIPALITY. (a) A home-rule municipality may license, regulate, control, or prohibit the erection of signs or billboards by charter or ordinance.
>
> (b) Subsection (a) does not authorize a municipality to regulate the relocation, reconstruction, or removal of a sign in violation of Subchapter A.

[226] Reagan Nat'l Adver. of Austin, Inc. v. City of Austin, 64 F.4th 287, 298, (5th Cir. 2023).
[227] Id.
[228] Id. (citing See Metromedia, Inc. v. City of San Diego, 453 U.S. 490, 514 (1981).)
[229] Id. (dissent is citing to *Metromedia* itself 453 at 514, "("Although the city may distinguish between the relative value of different categories of commercial speech, the city does not have the same range of choice in the area of noncommercial speech to evaluate the strength of, or distinguish between, various communicative interests.").
[230] Id.
[231] Texas Local Govt Code, § 216.901, https://statutes.capitol.texas.gov/Docs/LG/htm/LG.216.htm#216

At least 334 Texas cities now ban billboards outright (*53*). As of August 21, 2004, there are 35 certified cities (*54*) that have demonstrated to TxDOT that they have established and will enforce OA standards and regulations for size, lighting, and spacing of billboards established by TxDOT. These cities regulate their own interstate corridor within their jurisdictions. In a way, they step into TxDOT's shoes on enforcement, although TxDOT is still ultimately responsible for OA control.

TxDOT does not issue permits inside the corporate limits of a certified city.

Under §21.192(c) certified cities have been given authority to issue permits on behalf of the department.[232]

> (c) The department, after consulting with the Federal Highway Administration, will determine whether a political subdivision has established and will enforce within its corporate limits standards that are consistent with the purposes of the Highway Beautification Act of 1965, 23 United States Code §131, federal regulations adopted under that act, and the Texas Federal-State Agreement on Outdoor Advertising, including the federal requirements for size, lighting, and spacing. The authorization under this section does not include the area in a municipality's extraterritorial jurisdiction.

Non-certified cities like Austin still regulate non-HBA covered billboards in city limits.

Local Regulation of On-Premise Signs

One question not really addressed in *Reagan* was how local jurisdictions may regulate the brightness of on-premise signs. On-premise commercial signs perform an important function in identifying and promoting businesses, and therefore they fall into the constitutional category of commercial speech.[233]

Reagan focused on the Austin ordinance on-/off-premise distinctions because those are built into the state's enactment of the federal HBA. In the HBA, Congress directed states receiving federal highway funding to regulate outdoor signs in proximity to federal highways, in part by limiting off-premise signs. §§131(b)-(c) allows exceptions for "signs, displays, and devices advertising the sale or lease of property upon which they are located" and "signs, displays, and devices advertising activities conducted on the property on which they are located."

States retain their local zoning control over off-premise and on-premise signs for safety and esthetic reasons. TxDOT, in a 2007 rule change (*55*), supported the principle of local control in

[232] TAC § 21.192 (c).
[233] For a discussion of commercial free speech, see Central Hudson Gas & Electric Corp. v. Public Service Comm'n. 447 U.S. 557 (1980) (The Constitution accords a lesser protection to commercial speech than to other constitutionally guaranteed expression).

the regulation of usage, timing, structure size, and placement of EBBs. In a 2007, TxDOT revised TAC §§21.163(c)(1), 21.163(d)(2), and 21.163(h) to clarify the necessity for prior municipal approval of any electronic sign. The new rule helped municipalities assist the state in the difficult task of regulating electronic signs/DBBs. Section 21.163(h) ensures that a permit for an EBB will only be granted by the state if the permit is accompanied by a certified copy of permission by the city. If a city did not address EBBs in its sign code, or did not have a sign code, permission would still be required, signed and certified by the appropriate city official. Such protections are seen as sufficient to ensure that no unauthorized EBBs are erected. This move allows some responsibility to cities to create and enforce DBB brightness and other standards related to the federal FSA criteria but not explicitly spelled out in the ranges of the 2007 FHWA Memo on CEVMS. FHWA also approved of the TxDOT rulemaking. The rules were drafted such that, even if TxDOT rules would allow an EBB along a state highway in a city or its extra-territorial jurisdiction, the city can prohibit the sign by simply refusing its permission.

The purpose for the 2007 amendments to §21.150 and §21.441 was to implement the provisions of House Bill 2944, passed by the 80th Legislature in 2007. House Bill 2944 amended Transportation Code, §391.068, to provide that the commission may not issue a permit for a sign within the jurisdiction of a municipality with a population of more than 1.9 million that exercises its authority to regulate OA, unless the municipality has first issued local permission for the sign.

In 2007, TxDOT acknowledged that the primary mechanism for effective control of OA is the elimination of non-conforming signs over time. It was the intent of the rules as proposed to prohibit any consideration for the conversion of a non-conforming sign to an electronic display. Paragraph (2) of §21.163(d) was revised to provide that "a legally conforming sign may be modified to an electronic sign if a new permit for the electronic sign is obtained from both the municipality and the department."[234]

New Zoning Types

Residential areas can often justify restrictions and lower sign heights. New types of zoning have caused problems for regulators recently—such as mixed use—which can contain commercial businesses on the ground floor with residential uses in higher floors that predominate in a building. TxDOT's recent rulemaking in 2024 protects residential areas and clarifies wording on sham zoning issues:

> *TAC §21.161. Zoned Commercial or Industrial Area.*
>
> (a) For purposes of this subchapter, a zoned commercial or industrial area is an area that:

[234] Id.

(1) is designated, through a comprehensive zoning action, for general commercial or industrial use by a political subdivision with legal authority to zone regardless of the specific label used by the zoning authority; and

(2) contains at least one commercial or industrial activity, as defined in §21.163 of this subchapter (relating to Commercial or Industrial Activity), that is located:

(A) within 800 feet from the center of the existing or proposed sign structure; and

(B) on the same side of the highway as the existing or proposed sign.

(b) An area that is zoned for mixed use, regardless of the specific label, is not considered to be a zoned commercial or industrial area if the land use of the area is predominantly residential.

(c) An area is not considered to be a zoned commercial or industrial area if the area is not a part of comprehensive zoning action and is created primarily to permit or accommodate commercial sign structures.

Looking Ahead at Safety and Aesthetics

Before the most recent Fifth Circuit remand was decided, the Seventh Circuit[235] examined a challenge to a city's sign-control ordinance ban on digital displays. The City of Madison's on/off-premise distinction in the city's sign code was held to be content-neutral—not triggering strict scrutiny—so intermediate scrutiny applied. This ban on digital-image signs was upheld.

To date the FSAs have not been updated to reflect current LED sign technology and challenges. States seek guidance but lack precise brightness guidance, creating their own standards in various ways. Traditional criteria found in the FSAs (e.g., location, size, lighting, and spacing between signs) are the items that states must examine to regulate new technology, as Montana has done. Interviews with state DOTs reveal that states desire more federal guidance after *Reed* and *Reagan* (*19*). State law changes in Texas, Oregon, Ohio, Kentucky, Tennessee, and Iowa reveal that states are attempting to satisfy the HBA and FSAs while balancing all stakeholder and government interests. The majority of states and localities have begun to permit DBBs in specific ways. States and localities typically allow static messages that rotate every 6 to 8 seconds, with the change from one message to another occurring instantaneously.[236] DBBs (or EBBs) are capable of adjusting to their environment, and many jurisdictions have regulations restricting light intensity as it corresponds to the time of day or the amount of natural light.[237] The International Dark Sky Association collaborates with cities and states to craft precise wording in

[235] Adams Outdoor Adver. Ltd. P'ship v. City of Madison, 56 F.4th 1111(decided Jan. 4, 2023).
[236] Or. Rev. Stat. §§ 377.710(6), 377.720(3)(d); Mich. Comp. Laws § 252.318(h).
[237] Del. Code Ann. Tit. 17 § 1110(b)(3)(e); Ark. Admin. Code § 001.01.2-7; 700 Mass. Code Regs. 3.17; see also Ariz. Rev. Stat. § 28-7902(E)(4) (requiring digital billboards to be turned off during nighttime hours).

localities, such as Blanco, Texas (*56*). One big tenet of freedom of speech is that states are free to regulate the time and manner of solicitation generally, in the interest of public safety, peace, comfort, or convenience.[238] How government regulates signs will continue to develop.

Changeable Copy—Novelty of DBBs and Evidence of Traffic Safety for Courts

In the literature and legal research, the researchers sought to identify existing research about the driver safety impacts of static signs and DBBs, looking at the effects of brightness/illumination and the distraction effects that visual complexity creates for operators near signs.

In 2007, FHWA provided guidance related to the issue on whether CEVMS may attract drivers' attention from their primary task in ways that compromise safety. The current FHWA guidance regarding CEVMS is that signs do not change content more frequently than once every 8 seconds (*22*).

Older studies on distraction have been done. Wachtel found an implication that the shorter the message duration, the longer the driver's glance was in anticipation of the next message (*57*). The CEVMS federal memo recommended 8 seconds for DBB message duration, and TxDOT implemented this in TAC 21.196.

> *§21.196. Requirements For an Electronic Sign.*
>
> (a) Each message on an electronic sign must be displayed for at least eight seconds. A change of message must be accomplished within two seconds and must occur simultaneously on the entire sign face.
>
> (b) An electronic sign must:
>
> (1) contain a default mechanism that freezes the sign in one position if a malfunction occurs; and
>
> (2) automatically adjust the intensity of its display according to natural ambient light conditions.
>
> (c) The owner of an electronic sign shall coordinate with state and local authorities to display, when appropriate, emergency information important to the traveling public, such as Amber Alerts or alerts concerning terrorist attacks or natural disasters. Emergency information messages must remain in the advertising rotation according to the protocols of the agency that issues the information.

[238] Cantwell v. Connecticut, 310 U. S. 296, 306-307, 60 S. Ct. 900, 84 L. Ed. 1213.

(d) The department will share the contact information required by §21.154(e) of this subchapter (relating to Permit Application) with the appropriate local authority that has jurisdiction over the location of the electronic sign.

Drivers engaging in visually demanding tasks have a crash risk three times higher than attentive drivers; while brief glances do not increase risk, glances of more than 2 seconds at least double crash risk (*58*).

In re-examining this area, the researchers found that both on-premise and off-premise signage can be bright and distracting (*59*) for drivers as they search to find guide signs—which can affect traffic safety. Although OAAA promotes "safe digital billboards,"[239] not all local governments have been able to keep up with technology in updating their ordinances to require automatic dimming technology or light-sensing devices.[240]

To what degree this DBB distraction affects crashes remains a difficult task to prove, yet courts have thus far accorded deference to the reasonable legislative intent of local governments that regulate billboards (static and digital) with a nexus to governmental interests in safety and aesthetics.

Safety Evidence Not Needed by Court

Why do courts not require empirical evidence of traffic safety to pass each sign ordinance? Common sense would dictate that the local government costs of doing long-term studies on traffic safety and DBBs each time the technology changes would be prohibitively expensive and time consuming. In this study, the researchers used cutting-edge technology for eye tracking data. There are practical and financial reasons for the court's deference to reasonable legislative intent and government goals, which pervade case law and regulatory standard setting with sign regulation. "Municipalities must be given a reasonable opportunity to experiment with solutions to address the secondary effects of protected speech."[241] As a result, the quantum of empirical evidence needed to satisfy heightened judicial scrutiny of legislative judgments will vary up or

[239] OAAA, Code of Industry Principles, Sept. 19, 2024, https://oaaa.org/policy-advocacy/oaaa-code-of-industry-principles. (""Provide Effective and Safe Digital Billboards: We are committed to ensuring that the commercial and noncommercial messages disseminated on standard-size digital billboards will be static messages and the content shall not include animated, flashing, scrolling, intermittent or full-motion video elements (outside established entertainment areas). We are committed to ensuring that the ambient light conditions associated with standard-size digital billboards are monitored by a light sensing device at all times and that display brightness will be appropriately adjusted as ambient light levels change.")

[240] In August 2023, Dallas City council voted to amend the Dallas Development Code to allow digital billboards and update nonconforming and enforcement procedures for signs. The new rules also include lighting and safety standards for digital signs, such as brightness, message duration and spacing among other digital signs.

[241] Reagan, 64 F.4th 287, 296 (2023).

down with the novelty and plausibility of the justification raised, according to the Fifth Circuit.[242]

The Reagan case, upon remand to the Fifth Circuit (2023), clarified how common sense was enough to justify sign regulation:[243]

> The City also argues, though it provides no evidence we can find, that off-premises signs are larger than those on-premises, and thus the former cause more visual clutter. More generally, Austin provided little empirical evidence supporting its restrictions. Nonetheless, intermediate scrutiny has "never required" a municipality to "demonstrate, not merely by appeal to common sense, but also with empirical data, that its ordinance will successfully" achieve the desired end. City of Los Angeles v. Alameda Books, Inc., 535 U.S. 425, 439, 122 S. Ct. 1728, 152 L. Ed. 2d 670 (2002). "[M]unicipalities must be given a reasonable opportunity to experiment with solutions to address the secondary effects of protected speech." Id. (quotation marks and citations omitted). As a result, "[t]he quantum of empirical evidence needed to satisfy heightened judicial scrutiny of legislative judgments will vary up or down with the novelty and plausibility of the justification raised." Nixon v. Shrink Missouri Gov't PAC, 528 U.S. 377, 391, 120 S. Ct. 897, 145 L. Ed. 2d 886 (2000).

Practical Problems in Enforcement and Technology Considerations

Digital signs also pose new hurdles for the states and local jurisdictions to regulate to ensure HBA, especially between on- and off-premise signs from a compliance perspective. TxDOT Project 0-7085 noted (*19*):

> States do not have consistency in their statutory/regulatory language for on-premise digital signs displaying off-premise content and there is enormous difficulty in finding and enforcing these situations. Some states also have a safe-harbor provision, whereby if a violation notice is issued, the sign owner has a certain number of days to correct the problem. Bad actors here can correct the issue and then repeat it at a later date. If there is no repeat offender language in a statute, the on-premise owner has no 'stick' applied to them. In this instance, a state may have to file an injunction and may be required to monitor on a cycle to show continued illegal operation. This is onerous for the state, and developing a standardized process to manage and monitor this is extremely challenging.

Specific issues with digital signs, especially those that relate to spacing, lighting, and size will continue to provide challenges to the DOTs. These elements were not anticipated by the HBA,

[242] Id.
[243] Reagan, 64 F.4th 287, 296 (2023).

and in light of how technology has changed in the interceding 65 years since passage of the HBA, realistically these need to be clarified. Digital signs are being regulated differently state by state, and unforeseen problems are occurring. For example, in Oregon, spacing between signs in cities is only 100 ft—whether the sign is digital or not—which may conflict with the intent of the HBA since it was written before this type of digital sign existed. Oregon has no setbacks from the right-of-way, which means signs tend to be as close to the road as possible, which also could cause driver glare issues with bright digital signs.

In addition, as transportation moves to a future with automated vehicles it will be important to ensure that the connected and artificial intelligence (AI) based technology on these vehicles is not 'distracted' or 'confused' by digital signs. The HBA will need to move with the times. Interactive billboards are in use in the United Kingdom, sparking privacy and cybersecurity concerns (*60*).[244] As Missy Cummings, an AI expert, points out, an autonomous vehicle camera can look at mobile billboards on the side of a moving truck and perceive nothing close to what a human would. In this instance, the camera detected a strong man graphic ad as several objects on a road: two trucks, a man, four poles, a bus, a traffic sign, fence, and building (*61*).

In San Francisco recently, robotaxis were paralyzed by something as simple as placing a cone on the hood of the car (*62*). This is in addition to robotaxis that have crashed with fire trucks on route to an emergency, blocked traffic lanes, obstructed public transit, and driven over a fire hose (*63*). The 'Coning' of Cruise and Waymo's driverless vehicles by the Safe Street Rebels also showed how quickly and easily a streetwise group could hijack public safety in a novel but terrifying way (*64*).

Ensuring new technology will be safe around all the many facets that surround the streets will require FHWA and the states to work together to ensure that perception, lighting, and digital processes on billboards are taken into consideration for the existing state of play and for the anticipated shift to a driverless car future.

Cybersecurity of DBBs

Digital signage systems are no longer seen as low-risk cybersecurity targets and have been hacked (*65*). Hackers are often drawn to them for the high-visibility notoriety they can get from compromising a large billboard (*66*). If hackers inject false information, it can have negative consequences during a public emergency. OAAA has acknowledged that protecting digital signage is important, and they issued a OAAA *Digital Billboard Security Guidelines* document (*67*) that recommends owners improve password strength, implement whitelist access only (for IP addresses), use multi-factor authentication, use a virtual private network, apply security patches as soon as possible from software vendors, and disable unused services (such as network

[244] At InfoComm 2024, Dan Ferrisi, group editor for commercial and security at Emerald, delved into this issue by hosting a panel discussion on cybersecurity vulnerabilities in digital signage.

printer access) (*68*). Billboard products should offer government and private customers multiple layers of security with strong password protection and a system that prevents outside software from gaining access to the sign's controller. A secure billboard system from an external vendor may want to have newer intrusion detection systems (*67*) and follow transport layer security protocols for network security and data integrity. If governments are sharing connections with DBBs for emergency messages, they should stay updated on the evolving data threat environment and best practices for securing digital signage systems.

At the end of the day, ensuring the safety of the motoring public is necessary, and that realistically means the current status quo on lighting standards for DBBs needs to be grounded in further testing and development of standards at the federal level.

EMCs—On-Premise Digital Signs

EMCs are typically LED signs that display messages or advertisements electronically and are used to advertise the goods or services of a business operating on the property where the sign is located (i.e., on-premise). These signs are often used by businesses, schools, or public entities and are usually regulated differently from off-premise signs by ordinances. EMCs are regulated mostly by local government, whereas DBBs fall under the regulatory framework of local, state, and/or federal government (e.g., the HBA). Though local government ordinances vary by state and county, many local jurisdictions allow for EMCs since they promote noncommercial entities and local businesses' interests on the same property. Business owners often purchase these EMCs outright and program them. Although EMCs seldom have spacing requirements under an ordinance, they are often bright and can be programmed to display scrolling messages, animation, and video (*69*). Not all EMCs have automatic dimming capabilities to adjust illumination to ambient lighting conditions, which means that these mostly on-premise signs can be unusually bright at night for drivers (*69*).

Some states and cities also call digital signs "electronic signs,"[245] EMCs, or EMDs. However, EMCs are mostly considered on-premise signs and are not regulated by the HBA. DBBs are off-premise or OA EMCs. This chart from ISA (*70*) shows differences between EMCs and billboards, providing a side-by-side comparison and contrast between on-premise and off-premise signs. Each type of sign has very distinct capabilities and purposes, each targets a

[245] Arizona (A.R.S. §§ 28-7902(E)-(L)); California (CAL. BUS & PROF. CODE § 5405(d)(1)); Colorado (COLO. REV STAT. § 43-1-404(1)(f)(I))(amended in 2021) ; Connecticut (CONN. GEN. STAT. §13a-123(f)); Delaware (DEL. CODE ANN. tit. 17 § 1110(b)(3)(e)); Georgia (GA. CODE ANN. § 32-6-75(c)(1)); Indiana (IND. CODE § 8-23-20-25.5); (105 IND. ADMIN. CODE § 7-3-1.5); Kansas (KAN. STAT. ANN. § 68.2234 (3)(e)); Michigan (MICH. COMP. LAWS § 252.318(f)); Minnesota (MINN. STAT.173.155); Missouri (MO. REV. STAT. § 226.540(1)(a))(2022); New York (N.Y. HIGH. LAW § 88 (2)(g)); Oklahoma (OKLA. STAT. tit. 69 §1275(d)(4)); Oregon (OR. REV. STAT. §§ 377.710(6) and 377.720(3)(d)); South Dakota (S.D. CODIFIED LAWS § 31-29-66(4)); Tennessee (TENN. CODE ANN. § 54-21-122); Utah (UTAH CODE ANN. § 72-7-505(1)(d)); Virginia (VA. CODE ANN. § 33.1-369).

specific audience, and each has traditionally been treated under separate legal and regulatory regimes.

With more recent recognition of light pollution, light trespass, environmental impacts upon wildlife (*71*), and Dark Sky initiatives,[246] cities are often seeking more modern approaches to restrict brightness of all signs and light pollution, regardless of sign location.[247] Over time more cities have added provisions on on-premise EMC brightness, with requirements on automatic dimming technology to adjust the brightness to the ambient light; however, EMCs are mostly on-premise signs.

Local sign codes should include regulations for all types of on-premise signs, including commercial (e.g., office, retail, etc.), industrial, multi-family developments, institutional, and public uses (including those public and institutional uses that are typically in residential districts), and entry signs for large subdivisions.[248]

When measuring the brightness of an on-premise EMC, the procedure and distances cities use to take the measurement should follow the guidelines set out by ISA's document titled *Night-time Brightness Level Recommendations for On-Premise Electronic Message Centers* (*72*).

SURVEY OF AASHTO OUTDOOR ADVERTISING POLICY TECHNICAL COUNCIL

The research team prepared survey questions to distribute to the AASHTO Technical Subcommittee on Outdoor Advertising Control. The Technical Council on Outdoor Advertising Policy and Technical Council on Outdoor Advertising Control Operations were the two target technical councils. The survey questions sought information on legislation/regulation, litigation, federal policy development, and perspective on challenges in regulating lighting on digital messaging.

Responses to the survey were collected between October 17, 2023, and January 9, 2024. The survey received 28 responses from 24 states. The responses are a snapshot in time and from a limited number of respondents. Policies are constantly changing and respondents may not have had all the information needed to answer some questions.

The following section lists questions asked in the survey and the respective responses.

Question 1 (Table 3). Does your agency or local agencies in your state have specific rules regarding digitization of existing or new advertising signs? If yes, are these laws, regulations, or both?

[246] See Supra Note 192.
[247] Dripping Springs, Texas, has passed an Outdoor Lighting ordinance and has declared itself a Dark Sky community, https://www.cityofdrippingsprings.com/Lighting
[248] Sign Research Foundation (SRF), Model Sign Code (2019), at 5.

Table 3. Responses to Question 1.

	Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	Montana	New Jersey	North	Ohio	Oregon	South	Texas	Utah	Virginia	Washington	Wyoming
Regulations		X	X			X	X	X	X	X	X		X	X	X	X	X	X	X	X			X	X
Laws		X	X	X	X	X	X	X	X			X	X	X	X	X		X	X					
Not Sure	X																				X	X		

A follow-up question (Table 4) asked respondents to upload an electronic version of the laws/regulations, and/or if the laws/regulations were available online to provide a link to those laws/regulations.

Table 4. Responses to Follow-Up Question.

	Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	Montana	New Jersey	North	Ohio	Oregon	South	Texas	Utah	Virginia	Washington	Wyoming
Provided Link			X		X		X	X		X	X	X	X	X		X	X	X	X					
Uploaded File		X		X		X			X					X	X			X	X				X	X
No Response	X																			X	X	X		

Finally, respondents were asked if they would like to provide more information, and the following responses were received:

- California state law does not specify digital only displays with the capability to cycle messages.
- When digitizing an existing board, they have to apply for an alteration. Alterations must have local approval first.

Figure 3 shows the answers to Question 2: approximately how many DBBs are active in your state?

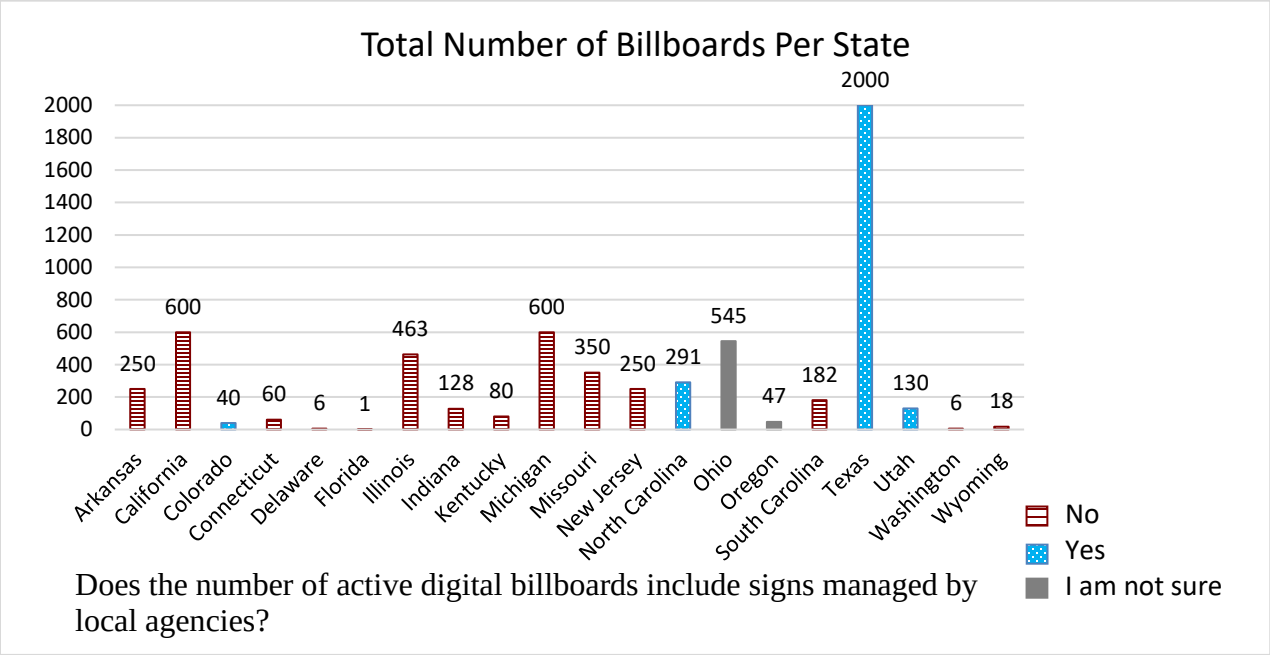

Figure 3. Responses to Question 2.

Question 2 included two follow-up questions that are shown in Table 5. The responses to this question were relatively inconsistent and the majority of the respondents did not have information on the number of signs managed by local agencies.

Table 5. Question 2 Follow-Up Questions.

State	Number of Signs Managed by the State	Number of Signs Managed by Local Agencies?
Alaska	0	0
Arkansas	250	Unknown
California	600	Unknown
Colorado	40	Unknown
Connecticut	60	0
Delaware	0	15
Florida	1	1
Illinois	463	Unknown
Indiana	128	Unknown
Kentucky	80	Unknown
Maryland	Unknown	Unknown
Michigan	600	
Missouri	350	0
New Jersey	All	None
North Carolina		3
Ohio		
Oregon	47	I don't know
South Carolina	182	0
Texas	1000	1000
Utah	0	130
Washington	0	Unknown
Wyoming	None	None

Table 6 shows Question 3: Does your agency have regulations on the sizing, spacing, location, or brightness of digital signs? If yes, please provide an electronic version if different than information provided in Question 1. Is there any information you would like to share?

Table 6. Responses to Question 3.

State	Response	Link	File
Alaska	I am not sure		
Arkansas	Yes		✓
California	Yes	✓	
Colorado	Yes		
Connecticut	Yes		✓
Delaware	Yes		
Florida	Yes		
Illinois	Yes		
Indiana	Yes		
Kentucky	Yes		
Maryland	No		
Michigan	Yes		
Missouri	Yes		
New Jersey	Yes		
North Carolina	Yes		
Ohio	Yes		
Oregon	Yes	✓	
South Carolina	Yes	✓	
Texas	Yes		
Utah	No		
Washington	Yes		
Wyoming	Yes		✓

Additional information submitted by respondents:

- There are thousands of digital displays in California, but only a small amount are permitted by Caltrans.
- Our size, spacing, and lighting regulations are the same for any off-premise sign regardless of if it is digital or static. Our only brightness reg. is that the sign must not cause glare or be too bright as to be a distraction.

Table 7 shows Question 4: Does your agency have plans to regulate emerging technology (e.g., digital and interactive billboards/connected vehicles) in signs going forward?

Table 7. Responses to Question 4.

Alaska	I am not sure
Arkansas	I am not sure
California	I am not sure
Colorado	I am not sure
Connecticut	No
Delaware	No
Florida	Yes
Illinois	Yes
Indiana	I am not sure
Kentucky	I am not sure
Maryland	No
Michigan	Yes
Missouri	No
New Jersey	I am not sure
North Carolina	I am not sure
Ohio	I am not sure
Oregon	Yes
South Carolina	No
Texas	I am not sure
Utah	I am not sure
Washington	No
Wyoming	No

How would you regulate these emerging issues?

- Depends on what the issue is and the administration in place at the time.
- As statute allows for current digital billboards.

- Signs on vehicles, we regulate through the Dept of Transportation only when the vehicles are parked or left where visible to the National Highway System (NHS). For vehicles actually driving on NHS with messages, the Oregon State Police regulate based on their criteria for distracted driving and safety issues. We have no current provisions for regulating signs on waterways.

Is there additional information you would like to provide?

- We have been contacted by companies exploring drone advertising.

Table 8 shows answers to Question 5: Does your agency see or expect any emerging issues with the safety, standards, or on-premises rules surrounding digital billboards?

Table 8. Responses to Question 5.

I am not sure	No	Yes	I am not sure	Yes	I am not sure	I am not sure	I am not sure	I am not sure	I am not sure	I am not sure	No	No	I am not sure	I am not sure	No	No	No	Yes	I am not sure	No	No
Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	New Jersey	North Carolina	Ohio	Oregon	South Carolina	Texas	Utah	Washington	Wyoming

What issues do you see or expect?

- Increase in distracted drivers.
- Emerging technology. Regulation language does not consider the new technology and the new technology coming to the states. No law or rules to control on-premises digital signs.

Is there any additional information you would like to provide?

- Current regulations have allowed and managed digital outdoor advertising as well as regulation for non-outdoor advertising signs that are visible to the NHS for over 10 years.

Table 9 shows answers to Question 6: Will regulatory changes be necessary for the law to keep up with the changing technology and emerging issues?

Table 9. Responses to Question 6.

Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	New Jersey	North Carolina	Ohio	Oregon	South Carolina	Texas	Utah	Washington	Wyoming
I am not sure	Yes	Yes	I am not sure	Yes	I am not sure	I am not sure	Yes	I am not sure	Yes	Yes	I am not sure	No	Yes	I am not sure	I am not sure	Yes	No	Yes	I am not sure	I am not sure	I am not sure

What changes may be necessary?

- Spacing and size.
- We need to update laws to specifically regulate digital billboards.
- Need measurable brightness standards that are easily tested and enforced.
- Update current regulations to even address digital billboards in the state.
- Updates regarding mobile or impermanent billboards, regarding rotating billboards or moving billboards, regarding bus shelter or bike rack billboard/advertisements.
- It seems likely that at some point regulations will need to be adjusted to address issues such as signs on marine vehicles designed to be viewed by traffic on portions of NHS, as well as possible regulation of interactive signs that may be at locations meant for walkers/hikers/bikers but visible to NHS.
- Add language to control the view shed, number of faces, the different ways signs can become digitally lit.

Table 10 shows answers to Question 7: Is it possible that on-premises signage may need regulation if changeable message/LED/digital signs affect or distract motorists using the highway?

Table 10. Responses to Question 7.

Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	New Jersey	North Carolina	Ohio	Oregon	South Carolina	Texas	Utah	Washington	Wyoming
I am not sure	No	Yes	I am not sure	Yes	No	No	Yes	I am not sure	Yes	Yes	I am not sure	I am not sure	Yes	No	Yes	Yes	Yes	Yes	I am not sure	No	Yes

How would you regulate, or what type of regulation may be needed?

- More clear definitions in order to preserve the 1,000-foot spacing rule.
- Need to regulate size, spacing, and lighting.
- New Jersey already has regulations regarding on-premises multimessage.
- Ohio's laws do not apply to on/off-premise advertising. We look at whether compensation is being paid for the placement of the message. If a non-compensated sign is creating a safety situation, we would need to amend the law to give the department jurisdiction.
- We have established Oregon Administrative Rule 734-060-0190 to regulate digital/LED signs that are visible to the NHS but are signs at a place of business that do not contain any compensated messages.
- State agencies may be contacted regarding on-premises signage to include LED and digital, but this information will be passed on to local agencies to handle.
- Brightness standards, flashing, and scrolling messages stopped, spacing/distances.
- This is in our rules and regulations.

Is there any additional information you would like to provide?

- Our highway patrol handles any on-premise complaints regarding changeable message signs

Table 11 shows answers to Question 8: Does your agency foresee litigation increasing in certain areas? (e.g., issues with mobile billboards, digital signs, zoning, safety of digital/LED/changeable message signs)?

Table 11. Responses to Question 8.

Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	New Jersey	North Carolina	Ohio	Oregon	South Carolina	Texas	Utah	Washington	Wyoming
I am not sure	Yes	I am not sure	I am not sure	Yes	No	I am not sure	I am not sure	I am not sure	Yes	I am not sure	No	No	Yes	No	No	Yes	No	Yes	No	No	No

What areas could see increased litigation?

- Unzoned areas that are in non-commercial/industrial areas.
- All of the above areas mentioned.
- As technology keeps improving and prices continue to lower for digital and LED signage, it seems likely we will see more digital signs; likely we will see an increase in litigation on placement, brightness, and what may constitute a sign at a business, rather than an outdoor advertising sign.
- Safety aspects.

Table 12 shows answers to Question 9: Has your agency received any public feedback on digital advertising?

Table 12. Responses to Question 9.

I am not sure	No	Yes	Yes	Yes	No	Yes	No	I am not sure	I am not sure	No	Yes	No	I am not sure	No	Yes	No	Yes	No	No	Yes	Yes
Alaska	Arkansas	California	Colorado	Connecticut	Delaware	Florida	Illinois	Indiana	Kentucky	Maryland	Michigan	Missouri	New Jersey	North Carolina	Ohio	Oregon	South Carolina	Texas	Utah	Washington	Wyoming

Was the feedback generally positive or negative? Any notable examples of feedback that you can share?

- Negative.
- We have received feedback when we've gone through our rulemaking process
- Negative. Typically we get complaints about brightness, which is not controlled.
- It is very little feedback that is received regarding off-premises digital signs. Mostly negative—content, brightness. Little positive—content was helpful in notifying driver of an area restaurant.
- Primarily complaints about brightness and that they are creating distractions for drivers.
- We do have concerned citizens call in or comment on our help site regarding the brightness of digital advertising. The feedback can be both positive and negative depending on if it is a safety hazard regarding the animation, brightness, time in between each advertisement, etc., but this gets addressed as soon as possible by our coordinators or a call will be given to the locals to address the issue if it is an on-premise.
- The feedback has been negative. To give a little more information, in Washington State we do not allow electronic signs outside of the on-premise signs. However, we currently

have six electronic permitted off-premise signs because they were located on a Map 21 route, and they are non-conforming signs.
- The negative feedback has come from signs that are located on our tribal lands. These are parts of our state highway system that we do not regulate.
- Negative. Concerned on brightness.

Is there any additional information you would like to provide?

- We receive occasional complaints from the public when signs have been converted from static to digital and/or the spacing of signs that are digital; however, I haven't seen any legislation or legislative concepts regarding changes to current spacing and permitting for digital OASs.

Table 13 shows answers to Question 10: Does your agency track vehicular incidents based on distracted driving, particularly in regard to digital signage?

Table 13. Responses to Question 10.

Alaska	I am not sure
Arkansas	I am not sure
California	I am not sure
Colorado	I am not sure
Connecticut	I am not sure
Delaware	I am not sure
Florida	I am not sure
Illinois	I am not sure
Indiana	I am not sure
Kentucky	No
Maryland	No
Michigan	No
Missouri	No
New Jersey	No
North Carolina	No
Ohio	No
Oregon	No
South Carolina	I am not sure
Texas	I am not sure
Utah	No
Washington	I am not sure
Wyoming	No

Is the agency interested in tracking such occurrences?

- Yes.
- Not at this time.
- We do not currently track. The agency could be interested in tracking occurrences to have metrics.
- I'm not sure it has even been discussed at this time. Our sign program is quite small, with only 47 digital signs in the state so far. As that number increases, more research will likely be needed.
- No.
- I do not know this information.

Is there any additional information you would like to provide?

- I am not aware of this particular tracking, but I will look into it. It could be beneficial to the ODA office and the agency as well.

CHAPTER 3:
SITE IDENTIFICATION AND HUMAN FACTORS INVESTIGATION PROTOCOL

SITE IDENTIFICATION

In order to conduct this study, information on digital and standard billboards needed to be collected. The study used a four-step process to identify the study sites:

- **Step 1:** Identify all DBBs across Texas and use the data for crash investigation.
- **Step 2:** Select four cities with a high density of DBBs with different driving conditions (e.g., urban freeway, rural freeway, non-freeway, etc.) as the human factors study locations.
- **Step 3:** Identify specific roads with a combination of digital and standard billboards and an approximate driving time of 30 to 40 minutes for the human factors study.
- **Step 4:** Select all DBBs, several standard billboards, and some other signs such as on-premises signs, guide and information signs, and changeable message signs.

The following sections provide a detailed explanation of these steps:

Step 1—Identify All Digital Signs

TxDOT supplied files to the research team to help identify digital sign locations. These files contained information on all advertising signs (digital and standard) that TxDOT had in its database. The files contained information about the location (i.e., geocoordinates, owner name, highway name, county name, address, and in some cases which face of the sign was electronic) of all signs in the state. The sign types include interstate signs, rural road signs, unpermitted signs, sign direction, and electronic signs. The research team filtered these files to only include the electronic signs. The other files contained information about the issued date and the sign opened date. The research team combined these three files based on the record ID, which was a common identifier in all three files. Table 14 presents the information about the number of electronic signs by the year issued or opened. The research team also received information about digital signs in certified cities. There were 89 useable signs in that dataset, but there was no information provided on when the signs may have been installed. Figure 4 shows a map with the location of each of the digital advertising signs.

Table 14. Number of Electronic Signs by Year Issued or Opened (TxDOT).

Year Issued or Opened	Number of Electronic Signs
2017 or earlier	19
2018	12
2019	20
2020	29
2021	34
2022	64
Not Available	10
Total	188

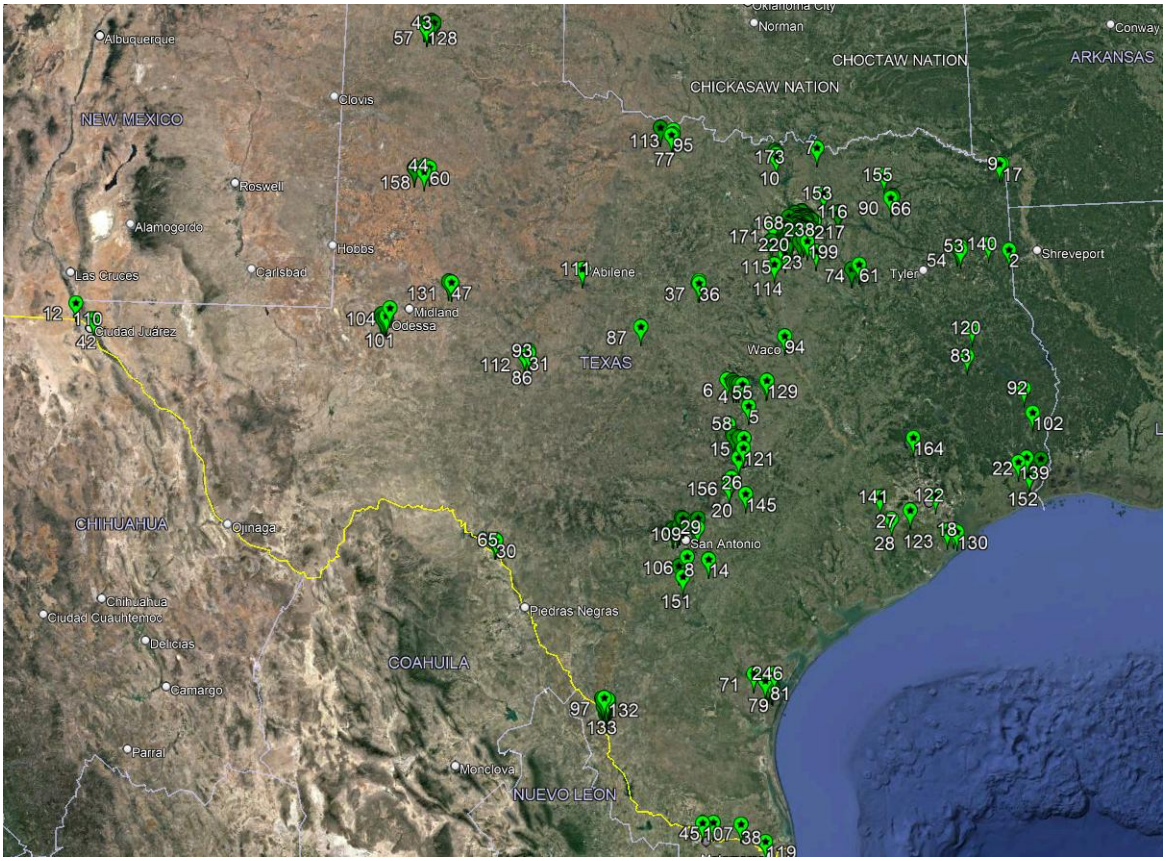

Figure 4. Locations of Digital Advertising Signs.

Step 2—Identify Four Study Sites

Based on information gathered in Step 1, four cities were selected to serve as study sites for the human factors study. The study team considered density of digital signs in the area as the main decision parameter. Other parameters such as city size and location diversity also played a secondary role in study site selection. The selected study sites were the cities of Amarillo, Arlington, Killeen, and San Antonio. Each of these cities offer unique characteristics and together provide for a range of conditions to study the interactions between signs and drivers.

Step 3—Select Study Routes

The presence of a variety of sign types along the driving route was the main decision parameter. In addition to a variety of signs, the study team considered visibility of digital and standard billboards from the road, availability of signs on both sides of the road, route circulation, and access to on- and off-ramps to enter and exit the study sites as factors that influenced study routes. A variety of roadway types such as freeway, frontage road, and non-controlled access facilities were desired.

Step 4—Select Study Signs

This step took place after the human factors runs were complete. At this point the study team had access to the video files that were collected as part of the driving part of the study. The study team used nighttime videos to identify signs that were visible during the night (were not turned off). All DBBs (except a few that were not visible from the study route or were located at areas where there were conflicts that made the data not useful), several standard billboards, and some other signs were selected and further investigated as part of the human factors study that included analyzing eye tracker data. Figure 5, Figure 6, Figure 7, and Figure 8 show the study sign types and locations in Amarillo, Arlington, Killeen, and San Antonio, respectively. The study mainly included digital and standard billboards, but a few other signs such as guide signs, information signs, on-premises digital signs, and CMS were also included.

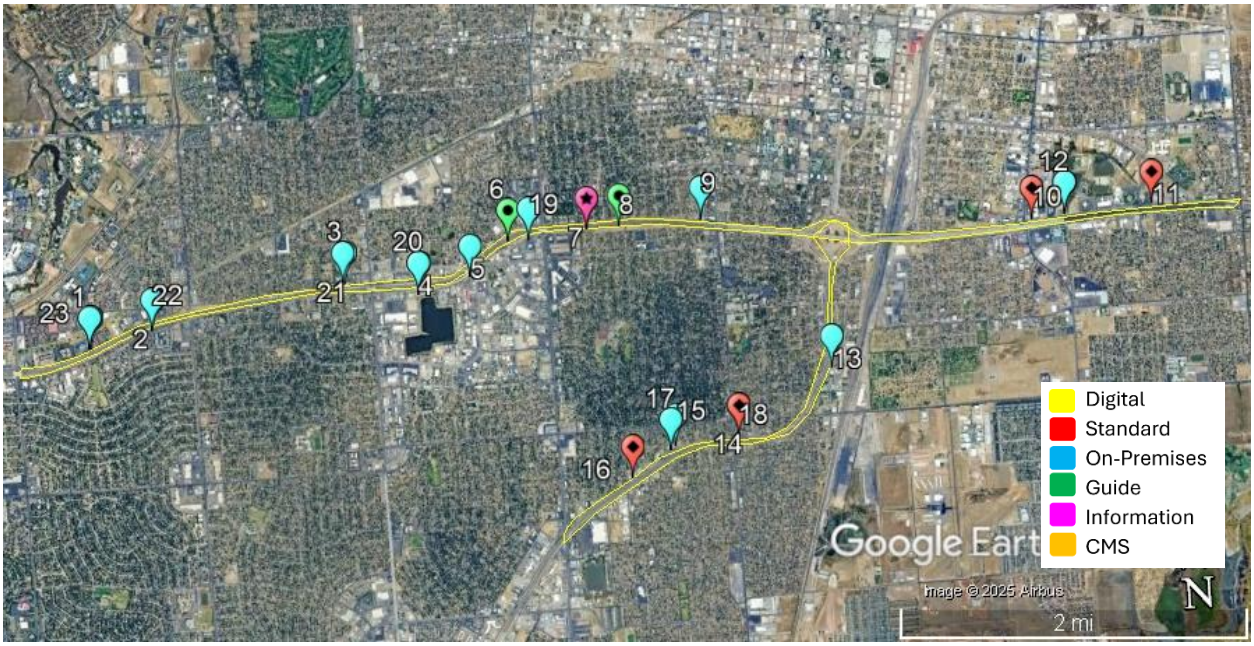

Figure 5. Amarillo Driving Route.

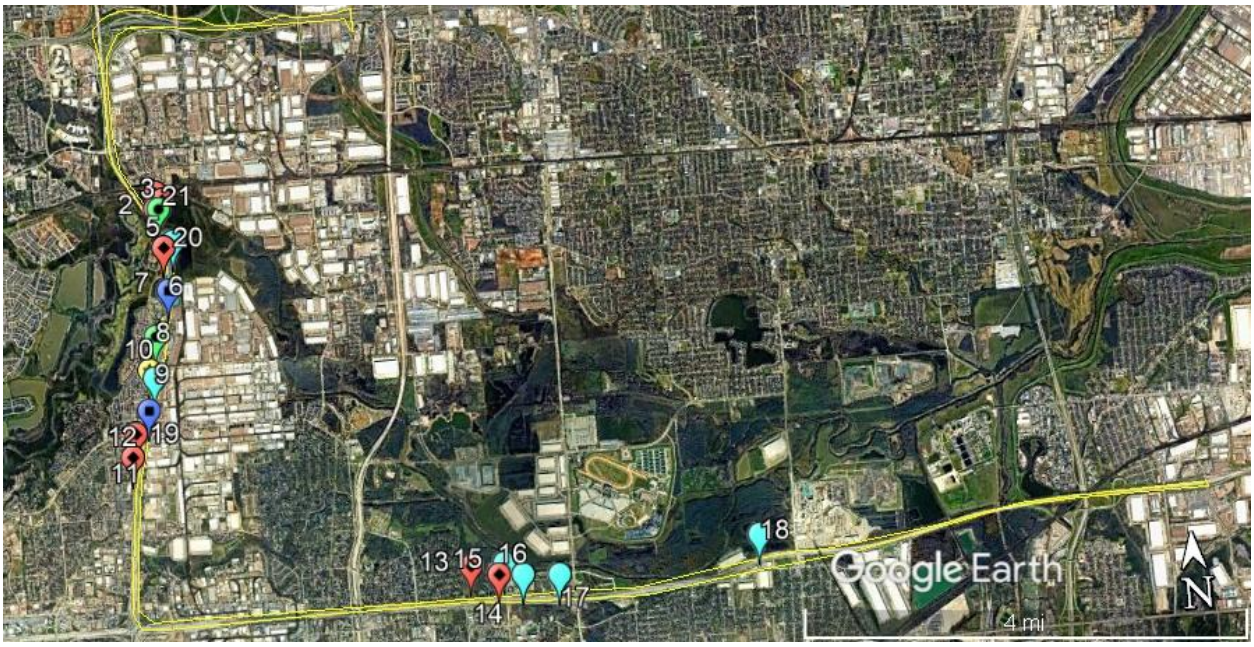

Figure 6. Arlington Driving Route.

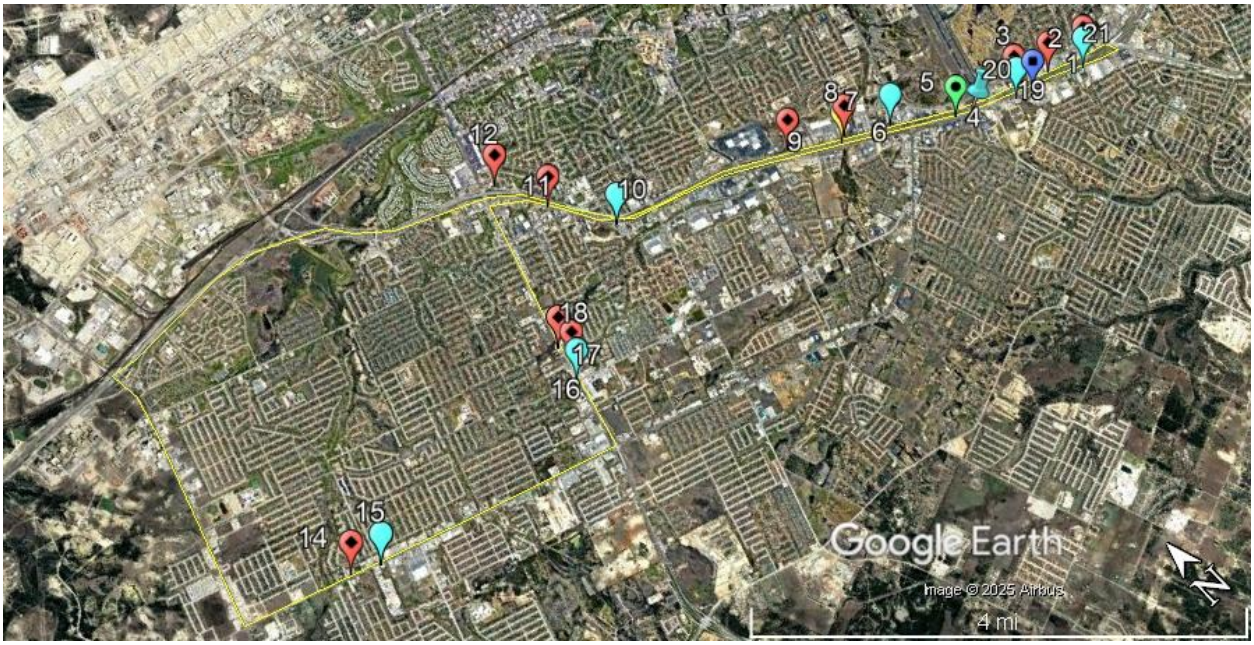

Figure 7. Killeen Driving Route and Study Signs.

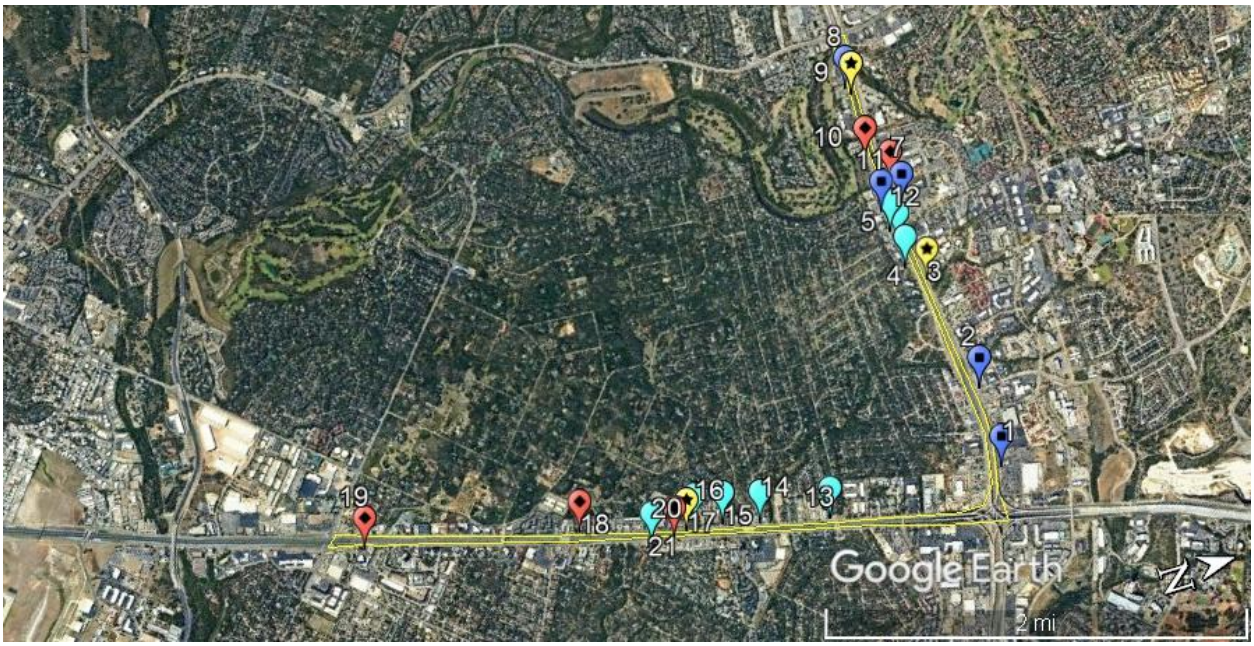

Figure 8. San Antonio Driving Route.

HUMAN FACTORS INVESTIGATION PROTOCOL

Participants

The goal was to recruit 25 participants from each study site to reach a target of 100 participants. Due to slower than expected participant recruiting in the smaller cities and cancellations of scheduled participants, the study team was not able to collect data for 25 participants at each site. The total number of participants who completed the study was 84.

Table 15. Count of Recruited Participants.

	Completed the Study
Amarillo	17
Arlington	28
Killeen	17
San Antonio	22
Total	**84**

Participant recruitment was conducted by online advertisement through Facebook and Instagram. Figure 9 shows an image of the online advertisement.

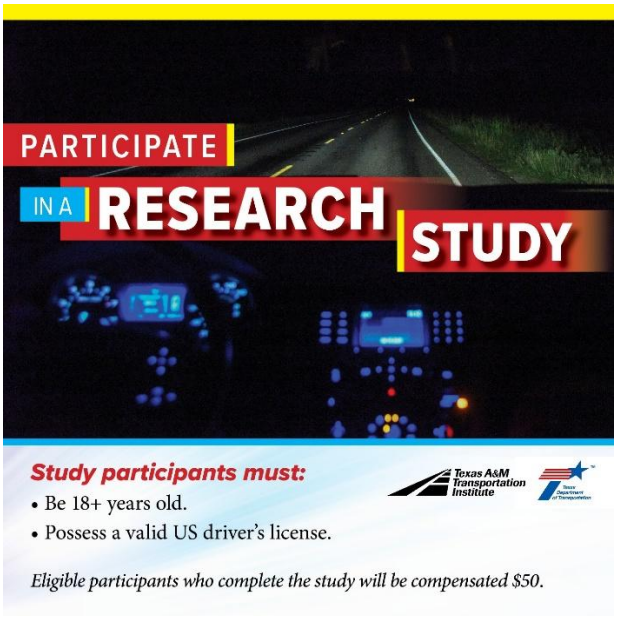

Figure 9. Online Advertisement Image.

The following text was included with the advertisement:

> The Texas A&M Transportation Institute (TTI) is recruiting participants in the [Amarillo, TX, Arlington, TX, Killeen, TX, and San Antonio, TX] area to participate in a research study sponsored by the Texas Department of Transportation (TxDOT). The purpose of this research project is to evaluate our in-vehicle monitoring system. Participants will drive an instrumented TTI vehicle along roads through the study area while driving normally. Participants are being recruited for both day and night testing.
>
> Eligible participants who complete the study will be compensated $50 via their choice of Venmo, PayPal, or an electronic Amazon gift card. The study will take between 60 to 90 minutes to complete. Participants are being scheduled during the day and at night between [Start Date] and [End Date].
>
> In order to qualify, you must meet the following requirements:
>
> - Are age 18+
> - Possess a valid US driver's license
> - Have normal (20/40 or better) or have corrected-to-normal vision
> - Are not on any medications that advise against taking while operating a moving vehicle
> - Are able to speak English
> - Can accept electronic payment (through Venmo, PayPal, or Amazon Gift Card)

If you are willing to participate, please complete this screening survey https://tti.qualtrics.com/jfe/form/SV_9B2pca6WbSWUplc If you meet the study requirements, a member of the research team will contact you via email.

If you have questions, contact Adam Pike at a-pike@tti.tamu.edu.

Thank you!

IRB 2024-0097

Approved (8/1/2024)

Each potential participant was contacted after responding to the online recruiting survey. The study team contacted eligible participants and scheduled a date/time for the survey. At the time of the study, the participant entered the testing location and received instructions for the study. The instructions included the purpose of the study, the general driving route, information about the vehicle, information about the after-study survey, and instructions for safe driving. The participants were not aware of the specific objective of the research. They were informed the study was about the vehicle monitoring systems and to drive naturally along the study route. After signing the consent form the participants were taken to the test vehicle (see Figure 10). Driver performance metrics such as speed, acceleration, steering wheel input, and travel path were monitored and recorded by the instrumented vehicle.

After the participant was comfortable in the vehicle, the Smart Eye tracking system was calibrated by having the participant look at several targets while sitting in their driving position. The Smart Eye system utilized three cameras mounted on the dash to provide eye tracking across the full driving view. The eye tracking location was superimposed on a forward-facing video feed. Figure 11 provides an image of the Smart Eye camera setup on the vehicle dashboard. After the eye tracker calibration, the participants then drove the vehicle while a research team member sat at the back of the vehicle providing navigation and monitoring the data logging equipment. After the driving task, participants returned to the study start location and filled out a computer-based survey and received payment.

Figure 10. TTI Instrumented Vehicle Used in the Study.

Figure 11. Smart Eye Camera Setup on Vehicle Dashboard.

Data Collection

Five different types of data were collected for this study:

- Demographic data (gender, age).
- In-vehicle data.
- Eye tracking data.
- Closeout survey data.
- Nighttime sign brightness information.

Demographic data were collected at the time of scheduling. In-vehicle data and eye tracking data were collected during the driving task, and the closeout survey data were collected after the driving task at the end of each participant's appointment. Eye tracking data required extensive

post processing to generate the gaze information the research team desired. The research team used iMotions software to collect and process the eye tracking data. During the post processing, target signs were identified and defined as an area of interest (AOI). Each AOI was monitored during the entire period that it was visible for the driver. In Figure 12, panel 1 shows a CMS on the right shoulder of the road. Panel 2 shows the AOI defined by the study team. In panel 3, driver eye tracking shows the driver looking at the truck on the left side of the road and then back to straight ahead. In panel 4, the driver is looking directly at the AOI, while in panel 5 the driver is looking back down the road straight ahead while the CMS is in the viewing window. In panel 6, the driver looks to the road without a sign in the viewing window, which shows normal driving conditions where there are no signs present.

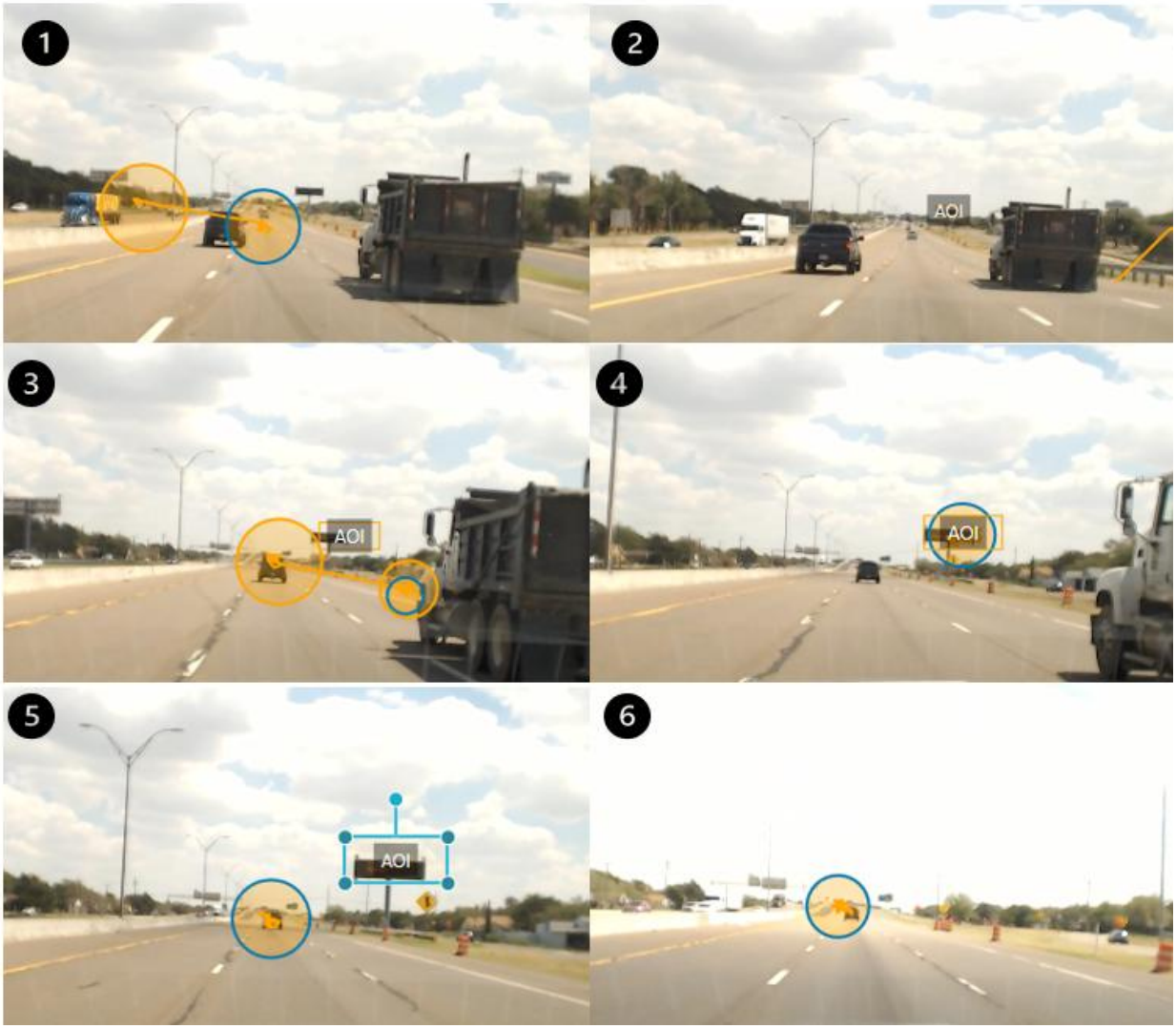

Figure 12. iMotions Eye Tracking and AOI Definition.

Digital and standard billboards along the study route were evaluated to determine their lighting levels at night. The research team considered several approaches to evaluate the sign lighting

characteristics. These approaches included measuring sign luminance, illuminance generated by digital signs, light trespass on surrounding properties, sky glow (related to the amount of light sent upward), uniformity of lighting, color of the lighting, and displayed color on the sign.

With many of the signs in urban areas, there were many other sources of lighting at the sign sites. This made many of the measurements difficult to isolate the lighting levels generated by the signs themselves. This is a limitation of field measurement and not being able to control all variables. The research team did not have access to control the sign contents so there was always some level of lighting from the signs being evaluated, and the digital sign message changed every 8 seconds or so. The most reliable, consistent, and accurate measurement was sign luminance. Sign luminance was measured with a handheld luminance meter (see Figure 13 left side) and an imaging colorimeter (see Figure 13 right side). The handheld luminance meter is a lower cost piece of equipment that takes quick measurements of luminance of a single point. The imaging colorimeter is a higher cost piece of equipment that is more complicated to operate and takes longer to take a measurement. An advantage of the imaging colorimeter is that it captures the entire sign with a single measurement and can capture both luminance and color at the same time. The imaging colorimeter measurements may take several seconds to take, which may limit the ability to capture sign color due to the message changing before the measurement is complete.

Figure 13. Handheld Luminance Meter (Left) and Imagin Colorimeter (Right).

CHAPTER 4:
CRASH INVESTIGATION

The research team determined the sites to include in the crash investigation using the sites identified in the previous chapter. Mainly, the team used only the signs that were digital and had the necessary information available for the crash analysis. In total, 131 signs from TxDOT supplied data and 89 signs from certified cities data were included. The research team first geo-coded all the identified locations and developed a data collection plan to collect site information to use in the crash study. The research team then developed a database for assessing the safety performance of DBBs on various highway types.

The research team assembled a database with spatial and temporal cross-reference information that incorporated crash, traffic, and geometric characteristics of the highway where the sign was located. The first effort in this task was to identify the influential area of each sign. The research team used the street view feature from Google Earth and located the area where the sign had an influence. For each analysis site, the team selected an equal length comparison site from the other side of highway. Figure 14 shows an example of the analysis and comparison sites. The sign was double-sided, so it had an influence on the drivers going in both directions. In addition, the drivers on the frontage roads were also influenced by this sign. For the traffic going in the southeast direction (left to right in the figure), the drivers exiting the ramp were also influenced. In this example, the lines represented by red (A1) and teal (A2) are the analysis sites (that are influenced by signs), and the lines represented by green (C1) and yellow (C2) are comparison sites. Green sites are comparison sites for red sites, and yellow sites are comparison sites for teal sites. The research team used the same approach for all signs and identified the analysis and comparison sites.

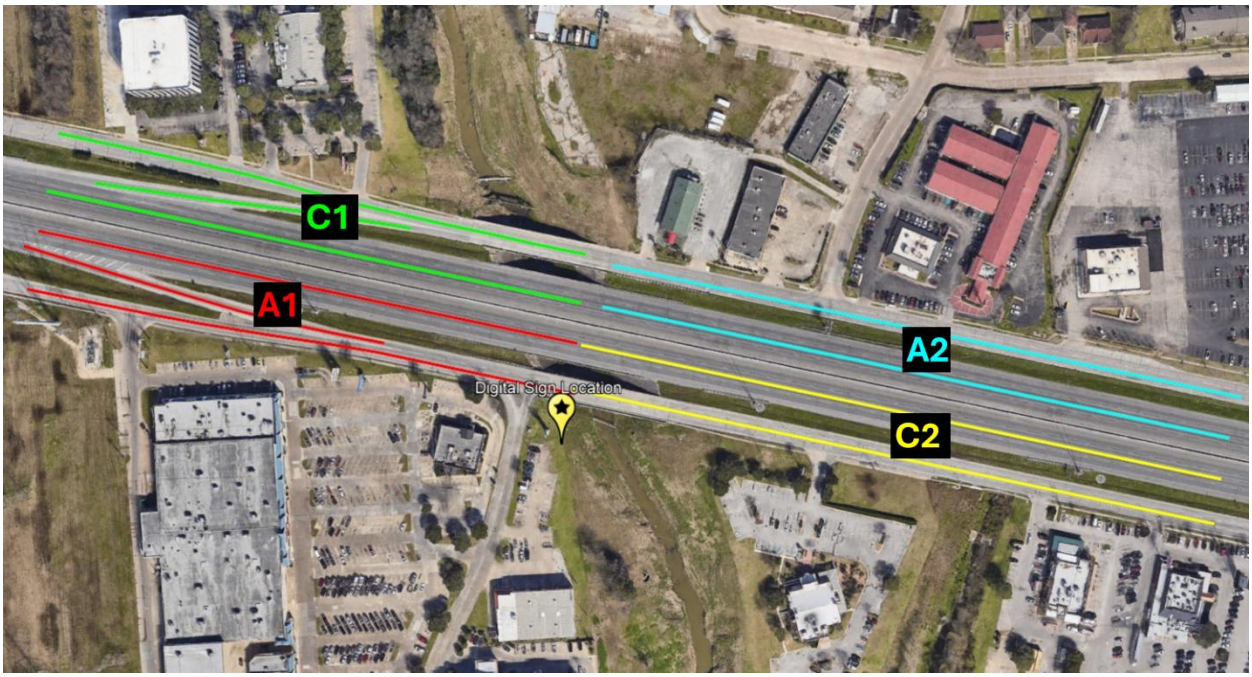

Figure 14. Sign Influence Area.

INSTALLATION DATES

The signs supplied by TxDOT contained information about the issued date for most signs and the opened date for very few signs. There was no information available about the issue date or opened date for the signs from the certified cities. As a result, it became difficult to identify the installation date and determine the before and after periods for the safety analysis. Alternatively, the team relied on the Google Earth street views to indirectly obtain this information. Mainly, the team used the street view timelines to determine the time the DBBs were functioning. Figure 15 shows the street view pictures before and after installation of a digital sign, as an example. For the TxDOT signs, if the signed opened date was available, then the team used that date to determine the before and after periods. In such cases, the before period was three years prior to the start of the opened date, and the after period was three years after the opened date, when available, or from the date of opening to June 30, 2023 (this is the latest date when the complete crash data were available to the research team). For the signs with only the issued date, the team used the earliest issued date or the street view date without digital signs to determine the end of the before period. In this case, the before period was three years prior, and the after period was three years after the earliest issued date or street view date, when available, or until June 30, 2023. For all certified cities signs, the team relied on the street view dates to determine the before and after periods. For the before period, the team considered three years of crash data before the street view date without digital signs. For the after period, the team considered three years from the street view date with digital signs, when available, or until June 30, 2023.

a) Before Installation (October 2017) b) After Installation (June 2019)

Figure 15. Before-After Period Determination from Google Earth Street View.

Since the ramp volumes were not available to the research team, they were excluded from the analysis. The research team collected all geometric and traffic variables that influence the safety of a roadway. Table 16 and Table 17 show the summary statistics of geometric variables for main lanes and frontage roads by site type, respectively.

Table 16. Summary Statistics of Variables—Main Lanes.

Site Type	Variable	Minimum	Maximum	Mean	Std Dev
Analysis	Number of Lanes	1	7	3.09	1.06
	Lane Width	10	26	11.91	1.10
	Left Shoulder Width	0	22	5.98	4.84
	Right Shoulder Width	0	36	8.15	4.99
	Sign Offset Distance	0	470	152.60	80.25
	Shoulder Rumble Strip Presence[1]	0	1	0.25	0.43
	Centerline Rumble Strip Presence	0	1	0.01	0.10
	Speed Limit	0	75	59.07	12.77
	Average Daily Traffic	4193	287931	97325	70902
Comparison	Number of Lanes	1	7	3.06	1.03
	Lane Width	2	60	11.94	2.84
	Left Shoulder Width	0	24	5.60	4.72
	Right Shoulder Width	0	23	7.98	4.70
	Sign Offset Distance	18	423	171.55	85.54
	Shoulder Rumble Strip Presence	0	1	0.24	0.43
	Centerline Rumble Strip Presence	0	1	0.01	0.10
	Speed Limit	30	75	60.14	10.98
	Average Daily Traffic	4193	287931	97325	70902

[1] For rumble strip presence 1 = yes, 0 = no.

Table 17. Summary Statistics of Geometric Variables—Frontage Roads.

Site Type	Variable	Minimum	Maximum	Mean	Std Dev
Analysis	Number of Lanes	1	4	2.37	0.64
	Lane Width	9	18.5	12.02	1.45
	Left Shoulder Width	0	16	1.46	2.39
	Right Shoulder Width	0	12	1.75	2.85
	Sign Offset Distance	0	560	150.18	137.56
	Shoulder Rumble Strip Presence[1]	0	1	0.01	0.07
	Centerline Rumble Strip Presence	0	0	0.00	0.00
	Speed Limit	0	60	44.81	6.49
	Average Daily Traffic	30	30627	9635	7879
Comparison	Number of Lanes	1	4	2.36	0.61
	Lane Width	9	22	12.10	1.56
	Left Shoulder Width	0	16	1.43	2.68
	Right Shoulder Width	0	13.5	1.47	2.72
	Sign Offset Distance	0	638	242.08	150.58
	Shoulder Rumble Strip Presence	0	1	0.01	0.11
	Centerline Rumble Strip Presence	0	0	0.00	0.00
	Speed Limit	0	55	44.77	6.54
	Average Daily Traffic	30	38131	10140	8113

[1] For rumble strip presence 1 = yes, 0 = no.

CRASH DATA

The research team obtained crash data from TxDOT's Crash Records Information System (CRIS) for the period January 2005 to June 2023. The team had to retrieve crashes from 2005 because for some of the signs, the street view without digital signs dated back to 2008. CRIS data elements are divided into three major groups: crash event and roadway characteristics, primary person characteristics, and vehicle (unit) characteristics. CRIS has over 150 fields that contain data about spatial and temporal characteristics (e.g., time, date, and geodesic coordinates), roadway and traffic characteristics (e.g., intersection-related, average daily traffic), crash contributing factors (e.g., distracted driving, weather, lighting, pavement conditions), manner of collision (e.g., head-on, rear-end, sideswipe), crash severity, vehicle type, driver characteristics, and passenger characteristics, among others.

In Texas, crashes are assigned to the centerline of the roadway, irrespective of the direction of the crash. This makes it difficult to assign crashes in situations where the crashes on a particular roadbed are sought, as is the case in this study. To overcome this situation, the research team used the vehicle direction populated in the unit file. Mainly, the research team used the direction of Unit 1 to assign the crash direction. The team developed the following process to identify the side of each crash and assign crashes to an appropriate site.

- Step 1: Locate crashes on the highway.
- Step 2: Identify the traveling directions of analysis and comparison sites.
- Step 3: Compare the traveling direction of Unit 1 from crash data with road directions.
- Step 4: Determine the side of the crash.

The vehicle traveling direction field in CRIS consists of the values shown in Table 18.

Table 18. Vehicle Traveling Directions in CRIS.

Value	Direction		
1	NORTH	7	WEST
2	NORTHEAST	8	NORTHWEST
3	EAST	9	NOT APPLICABLE
4	SOUTHEAST	10	NOT REPORTED
5	SOUTH	11	UNKNOWN
6	SOUTHWEST		

Based on Table 18, the side of the crash was determined. For instance, consider a crash that has two vehicles involved. Their traveling directions are populated as 4 (SOUTHEAST), and 5 (SOUTH), and it is assigned to the centerline. Assume that this crash occurred at a point where red and green lines are located in Figure 14. In this case, since both involved vehicles are traveling to the south or southeast, it can be determined that the crash is on the analysis site (red line) and not on the comparison site (green line).

For each of the crashes identified near the digital signs, there are three possible identification results for where the crash has occurred: analysis site, comparison site, or undetermined (e.g., the vehicle traveling direction is unknown, not reported, or not intuitive with respect to the direction of the highway). The undetermined crashes are excluded from the analysis.

Table 19 shows the frequency of crashes by collision type for analysis and comparison types in the before and after periods.

Table 19. Crashes by Collision Type on Analysis and Comparison Sites.

Site Type	Collision Type	Before Period		After Period	
		Frequency	Percent	Frequency	Percent
Analysis	All	5285	100%	5103	100%
	Distracted	752	14%	683	13%
	Single-vehicle (SV)	955	18%	934	18%
	Rearend (RE)	1363	26%	1359	27%
	Sideswipe (SS)	1045	20%	1166	23%
	Multi-vehicle non-intersection-related	2897	55%	2947	58%
Comparison	All	5040	100%	4996	100%
	Distracted	828	16%	721	14%
	SV	989	20%	971	19%
	RE	1225	24%	1342	27%
	SS	1017	20%	1055	21%
	Multi-vehicle non-intersection-related	2712	54%	2922	58%

Note: Before period is 3 years, whereas the average after period is 2.35 years.

BEFORE-AFTER ANALYSIS

The *Highway Safety Manual* Volume 3 Part D, as well as several other studies, has employed advanced techniques to conduct before-after safety analysis of countermeasures (*73*, *74*, *75*). These methods include observational before-after studies and the cross-sectional approach. Each method has its strengths and weaknesses. The cross-sectional approach offers the advantage of using regression models for assessing alternative improvements in various highway sections. However, a limitation is that a typical regression model might not account for all potential factors; some may not be significant in the model, and others might not be measurable within the study's parameters. Factors not considered could affect the model's accuracy. In contrast, the before-after approach is advantageous because it is a controlled experiment that examines differences in samples with similar characteristics, except for the treatment, reducing the potential influence of other factors.

In the observational before-after method, a variety of approaches are utilized, such as the naïve, comparison group approach, Empirical Bayes, and Full Bayes methods. Independent of the method used, before-after studies are usually accomplished using two tasks (*76*):

- Task 1: Predict what would have been the safety of a site in the after period, had the treatment not been implemented.
- Task 2: Estimate the safety of the treatment at the site after implementation.

For accomplishing these two tasks, the following terms need to be explained:

- The variable π is defined as the expected number of crashes at a specific site in the after period if the treatment has not been implemented. This variable only applies for the

targeted crashes (i.e., single-vehicle run-off-road (SVROR), opposite direction, rear-end) and/or their severity (i.e., fatal, incapacitating injury, property damage only). π is referred to as the predicted value.

- The variable λ is used to define the expected number of crashes in the after period (after the implementation of the treatment). λ is referred to as the 'estimated value.'

The effects of a treatment are estimated by comparing both variables above in the following manner:

- The reduction (or increase) in the expected number of crashes is given as $\delta = \pi - \lambda$. A positive number indicates a decrease in the expected number of crashes.
- The ratio or the Index of Safety Effectiveness is defined as $\theta = \frac{\lambda}{\pi}$. If the number of crashes analyzed is below 500 for the before period, θ needs to be adjusted by the following factor: $1 + \frac{Var\{\pi\}}{\pi^2}$. This adjustment is used to minimize the bias caused by a small sample size. The Index of Safety Effectiveness therefore becomes the following: $\theta = \frac{\frac{\lambda}{\pi}}{\left[1+\frac{Var\{\pi\}}{\pi^2}\right]}$.

A value below 1.0 indicates a reduction in the number of crashes.

The variable $Var\{\pi\}$ is referred to as the variance of π, while the variable $Var\{\lambda\}$ is referred to as the variance λ. The variance is a measure of uncertainty associated with the estimated value.

The variance of the reduction, δ, is calculated as follows:

$$Var\{\delta\} = Var\{\pi\} + Var\{\lambda\} \quad (1)$$

The variance of the Index of Safety Effectiveness is equal to:

$$Var\{\theta\} = \theta^2 \left[\frac{\left(\frac{Var\{\lambda\}}{\lambda^2}\right)+\left(\frac{Var\{\pi\}}{\pi^2}\right)}{\left(1+\frac{Var\{\pi\}}{\pi^2}\right)^2}\right] \quad (2)$$

Before-After Study with Comparison Group

This method utilizes a comparison group to capture local and regional changes. The procedure for using the before-after study with comparison group is described using the following steps.

Step 1: Select the Comparison Sites

The comparison sites should be as identical as possible to the treatment sites. As previously described, in this study, the research team used the opposite side of the highway where the EBBs are installed as the comparison sites. Table 20 lists the variables used when a comparison group is utilized. The Latin characters represent the number of crashes that occurred at the sites under

study. The Greek letters represent the expected or estimated number of crashes at those sites. How these variables are used is described in Table 20.

Table 20. Observed and Expected Number of Crashes.

	Treatment Group	Comparison Group
Before	K, κ	M, μ
After	L, λ	N, ν

Step 2: Estimate the Expected Number of Crashes in the After Period

Estimating expected crashes and variances in the after period is necessary to account for influences that affect safety other than the treatment itself. Since other factors may effect predicting after-period crash frequency and variances that are either not measured or produce an influence on safety, they must be considered. The analytical procedure used in this study was described in detail in Hauer (76). The expected number of after-period crashes and their variances for site *i* had the treatment not been implemented at the treated site is given as:

$$\hat{\pi} = \hat{r}_T K \text{ and } V\hat{A}R(\hat{\pi}) = \hat{\pi}^2\left(1/K + V\hat{A}R\{\hat{r}_T\}/{r_T}^2\right) \quad (3)$$

$$\text{with, } \hat{r}_T = (N/M)/(1 + 1/M) \text{ and } V\hat{A}R\{\hat{r}_T\}/{r_T}^2 \cong 1/M + 1/N$$

where,

K = Total crash counts during the before period in treated group.

M = Total crash counts during the before period in comparison group.

N = Total crash counts during the after period in comparison group.

Step 3: Compute the Sum of the Predicted Crashes over All Treated Sites

It is widely recognized that the safety effect of a treatment varies from one site to another. Thus, instead of a single site, the average safety effect of the treatment for a group of sites must be calculated. To account for this, the expected number of after-period crashes and their variances for a group of sites had the treatment not been implemented at the treated sites is given as:

$$\hat{\pi} = \sum_{i=1}^{N} \hat{\pi}_i \text{ and } Var(\hat{\pi}) = \sum_{i=1}^{N} Var(\hat{\pi}_i) \quad (4)$$

where,

N = Total number of sites in the treatment group.

$\hat{\pi}$ = The expected after-period crashes at all treated sites had there been no treatment.

Step 4. Compute the Sum of the Actual Crashes over All Treated Sites

For a treated site, crashes in the after period are influenced by the implementation of the treatment. The safety effectiveness of a treatment is known by comparing the actual crashes with the treatment to the expected crashes without the treatment. The actual number of after-period crashes for a group of treated sites is given as:

$$\hat{\lambda} = \sum_{i=1}^{N} L_i \tag{5}$$

where,

L_i = Total crash counts during the after period at site *i*.

Step 5. Compute the Safety Effectiveness of the Treatment

The index of effectiveness (θ) (also referred to as crash modification factor [CMF]) is defined as the ratio of what safety was with the treatment to what it would have been without the treatment. The parameter θ gives the overall safety effect of the treatment and is given by:

$$\hat{\theta} = \frac{\left(\frac{\lambda}{\pi}\right)}{\left(1+\frac{Var(\hat{\pi})}{\hat{\pi}^2}\right)} \tag{6}$$

The percent change in the number of crashes due to the treatment is calculated by $100(1-\hat{\theta})$ percent. If $\hat{\theta}$ is less than 1, then the treatment has a positive safety effect. The estimated variance and standard error of the estimated safety effectiveness are given by:

$$Var(\hat{\theta}) = \hat{\theta}^2 \frac{\left(1/L+Var(\hat{\pi})/\hat{\pi}^2\right)}{(1+Var(\hat{\pi})/\hat{\pi}^2)^2} \tag{7}$$

$$s.e.(\hat{\theta}) = \sqrt{Var(\hat{\theta})} \tag{8}$$

The approximate 95 percent confidence interval for θ is given by adding and subtracting $1.96 \times s.e.(\hat{\theta})$ from $\hat{\theta}$. If the confidence interval contains the value 1, then no significant effect has been observed.

Table 21 presents the average safety effect of installing EBBs when all highway types are considered. The analysis was done by these collision types: total, distracted, single-vehicle (SV), rearend (RE), sideswipe (SS), and multi-vehicle (MV) non-intersection (non-int) crashes. This table shows there is no change in total crashes since the estimated CMF is 0.98. There is a marginal increase in distracted and SS crashes and a marginal reduction in RE and MV non-int crashes, but none of the results are statistically significant at 5 percent significance level. Thus, there is not enough evidence to prove that the EBBs will either increase or decrease the traffic crashes.

Table 21. Overall Safety Effectiveness of DBBs.

Variables	Collision Type					
	Total	**Distracted**	**SV**	**RE**	**SS**	**MV non-int**
Predicted Crashes ($\hat{\pi}$)	5238.9 (208.8)	654.8 (46.0)	937.6 (59.9)	1493.2 (85.7)	1084.0 (67.6)	3121.3 (141.5)
Estimated Crashes ($\hat{\lambda}$)	5103 (71.4)	683 (26.1)	934 (30.6)	1359 (36.9)	1166 (34.1)	2947 (54.3)
Safety Index ($\hat{\theta}$)	0.98 (0.04)	1.05 (0.08)	1.00 (0.07)	0.91 (0.06)	1.08 (0.07)	0.95 (0.05)
Confidence Interval of $\hat{\theta}$	(0.89,1.06)	(0.88,1.21)	(0.86,1.14)	(0.80,1.03)	(0.93,1.23)	(0.86,1.04)

Note: Value in the parentheses is the standard error of the estimate.

Table 22 presents the average safety effect of installing EBBs by highway type. This table shows there is no change in crashes on any highway type due to the installation of EBBs since 1.0 is always included in all confidence intervals. This result shows that there is not enough evidence to prove that the EBBs have an effect on safety on any particular type of highway.

Table 22. Safety Effectiveness of DBBs by Road Type.

Road Type	Variables	Collision Type					
		Total	**Distracted**	**SV**	**RE**	**SS**	**MV non-int**
Freeway Main Lanes	Predicted Crashes ($\hat{\pi}$)	4099.1 (173.9)	466.7 (38.1)	858.9 (58)	1307.8 (80.2)	934.1 (54.2)	2746.1 (96.5)
	Estimated Crashes ($\hat{\lambda}$)	3924 (62.7)	493 (22.3)	813 (28.6)	1172 (34.3)	1042 (32.3)	2607 (51.1)
	Safety Index ($\hat{\theta}$)	0.96 (0.05)	1.07 (0.1)	0.96 (0.08)	0.9 (0.07)	1.12 (0.08)	0.96 (0.04)
	Confidence Interval of $\hat{\theta}$	(0.88, 1.05)	(0.88, 1.26)	(0.81, 1.10)	(0.79, 1.02)	(0.98, 1.27)	(0.88, 1.03)
Frontage Roads	Predicted Crashes ($\hat{\pi}$)	565.2 (42.9)	126.6 (18.6)	50.1 (10.3)	74.9 (13.9)	74.7 (14.7)	170.6 (21.8)
	Estimated Crashes ($\hat{\lambda}$)	627 (25.1)	105 (10.3)	75 (8.7)	80 (9.0)	68 (8.3)	161 (12.7)
	Safety Index ($\hat{\theta}$)	1.12 (0.1)	0.85 (0.15)	1.57 (0.36)	1.11 (0.24)	0.95 (0.22)	0.96 (0.15)
	Confidence Interval of $\hat{\theta}$	(0.93, 1.31)	(0.57, 1.14)	(0.88, 2.25)	(0.66, 1.56)	(0.54, 1.36)	(0.69, 1.24)
Non-Freeway Main Lanes	Predicted Crashes ($\hat{\pi}$)	562.5 (41.5)	58.5 (11.3)	36.4 (9.0)	110.3 (18.0)	70.0 (15.6)	199.9 (25.3)
	Estimated Crashes ($\hat{\lambda}$)	552 (23.5)	85 (9.3)	46 (6.8)	107 (10.4)	56 (7.5)	179 (13.4)
	Safety Index ($\hat{\theta}$)	0.99 (0.09)	1.51 (0.33)	1.35 (0.37)	1.00 (0.19)	0.84 (0.21)	0.91 (0.14)
	Confidence Interval of $\hat{\theta}$	(0.83, 1.16)	(0.88, 2.14)	(0.63, 2.07)	(0.64, 1.36)	(0.44, 1.25)	(0.66, 1.17)

Note: Value in the parentheses is the standard error of the estimate.

CHAPTER 5:
HUMAN FACTORS EVALUATION

To evaluate the potential impact of DBBs and compare it to standard billboards, the study team conducted a comprehensive human factors study. The human factors study was designed to capture detailed information on human behavior and interaction between the driver and the billboards while driving. The study team obtained approval from the Institutional Review Board to conduct this study. The Institutional Review Board oversees studies involving human subjects and is governed by the Texas A&M Human Research Protection Program. The study team submitted a detailed Institutional Review Board application and received approval to conduct the study.

Four cities were selected at the study sites, and the study team traveled to each city to conduct the study. At each study site the study team recruited participants by posting advertisements on Facebook and Instagram, as detailed in Chapter 3. In the advertisement, the volunteers completed an online recruiting survey that the study team used to ensure balanced participation across different age groups and genders. Altogether, 238 eligible participants responded to the recruiting survey. Ninety-seven participants were scheduled to participate, of which 84 started and finished the study. Thirteen participants did not show up to the study appointment. Figure 16 provides a summary of the participant age range and gender distribution at each study site. Figure 17 provides an overall age distribution of all participants.

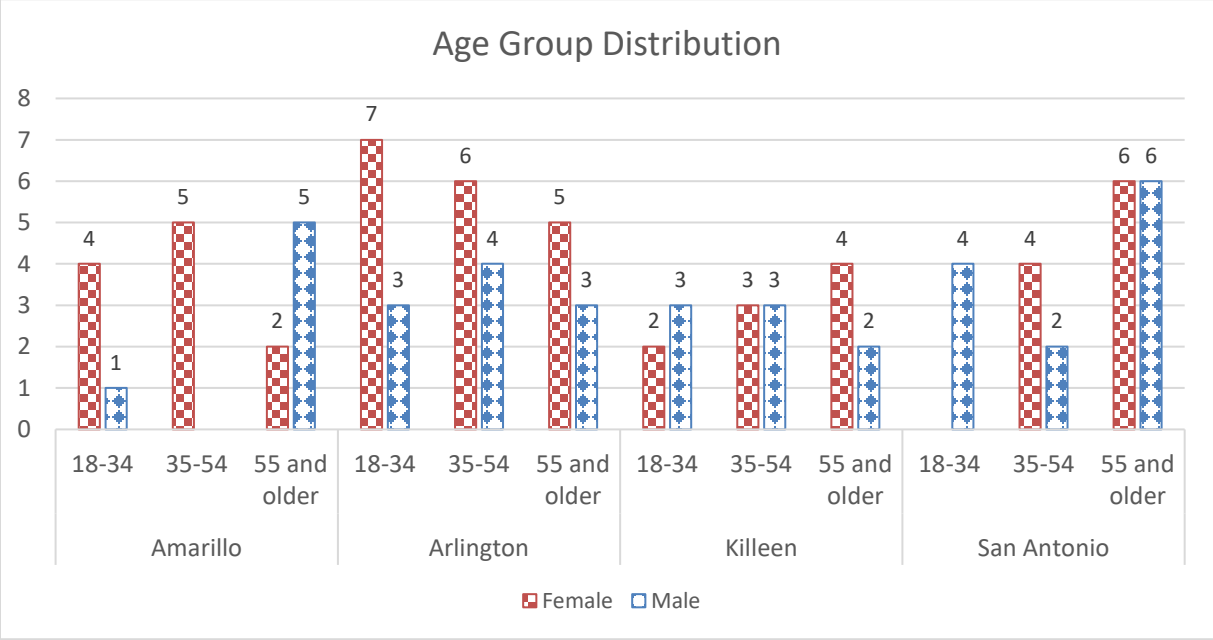

Figure 16. Age Group Distribution for Different Study Sites.

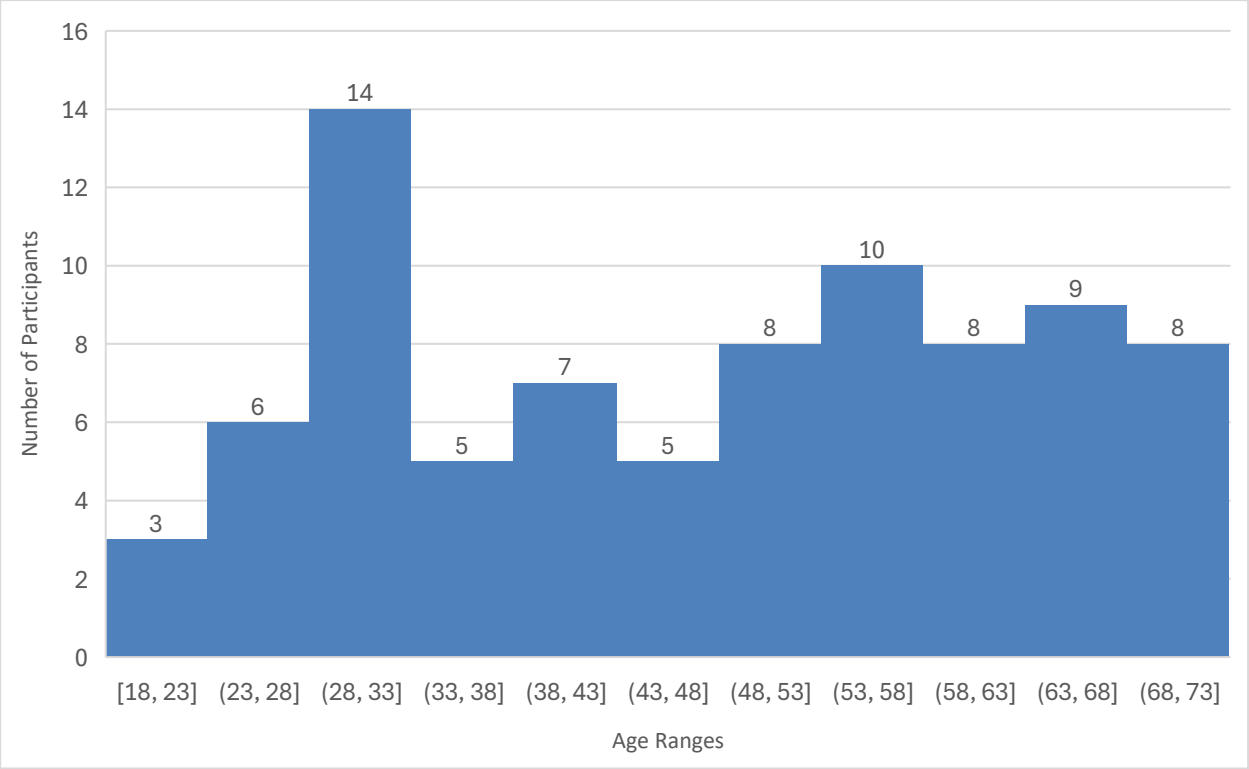

Figure 17. Overall Age Distribution.

CLOSEOUT SURVEY SUMMARY

The closeout survey included a series of 12 open-ended questions, and participants were able to disclose their opinions on different aspects of signage. In the section below, the participant responses to each question are discussed.

Q1. Was there anything memorable from the driving part of the study?

Answers to this question varied significantly and participants expressed opinions on subjects such as traffic, the vehicle, isolated incidents that happened during their ride, or construction on the driving route. There were no specific responses pertaining to any of the advertising signs. Remember, at this time the participants were unaware of the true purpose of the study.

Q2. Do you have any general comments on large advertising billboard signs?

The answers to this question varied, but most respondents mentioned that they did not have any comments or that they did not really pay attention to them. Some participants that reported noticing or paying attention to the billboards mentioned context-based interaction with the billboards. In summary, 27 responses were impartial toward billboards, 17 had negative concerns, 1 had a positive response, and 39 had no specific response.

Some context-based answers are:

- "Some of the signs were clear and others were hard to see due to them being faded. I only remember one sign about the Texas Rangers as sports piques my interest."
- "Only large advertisement I pay attention to is the lottery billboard! Most others are not really noticeable unless it pertains to a movie or a show being featured in the city. They are not really intrusive to my driving."
- "The only large advertising billboard signs that make an impression on me are ones that are repetitive in terms of exposure. So whether I drive past it multiple times a day or there are multiple in a town that I would drive by. I generally do not notice other billboards."

Some participants expressed strong negative views on advertising billboards. Some examples are:

- "Depending on the location, I think that large billboards can be a driving distraction; more so with the new electronic billboards that change to a new advertisement every so often."
- "I do not like the digital ones. They are very distracting, especially at night."

Q3. Do you have any concerns about large digital advertising billboard signs when you drive during the day?

Around 20 percent (22 participants) expressed concerns about DBBs during the day, and the majority of these concerns were related to the changing images on the billboards and not the brightness. One participant mentioned that the viewing angle could play a role in the amount of distraction caused by the DBB: "If they are too far to the right, yes. If they are right up on the 'road' area, no. A person could get distracted if it is too far to the right. If it is closer to the road area 'left,' then the person could take a quick glance."

Q4. Do you have any concerns about large digital advertising billboard signs when you drive at night?

Around 58 percent (49 participants) expressed concern about DBBs at night, with the majority of the answers being about brightness of the DBBs. Some participants recommended adjusting the lighting level on the DBBs at night to decrease the distractions. One participant was in favor of DBBs at night and mentioned that they welcome DBBs when they are in unfamiliar driving environments and welcome the information provided by them. A concern of researchers is that the participants combine opinion of on-premise digital signage with DBBs. Some reference to signs being too bright was specific to on-premise signage.

Q5. What could be done to improve large digital advertising billboard signs during the day?

Participants recommended keeping advertisements static for longer durations, reducing brightness, using softer or neutral colors, and positioning them in less congested or scenic areas to reduce visual clutter (Table 23). There is a preference for static, non-intrusive ads during the day. A simpler design approach would likely be more effective and less distracting.

Table 23. Summary of Responses to Question 5.

Change	Votes
Nothing	33
Brightness	10
Flickering	28
Color	2
Remove	2
Size	7
Spacing	9

Q6. What could be done to improve large digital advertising billboard signs at night?

Many participants recommended dimming the lights, avoiding flashing effects, reducing the frequency of changes, and implementing specific brightness limits (Table 24). Some suggested placing billboards at a distance from dark stretches of highway. Participants overwhelmingly support reducing brightness and flashy animations at night, indicating a demand for standards that minimize nighttime distractions and support night visibility for drivers.

Table 24. Summary of Responses to Question 6.

Change	Votes
Brightness	55
Spacing	6
Flickering	15
Color	5
Size	2
Nothing	12
Remove	5
Make them solar	1

Q7. Do you have any concerns about traditional large advertising billboard signs that are not digital?

Traditional billboards were generally viewed as less distracting than digital ones, with fewer complaints about brightness and movement. However, some participants still found them visually unattractive or too large. Traditional billboards are more acceptable to drivers, with

fewer complaints about their visual impact or distracting elements. They are less likely to draw drivers' attention away from the road compared to digital signs.

Q8. Do you have any concerns about business signs that are digital (i.e., a business sign that is on the business property and displays images or messages on a digital screen)? See Figure 18.

Figure 18. Examples of Digital Signs for Question 8.

Responses varied for this question, with some participants noting these signs can be too bright or distracting, especially if they feature moving or flashing elements. Others do not find them concerning, particularly if the brightness is controlled. The perception of digital business signs is mixed, with brightness control appearing as the primary factor for acceptability. Signs closer to the road should avoid rapid changes to reduce distraction.

Q9. Do you have any concerns about the brightness of digital advertising signs at night?

Brightness at night was a significant concern for the participants, with 83 percent of respondents having concerns. Many respondents mentioned that overly bright signs impaired their vision, caused glare, and could temporarily "blind" them. Brightness management is seen as crucial to prevent nighttime accidents. Excessive brightness at night was widely regarded as dangerous, with a strong call for stricter brightness controls. Many participants expressed concerns about how these signs affect their ability to focus on the road. Some participants also pointed out that DBBs could contribute to light pollution or could impact the wildlife. One participant noted, "If they are too bright, they are harder to read and more of a distraction than anything."

Q10. Do you find digital advertising signs to be distracting?

Consistent with answers to other questions, most participants found DBBs distracting to some degree, especially when they feature frequent content changes, animations, or bright colors. A

few respondents admitted to looking at these signs out of curiosity, acknowledging that it diverts attention from driving. Thirty-three percent of respondents indicated the signs are distracting, 29 percent indicated they are distracting sometimes, and 38 percent indicated they are not distracting.

Q11. Do you think there should be restrictions on digital advertising signs?

Sixty-two participants (74 percent) answered yes to this question and supported restrictions, including limits on brightness, transition speed, and animation (Table 25). Some also suggested spacing requirements to prevent visual clutter along highways.

A follow-up question asked, "What restrictions do you think should be implemented?"

There was strong support for imposing regulations on DBBs. Suggested restrictions included brightness caps, slower transition times, fewer allowed animations, and strategic placement to minimize driver distraction.

Table 25. Summary of Responses to Question 11.

Change	Votes
Brightness	46
Spacing	10
Flickering	21
Size	3
Remove	2
Make them solar	1

Q12. Do you have any final comments regarding the use of digital advertising signs along highways?

Participants' final remarks emphasize the need for responsible advertising that considers driver safety. Many advocated for stricter regulations and suggested limiting the number of billboards in high-traffic areas. Some expressed nostalgia for simpler, less invasive signage, while others recognized the utility of digital signs for essential information like Amber Alerts. There is a consensus on balancing advertising needs with road safety. While digital signs are acknowledged as beneficial in some contexts, many participants believe they should be regulated more tightly to reduce distractions and enhance safety.

EYE TRACKER DATA ANALYSIS

Parameter Definition

Four different types of data were compiled to create the data for the analysis. The following section defines all the parameters:

- **Sign Unique Name:** A unique name that was created using the study site name and the sign number at each site.
- **Site Name:** Study site name (i.e., Amarillo, Arlington, Killeen, San Antonio).
- **Sign Number:** A number assigned to each sign at each site for identification.
- **Participant Number:** A number assigned to each participant.
- **Age Range:** A categorical parameter with three categories: 18–34, 35–54, and 55 and older. Participants chose one of these options when filling out the initial survey to express interest in the study.
- **Gender:** A categorical parameter with two options (i.e., male or female) that was included as part of the responses to the initial survey.
- **Glasses:** A categorical parameter with two options (i.e., yes or no) indicating if the participant wears glasses during driving or not.
- **Typical Miles Driven:** A categorical variable that was included in the initial survey and had four categories: Less than 8000 miles/year, Between 8000 and 12000 miles/year, Between 12000 and 16000 miles/year, and More than 16000 miles/year.
- **Age:** Actual age entered at the time of testing.
- **Vision:** Visual acuity measured at the time of testing.
- **Colorblind:** Color blindness measured using the Dvorine test at the time of testing.
- **Test Time:** A categorical variable (i.e., day or night) showing the time of testing.
- **Sign Type:** A categorical variable (i.e., Digital, Standard, CMS, Guide, Information, and On-premise) showing different categories of sign.
- **Driving Condition:** A categorical variable (e.g., driving normally, stopped at signal, changing lane, blocked by a truck, etc.).
- **Sign Viewed:** A binary variable (i.e., yes or no) showing if the sign was viewed.
- **Calibration Quality:** A categorical variable showing the calibration quality for the eye tracker (i.e., low, medium, high).
- **Road Curvature:** A categorical variable showing the location of the sign with respect to the road (i.e., tangent, inside, outside) as shown in Figure 19.
- **Lateral Offset:** An integer showing the lateral distance from the shoulder of the road to the base of the sign as measured in Google Maps.
- **Lighting Type:** A categorical variable showing the illumination option for the sign.
- **Sign Location:** A categorical variable showing the location of the sign with respect to the driver (i.e., left, right, overhead).
- **Visual Complexity:** A categorical variable between 1 and 6, with 1 being the least complex and 6 being the most complex. For daytime participants, visual complexity was determined based on daytime conditions, while for nighttime participants, visual complexity was determined based on nighttime driving conditions. The team found little difference between daytime and nighttime complexities at the sites evaluated. Table 26,

Table 27, Table 28, and Table 29 show visual complexity values for different signs during day and night for Amarillo, Arlington, Killeen, and San Antonio, respectively.

- **Dwell count:** Number of times the sign was looked at by the respective participant. This parameter was 0 if the sign was not looked at and 1 if the sign was looked at.
- **Dwell time (gaze, ms):** Length of time the sign was looked at in milliseconds.

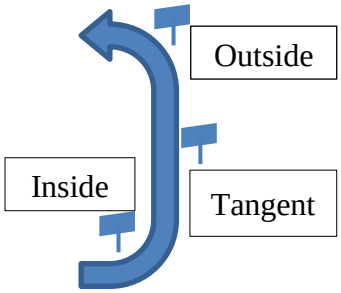

Figure 19. Road Curvature Options.

Table 26. Amarillo Sign Complexity Values.

Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity	Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity
Amarillo1	2	2	Amarillo13	2	2
Amarillo2	2	2	Amarillo14	2	2
Amarillo3	3	3	Amarillo15	2	2
Amarillo4	3	3	Amarillo16	2	2
Amarillo5	4	4	Amarillo17	1	1
Amarillo6	3	3	Amarillo18	2	2
Amarillo7	1	1	Amarillo19	3	3
Amarillo8	2	2	Amarillo20	3	3
Amarillo9	2	2	Amarillo21	4	4
Amarillo10	2	2	Amarillo22	2	2
Amarillo11	3	3	Amarillo23	2	2
Amarillo12	4	4			

Table 27. Arlington Sign Complexity Values.

Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity	Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity
Arlington1	2	2	Arlington12	3	3
Arlington2	2	2	Arlington13	2	2
Arlington3	2	2	Arlington14	3	3
Arlington4	2	2	Arlington15	3	3
Arlington5	2	2	Arlington16	3	3
Arlington6	2	2	Arlington17	1	1
Arlington7	2	2	Arlington18	2	2
Arlington8	2	2	Arlington19	4	4
Arlington9	3	3	Arlington20	2	2
Arlington10	3	3	Arlington21	2	2
Arlington11	2	2			

Table 28. Killeen Sign Complexity Values.

	Daytime Visual Complexity	Nighttime Visual Complexity	Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity
Killeen1	3	3	Killeen12	3	3
Killeen2	2	2	Killeen13	3	3
Killeen3	3	3	Killeen14	3	3
Killeen4	2	2	Killeen15	4	4
Killeen5	1	1	Killeen16	4	4
Killeen6	4	4	Killeen17	3	3
Killeen7	4	4	Killeen18	3	3
Killeen8	4	4	Killeen19	3	3
Killeen9	3	3	Killeen20	4	4
Killeen10	1	1	Killeen21	4	4
Killeen11	1	1			

Table 29. San Antonio Sign Complexity Values.

Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity	Sign Unique Name	Daytime Visual Complexity	Nighttime Visual Complexity
San Antonio1	3	3	San Antonio12	4	4
San Antonio2	2	2	San Antonio13	3	3
San Antonio3	2	2	San Antonio14	4	4
San Antonio4	3	3	San Antonio15	4	4
San Antonio5	4	4	San Antonio16	5	5
San Antonio6	3	3	San Antonio17	4	4
San Antonio7	2	2	San Antonio18	3	3
San Antonio8	4	4	San Antonio19	2	2
San Antonio9	3	3	San Antonio20	4	4
San Antonio10	3	3	San Antonio21	4	4
San Antonio11	4	4			

Data Review

The study team recorded all participant interactions with the signs. Table 30 summarizes the count of possible interactions for each sign type by study site. During the study, several isolated incidents led to the study team diverting from the study routes which caused some missing interactions. In some cases, adjacent trucks or other visual influences kept a sign from being visible to a participant. Table 31 summarizes the number of actual interactions that took place. After reviewing the eye tracker data, the number of instances where participants did NOT look at signs are summarized in Table 32, while the instances where participants looked at signs are summarized in Table 33. Using the data in Table 32 and Table 33, the researchers calculated the percentage of instances where participants looked at each sign type at each study site, as summarized in Table 34.

Table 30. Instances of Each Type of Sign at Each Study Site.

	Digital	Standard	CMS	Guide	Information	On-Premises
Amarillo	272	68	17	34	-	-
Arlington	196	224	28	56	28	56
Killeen	102	170	17	17	17	17
San Antonio	168	84	84	-	-	105
Grand Total	738	546	146	107	45	178

Note: - indicates no data available.

Table 31. Instances of Each Type of Sign Visible at Each Study Site.

	Digital	Standard	CMS	Guide	Information	On-Premises
Amarillo	250	56	16	31	-	-
Arlington	194	218	27	55	28	56
Killeen	102	170	17	17	17	17
San Antonio	168	84	84	-	-	105
Grand Total	**714**	**528**	**144**	**103**	**45**	**178**

Note: - indicates no data available.

Table 32. Instances of Each Type of Sign NOT Being Looked at.

	Digital	Standard	CMS	Guide	Information	On-Premises
Amarillo	197	48	8	20	-	-
Arlington	132	162	20	27	17	46
Killeen	73	120	3	13	7	9
San Antonio	135	56	33	-	-	58
Grand Total	537	386	64	60	24	113

Note: - indicates no data available.

Table 33. Instances of Each Type of Sign Being Looked at.

	Digital	Standard	CMS	Guide	Information	On-Premises
Amarillo	53	8	8	11	-	-
Arlington	62	56	7	28	11	10
Killeen	29	50	14	4	10	8
San Antonio	33	28	51	-	-	47
Grand Total	177	142	80	43	21	65

Note: - indicates no data available.

Table 34. Percent Time Participants Looked at the Signs.

	Digital	Standard	CMS	Guide	Information	On-Premises
Amarillo	21	14	50	35	-	-
Arlington	32	26	26	51	39	18
Killeen	28	29	82	24	59	47
San Antonio	20	33	61	-	-	45
Average	**25**	**26**	**55**	**37**	**49**	**37**

Note: - indicates no data available.

Modeling Gaze Dwells

As seen in Table 34, not all signs were looked at despite being visible to the driver. The study team used logistic regression to understand which factors contributed to looking at each sign. Logistic regression is a machine learning technique that predicts the probability of an outcome. In the study data, a parameter called “Gaze Dwells” determined if a participant had a “Gaze

Dwell" at the sign or not. This parameter was a binary variable, with 0 signifying not looking at the data and 1 signifying looking at the data. The initial parameters used as predictors are listed in Table 35.

Table 35. Gaze Dwell Model Parameters.

Parameter Name	Type	Range/ Categories
Gaze Dwells	Binary	{0, 1}
Site Name	Categorical	{Amarillo, Arlington, Killeen, San Antonio}
Sign Type	Categorical	{Digital, Standard, Guide, CMS, Information, On-Premises}
Age Range	Categorical	{18–34, 35–54, 55 and older}
Gender	Categorical	{Male, Female}
Driving Condition	Categorical	{Driving Normally, Stopped at light, Change lanes, Blocked by tree, Curve, Traffic at light, Accident in shoulder, Construction nearby}
Test Time	Categorical	{Day, Night}
Visual Complexity	Categorical	{1, 2, 3, 4, 5, 6} (1: Least complex, 6: Most Complex)
Road Curvature	Categorical	{Tangent, Outside, Inside}
Lateral Offset (feet)	Integer	[0, 389]

Since the response variable is of type "Binary," the logistic regression technique would be a top choice for the analysis. In logistic regression, the model assigns a value between 0 and 1 for each instance. Then a classifying threshold is used to classify the instance. For a binary variable only one classifying threshold is used. The study team used a 0.5 value for this threshold. In other words, the model predicted values between 0 and 1, and if the predicted values were greater than or equal to 0.5, the study team assigned them to class "1," and "0" otherwise. The research team first randomly selected 30 percent of the data to train the model and then used the remaining set to test the model and calculate fit statistics. After building a model with all variables, the study team removed the non-significant parameters from the model and repeated the process. Table 36 shows the parameters for the final Gaze Dwell model. The confusion matrix is shown in Table 37, which implies an accuracy level of 0.731.

Table 36. Gaze Dwell Final Model Coefficients.

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	0.0121903	0.4444352	0.027	0.978118	
SiteNameArlington	0.4830243	0.1965799	2.457	0.014005	*
SiteNameKilleen	0.853295	0.2314563	3.687	0.000227	***
SiteNameSan Antonio	0.5819668	0.2359373	2.467	0.01364	*
SignTypeDigital	−0.6958081	0.2604845	−2.671	0.007558	**

SignTypeGuide	−0.8052432	0.3577066	−2.251	0.024377	*
SignTypeInformation	−0.7409595	0.4404259	−1.682	0.092497	.
SignTypeOn Premises	−0.5070307	0.2872807	−1.765	0.077575	.
SignTypeStandard	−0.9705855	0.2657232	−3.653	0.00026	***
AgeRange35-54	0.204082	0.1684024	1.212	0.225562	
AgeRange55 and older	0.1301921	0.164218	0.793	0.427894	
TestTimeNight	−0.2283739	0.1322535	−1.727	0.084206	.
VisualComplexity2	0.1971043	0.2805159	0.703	0.482274	
VisualComplexity3	−0.2275626	0.2746823	−0.828	0.407412	
VisualComplexity4	−0.6052681	0.2923628	−2.07	0.038428	*
VisualComplexity5	−2.0495024	1.0815893	−1.895	0.058106	.
RoadCurvatureOutside	0.6027752	0.2767859	2.178	0.029423	*
RoadCurvatureTangent	0.0584872	0.2486962	0.235	0.814073	
LateralOffset	−0.0048575	0.0009879	−4.917	8.78E-07	***

Signif. codes: *** = 0, ** = 0.001, * = 0.01, . = 0.05, and ‘ ‘ = 1.

Table 37. Confusion Matrix for the Final Gaze Dwell Model.

		Actual	
		0	1
Predicted	0	354	123
	1	19	32

Accuracy: 0.731

Impact of Study Site

The results show that the study site for all sites was a significant variable. This shows that dwell rates followed different patterns at different study sites.

Impact of Sign Type

CMS were automatically selected as the reference class, and Information and On-Premises signs were not significantly different from CMS.

Digital signs, Standard signs, and Guide signs all had negative coefficients, meaning that they were looked at less often that CMS. To compare digital (coefficient = −0.68387) and Standard Signs (coefficient = −0.78946), the researchers calculated the odd ratio (OR) for each category.

$$OR = e^{Coefficient}$$

For digital signs:

$$OR = e^{-0.69581}$$

For standard signs:

$$OR = e^{-0.97059}$$

$$Relative\ OR = \frac{OR_{Digital}}{OR_{Standard}}$$

The odds ratios are as follows:

- Digital Signs (OR): 0.4987
- Standard Signs (OR): 0.3788
- Relative Odds (Digital vs. Standard): 1.3165

This means that the odds of a Digital sign being viewed are 31.6 percent higher than those of a Standard sign. This takes into account all of the factors that were included in the model and not just the actual number of dwells on each sign type.

Impact of Gender

The positive coefficient for Male indicates that males are more likely to look at a sign compared to females.

Calculating the odds ratio for males:

$$OR = e^{0.315702} = 1.3712$$

This means that males are 37.12 percent more likely to look at signs than females.

Impact of Lateral Offset

Lateral offset was measured in feet. The coefficient for lateral offset is equal to −0.00492, which means that for each 1-foot increase in lateral offset, the odds of the sign being viewed would decrease by around 0.5 percent ($e^{0.00486}$ = 0.9951, 1-0.9951 = 0.0049).

This small but significant negative effect indicates that as the lateral offset increases, the likelihood of viewing the sign slightly decreases.

Impact of Visual Complexity

Signs located in complex scenes (i.e., signs with image complexity of 4 and 5) were significantly different from signs with lower levels of complexity.

For images with a complexity level of 4:

$$OR = e^{-0.6023} = 0.54756$$

And for the signs with a visual complexity level of 5:

$$OR = e^{-2.04950} = 0.1288$$

Compared to signs with a visual complexity level of 1, signs with a visual complexity level of 4 and 5 were looked at 45 percent (1-0.54756) and 87 percent (1-0.1288) less respectively. While a visual complexity of 1, 2, and 3 were not significantly different from each other, the number of looks at signs with higher levels of complexity are significantly impacted. The reduction in looks in more visually complex scenarios is likely due to a limited about of driver attention getting split between more targets.

Modeling Dwell Time

For the signs that were not looked at, Gaze duration was recorded as 0 seconds. The study team used the Survival Analysis method to investigate the gaze duration pattern and compare digital to standard signs.

Survival Analysis is a statistical methodology designed to analyze the time until a specific event. It is widely used in medicine, engineering, and transportation fields to study the duration of time before events such as failure, death, or completion occur. This method accounts for "censoring," which happens when the event of interest does not happen for the duration of study period. In this study, looking at the sign is assumed to be the target event (not looking = censoring), and the duration of looking is assumed to be the survival time.

The Kaplan-Meier estimator is one of the most commonly used non-parametric methods in survival analysis. It provides a stepwise estimate of the survival function, defined as the probability that the events have not occurred by a given time. The Kaplan-Meier survival function is given by:

$$S(t) = \prod_{t_i \leq t} \left(1 - \frac{d_i}{n_i}\right)$$

where:

t_i = the time at which an event occurs.

d_i = the number of events at t_i.

n_i = the number of subjects at risk just before t_i.

The Kaplan-Meier method accommodates right-censored data (subjects who do not experience the event during the study period).

In this study, Kaplan-Meier survival analysis was used to compare the survival probabilities of two groups categorized by SignType (Digital and Standard). The event of interest was Dwell Time, defined as the duration before the observer ceased engagement with the signage.

The analysis provided estimates of:

- Survival probabilities at specific time intervals.
- Confidence intervals for the survival estimates.
- Number of individuals at risk and events observed at each time point.

The study team selected digital and standard signs only and conducted a Kaplan-Meier test. The outputs of the Kaplan-Meier test for digital and standard signs at 500 milliseconds (0.5 seconds) intervals are shown in Table 38.

Table 38. Kaplan-Meier Test Results for Gaze Time.

Sign Type = Digital							Sign Type = Standard						
time	n.risk	n.event	survival	std.err	lower 95% CI	upper 95% CI	time	n.risk	n.event	survival	std.err	lower 95% CI	upper 95% CI
500	92	87	0.51	0.04	0.45	0.59	500	48	95	0.34	0.04	0.27	0.42
1000	57	35	0.32	0.03	0.26	0.39	1000	21	27	0.15	0.03	0.10	0.22
1500	40	17	0.22	0.03	0.17	0.29	1500	13	8	0.09	0.02	0.05	0.15
2000	21	19	0.12	0.02	0.08	0.18	2000	7	6	0.05	0.02	0.02	0.10
2500	12	9	0.07	0.02	0.04	0.12	2500	5	2	0.03	0.02	0.01	0.08
3000	10	2	0.06	0.02	0.03	0.10	3000	4	1	0.03	0.01	0.01	0.07
3500	7	3	0.04	0.01	0.02	0.08	3500	3	1	0.02	0.01	0.01	0.06
4000	5	2	0.03	0.01	0.01	0.07	4000	2	1	0.01	0.01	0.00	0.06
4500	2	3	0.01	0.01	0.00	0.04	4500	2	0	0.01	0.01	0.00	0.06
5000	2	0	0.01	0.01	0.00	0.04	5000	1	1	0.01	0.01	0.00	0.05
5500	1	1	0.01	0.01	0.00	0.04	5500	1	0	0.01	0.01	0.00	0.05
6000	1	0	0.01	0.01	0.00	0.04	6000	1	0	0.01	0.01	0.00	0.05
6500	1	0	0.01	0.01	0.00	0.04							
7000	1	0	0.01	0.01	0.00	0.04							
7500	1	0	0.01	0.01	0.00	0.04							

The results show that:

- The DBBs generally exhibited higher survival probabilities than the standard billboards, suggesting longer dwell times on digital signs.
- Survival probabilities declined more rapidly for the standard billboards, indicating faster disengagement (shorted dwell times) with these signs.

To assess whether the observed differences in survival probabilities between the two groups are statistically significant, a log-rank test was conducted. This test compares the survival curves under the null hypothesis that both groups have identical survival experiences. Figure 20 shows the Kaplan-Meier curves, and Table 39 shows the results of the log-rank test.

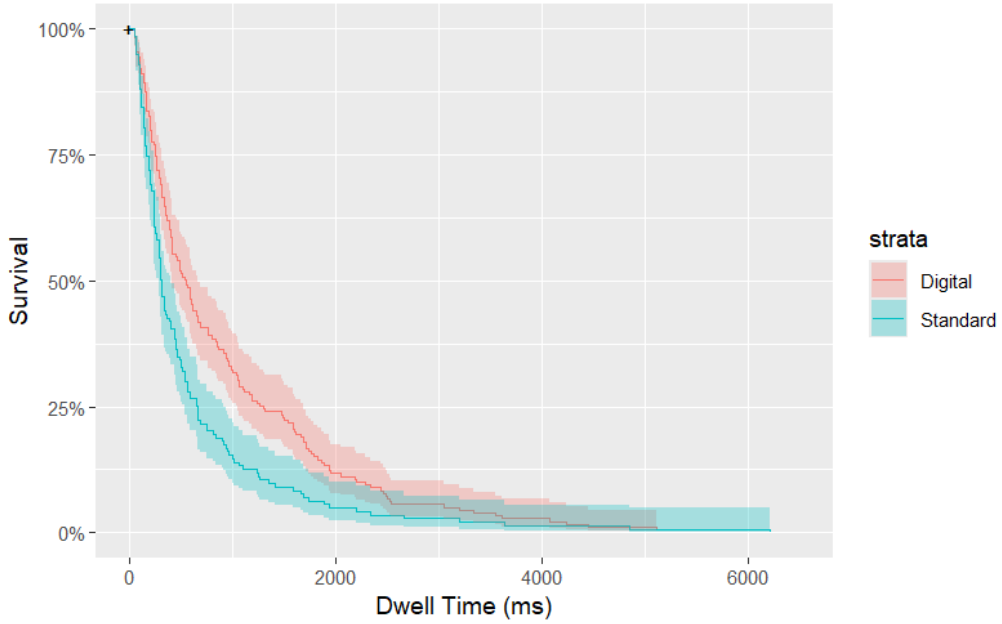

Figure 20. Kaplan-Meier Curves for Digital and Standard Signs.

Table 39. Log-Rank Test Results.

	N	Observed	Expected	(O-E)^2/E	(O-E)^2/V
SignType=Digital	738	179	210	4.58	13.4
SignType=Standard	546	143	112	8.58	13.4

Note: Chisq = 13.4 on 1 degrees of freedom, p = 2e-04

The p-value (0.0002) is much smaller than the significance level ($\alpha = 0.05$). This indicates a statistically significant difference in survival distributions between the Digital and Standard sign types. Figure 21 shows the dwell times by study site for digital and standard signs. In every site, dwell times were longer for digital than standard signs.

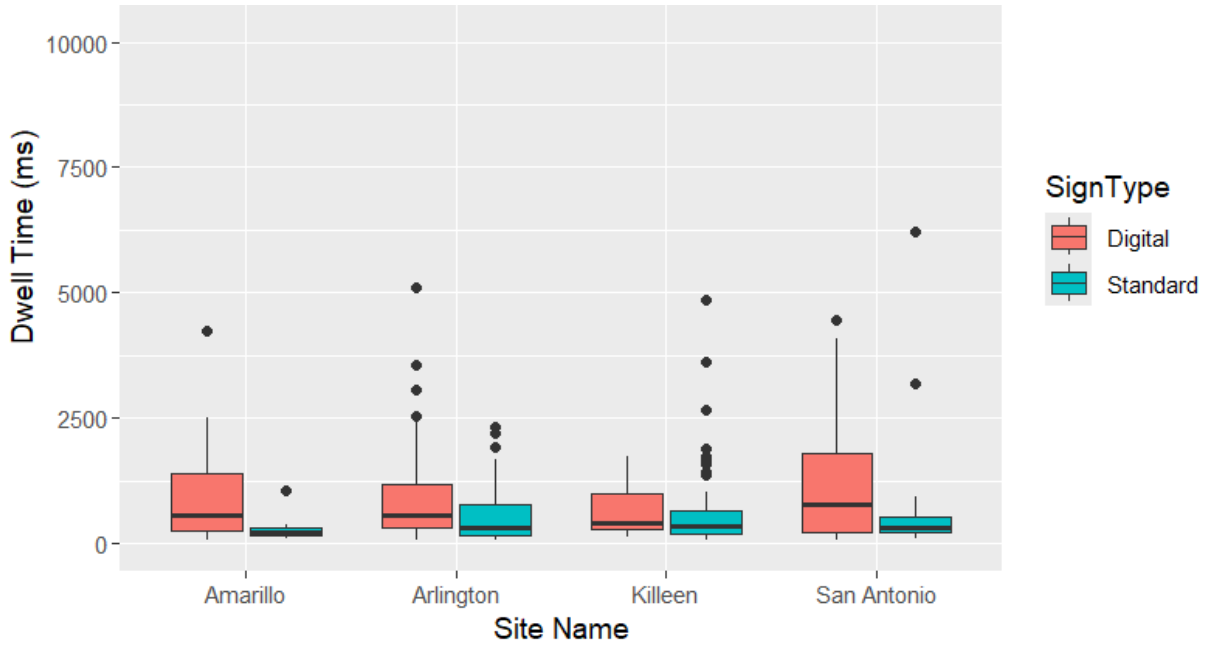

Figure 21. Dwell Times for Digital and Standard Signs by Study Site.

Discussion

The eye tracker data were analyzed to understand how the research participants viewed the billboards. DBBs bring the possibility of modifying the displayed messages and how bright those messages are. While this feature makes switching billboard messages very easy, it provides the opportunity for the DBB owners to increase the frequency of the messages such that they can change quickly and potentially be displayed too bright at night. Change in the displayed message (flicker) is one of the most prominent attention grabbers and when displayed in the viewing cone of the driver, they attract more attention than regular billboards (*77*).

During this study, eye tracking data were collected using a state-of-the-art vehicle-mounted eye tracker device that collected eye movements of 84 participants spread across 4 open-road study sites. The study team recruited participants from different age groups in each study site and conducted the study during the day and night. Among numerous parameters collected during the study, the study team investigated two main parameters, namely Dwell and Dwell Time. Dwell is the parameter showing if a driver looked at the sign or not. Dwell Time shows the duration of looking at the signs. For signs that were not looked at (Dwell = 0), Dwell Time was also recorded as 0. Dwell was modeled using a logistic regression model, and the results showed that DBBs are 31 percent more likely to be looked at compared to standard billboards. The collected data included a small number of Guide, Information, CMS, and On-premise signs that were included in the logistic regression model but are not discussed here.

The Dwell Time was investigated using the Survival Analysis method. In survival analysis, occurrence and duration of an event are considered simultaneously. For survival analysis, the

database was filtered to include only digital and standard billboards. The results showed that DBBs showed higher survival probabilities than the standard billboards, suggesting longer Dwell Times for DBBs. Moreover, the survival probabilities declined faster for standard billboards, which suggests faster disengagement with standard billboards. While this difference was graphically evident using the Kaplan-Meier curves, a Log-Rank test was performed, and it was confirmed that the difference between these two groups were statistically significant.

SIGN LUMINANCE MEASUREMENTS

The research team evaluated the luminance of 20 DBBs, 12 standard billboards, and 6 on-premise signs. The 20 DBBs resulted in over 80 different advertisements being evaluated. The on-premise signs were digital displays or internally illuminated signs. Luminance measurements and digital images were collected at each sign. Each sign was evaluated in place with no control of the sign or adjacent lighting by the research team. The signs were evaluated in the conditions that drivers would see them.

General observations were that the DBBs have very uniform lighting levels compared to the standard billboards that can vary greatly across the sign. Uniformity in lighting is good since it will result in the observer needing less time to understand the message. A range of brightness levels for the various sign types were found. The DBBs had fewer cases with bright signs, and the bright DBBs were not as bright as the bright on-premise signs. The standard billboards were generally not as bright as the digital signs. Figure 22 provides an example image of a standard billboard with uneven lighting. Figure 23 is the luminance image of the billboard. Using the scale on the right side of the image, the range of luminance values of the billboard are apparent. The bright spot where the light is shining on the white letters in the lower left portion of the billboard is over 150 cd/m^2, whereas the right half of the billboard is mostly below 40 cd/m^2. Comparatively, Figure 24 provides an image of a DBB with uniform brightness. Figure 25 is the same DBB with the luminance measurements. The sign is very uniform, with the same color having the same luminance levels across different parts of the sign. The white numbers range between 200 and 300 cd/m^2 and the yellow background between 150 and 200 cd/m^2. White and yellow are typically the brighter colors, and care needs to be taken to lower their brightness at night. With digital signs any color can be too bright if the sign is not properly set up. Table 40 provides a summary of the luminance values captured at the signs evaluated.

Figure 22. Image of Standard Billboard with Uneven Lighting.

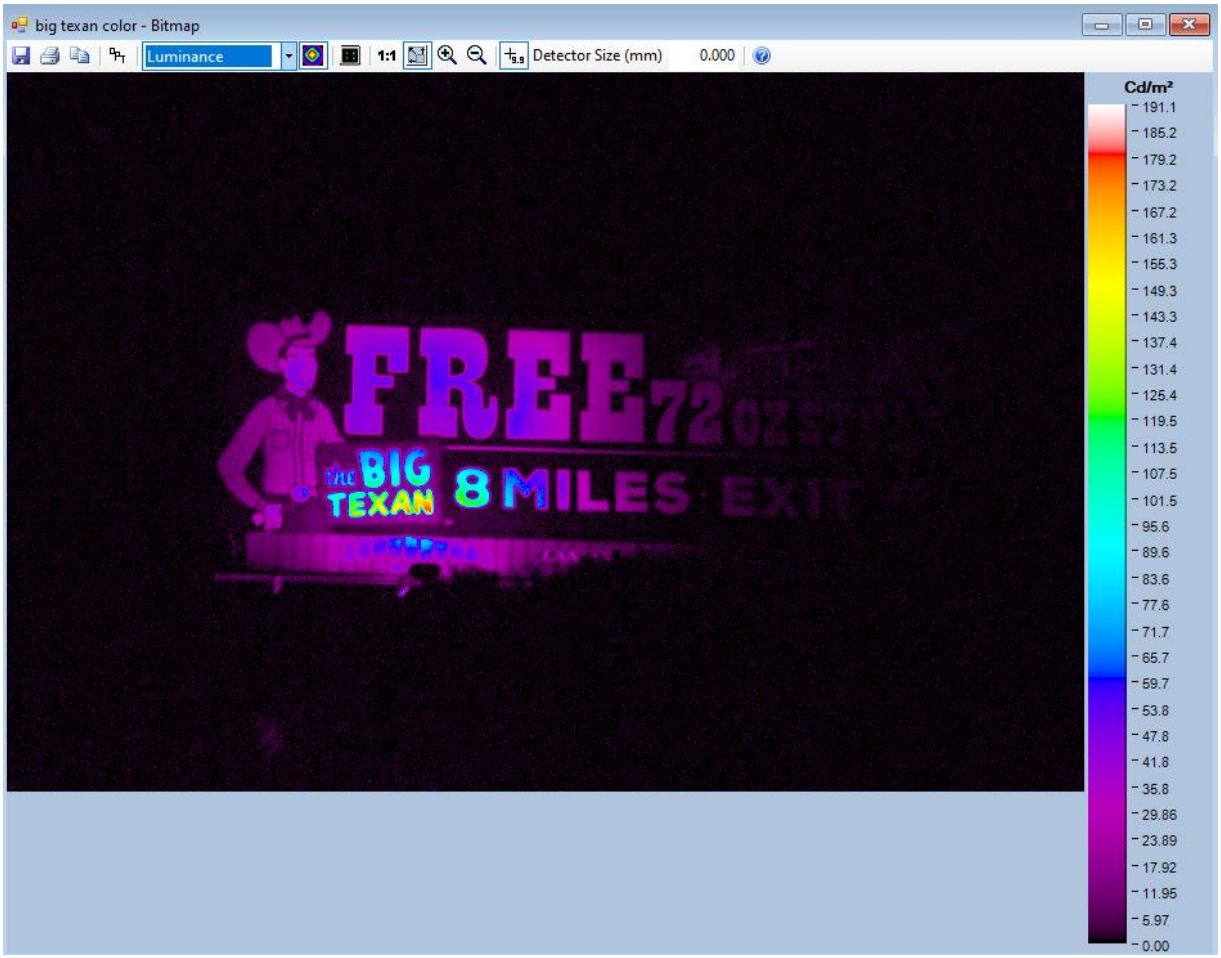

Figure 23. Luminance Values of Standard Billboard.

Figure 24. DBB Image.

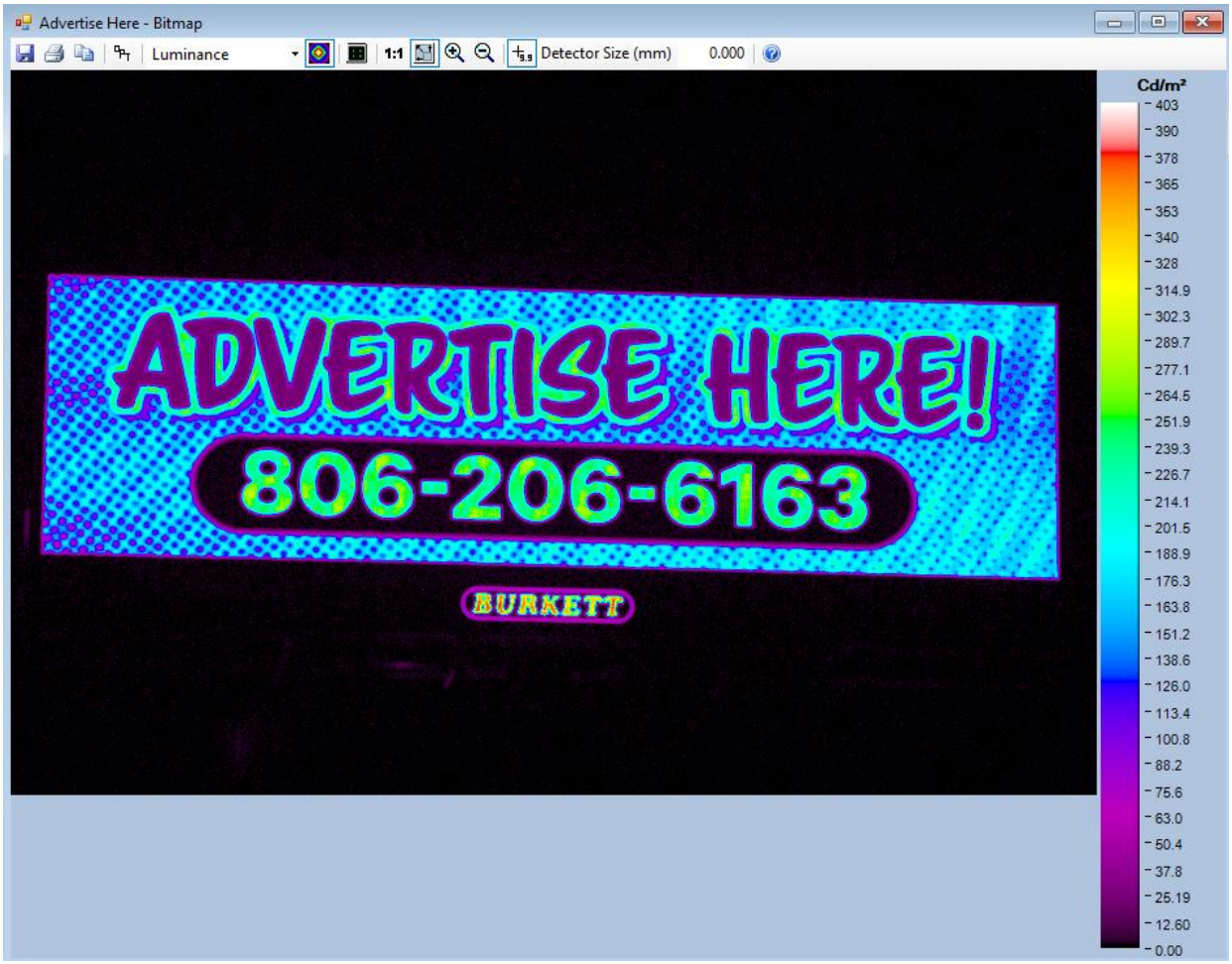

Figure 25. Luminance Values of DBB.

Table 40. Luminance Level Range of Evaluated Signs.

Sign Type	Range of Luminance Levels by Color (cd/m^2)				
	White	Yellow	Red	Blue	Other
Digital Billboard	72–569	51–490	4–116	1–75	0.5–141
Standard Billboard	6–150	35	4–12	0.3–19	1–14
Digital On-premise	125–3800	N/A	24–1200	8–1800	12–1700
Internally Illuminated On-premise	60	N/A	N/A	10	N/A

CHAPTER 6:
GUIDANCE AND RECOMMENDATIONS

SUMMARY OF FINDINGS

The state-of-practice review found varying levels or regulations governing DBBs. There is limited federal guidance, resulting in many state and local agencies trying to develop their own regulations. These regulations often try to limit conversion of standard billboards to digital, establish minimum spacings between DBBs, and require dimming of the signs at night. Some jurisdictions have not allowed off-premise DBBs, but are limited on what they can do to on-premise digital signing.

The proximity of the sign, whether digital or standard, to the roadway impacted how often the signs were looked at. Signs closer to the road will draw more looks than those farther away. Signs in less visually complex environments were looked at more often than signs in more complex environments. The findings of this study suggest that DBBs are looked at more often and for longer durations than standard billboards. Although this type of advertising might attract more and longer looks and benefit advertisers, it might have adverse traffic safety effects. Numerous studies have shown that taking eyes off the roadway significantly increases the risk of crashes and incidents (*78*). The safety evaluation portion of the study did see some minor impacts on crashes but no statistically significant crash impacts.

Digital signing that is too bright might cause glare or disability glare to drivers, especially older drivers. This glare could prevent critical information such as warning, guide, and advisory signs from being seen for both younger and older drivers. The research team found both on- and off-premise signing that were very bright. Many of the observed off-premise DBBs were typically within a more reasonable range of brightness levels compared to on-premise digital signs. The DBBs were typically brighter than standard illuminated billboards. The driving study close-out survey gathered many responses from participants that indicated sign brightness was a concern.

RECOMMENDATIONS

Sign Location

Advertising signs are meant to take a driver's attention away from the roadway. The summary of findings above discusses the impact of sign type, sign proximity to the roadway, and visual environment. The research team was unable to generate specific quantitative findings with respect to sign spacing or location but were able to generate recommendations to help minimize distraction to drivers. The impact of added distraction from advertising signs needs to be considered when allowing signs to be placed. Advertising signs near traffic control devices will have a negative impact on the effectiveness of the traffic control device due to added distraction. The same holds true when considering locations around more complex driving situations such as intersections and interchanges. Adding advertising signs into areas with complex backgrounds will limit the effectiveness of the advertising signs due to drivers typically allocating more time to the driving task in complex visual environments. Any addition of advertising signs will make the visual environment more complex and add to distraction. Isolated advertisement signs can be more effective and limit conflict with other traffic control devices. The research findings found that digital signs

cause more distraction than standard signs, which should be considered when allowing specific sign types or conversion of signs.

Sign Brightness

Most digital sign guidance indicates that the signs should dim at night compared to daytime lighting levels. Several groups have recommended various sign lighting levels to keep digital signs from being too bright at night. The lighting measurements include luminance and illuminance. Illuminance is a measure of how much light is falling on a surface from a light source. The light source would be the digital sign. Change in illuminance over ambient is a common measure used with a typical allowable increase of 0.3 foot-candles. Illuminance is easy to measure but requires being able to turn the sign off to get the ambient condition for lighting level verification. Evaluating illuminance lighting increases over ambient has several shortcomings. These include having high light output from signs in areas with other light sources due to high ambient levels of light, tall signs casting less light to the ground resulting in higher light levels from the sign, and the measurements being dependent on distance. Luminance is more difficult to evaluate directly but can be converted from illuminance if the sign size is known. Luminance is a measure of light coming from a light source. Luminance can be used to measure how bright specific colors of a sign are or the overall amount of light coming from the sign. Luminance levels between 100 and 500 cd/m^2 at night are the typical maximum levels recommended. The overall sign luminance level and the maximum luminance of individual colors needs to be considered.

The OAAA-recommended brightness criteria for DBBs is as follows:

> Light produced by a digital billboard should not exceed 0.3 footcandles over ambient light levels. Measurement should be taken utilizing a footcandle meter from the following distances (perpendicular to the face of the digital billboard): Posters: 150 feet; 10’6x36 Bulletins: 200 feet 14x48 Bulletins: 250 feet; 20x60 Bulletins: 350 feet. The measurement distances are based on the average minimum viewing distances for each type of billboard. Digital billboards must have automatic dimming capability.

The 2007 CEVMS memo from FHWA required this adjusting: “Brightness: Adjust brightness in response to changes in light levels so that the signs are not unreasonably bright for the safety of the motoring public” (*79*).

Additional Sign Policy

Advertising sign policy should address digital signing to minimize negative impacts on traffic safety. This policy should apply to all signs whether they be on- or off-premise. Sign location and brightness are two key factors. Policy should also govern how often the messages change and how the change occurs. Current Texas regulation as noted below indicates the message must be displayed for at least 8 seconds. The research team found off-premise signs changing in less than 8 seconds. A longer message length would be beneficial to minimize distraction. When the message changes it draws added attention, which results in greater driver distraction. A message duration related to roadway speed and visibility distance to minimize

the number of message changes a driver would see would be ideal. The 2-second requirement for the change and the entire message changing at once are common requirements.

Texas current regulations require:[249]

> *§21.196.Requirements For an Electronic Sign.*
>
> (a) Each message on an electronic sign must be displayed for at least eight seconds. A change of message must be accomplished within two seconds and must occur simultaneously on the entire sign face.
>
> (b) An electronic sign must:
>
> (1) contain a default mechanism that freezes the sign in one position if a malfunction occurs; and
>
> (2) automatically adjust the intensity of its display according to natural ambient light conditions.

Large off-premise DBBs are not allowed to have motion or video. This does not hold true for all on-premise signs. The research team saw numerous digital on-premise signs with scrolling displays, signs with video, and various motion elements. Motion is a major attractor of attention and will result in more drivers looking at the signs and potentially for longer periods. This will reduce traffic safety. All codes, rules, and regulations should ban motion and video from all signs that are viewable to the driving public.

Future Research

Although this study encompassed four different cities in Texas, the study team believes it would be beneficial to conduct similar in-vehicle evaluations in other regions of the country. Other states might have regulations or practices in place that could impact the human interactions with billboards. Different driver characteristics and familiarity with digital signing may also impact the results.

The research team found that signs closer to the road were viewed more frequently than signs farther away. Driver eye glance patterns found shorter dwell time on signs farther from the road. The research team did not evaluate total eyes off the road time when the participants were viewing the advertising signs. The combination of the amount of time drivers' eyes are off the road and sign offset distance from the roadway

[249] TAC § 21.196, https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=43&pt=1&ch=21&rl=196#:~:text=Each%20message%20on%20an%20electronic%20sign%20must,accomplished%20within%20two%20seconds%20and%20must%20occur ; TXDOT Rulemaking , July 2024, https://www.sos.state.tx.us/texreg/archive/August162024/Adopted%20Rules/43.TRANSPORTATION.html#:~:text=message%20on%20an%20electronic%20sign%20must%20be%20displayed%20for%20at%20least%20eight&text=accomplished%20within%20two%20seconds%20and%20must%20occur%20simultaneously%20on%20the%20entire%20sign%20face.

may generate an offset distance that is a best compromise for distraction time in combination with how often the signs are viewed.

The research team evaluated the signs on open roads without control over the sign messages, brightness, change time, or any other sign characteristics. The research team recommends a more controlled study to develop specific recommended values for sign brightness. The majority of the digital signs in the study had a similar range of sign brightness levels, resulting in the inability to see if brighter signs were looked at more frequently than less bright signs. The inability to control specific advertisements that each participant saw was also a limiting factor.

A large issue the research team found was concerning on-premise digital signing. The research team found many on-premise digital signs where much brighter than the typical DBB and many on-premise signs incorporated motion into their displays. Both motion and overbrightness generate added distraction and pose greater safety risk than if the signs were required to follow guidelines and requirements that off-premise signs face. Additional efforts are needed to develop rules and regulations and model sign codes or ordinances that local entities can utilize to better account for digital signing and the need to minimize the digital sign impact on safe vehicle operation.

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