O – Residential Building – 4th Avenue North at Roy Street

P – Theater Posters - Mercer Street

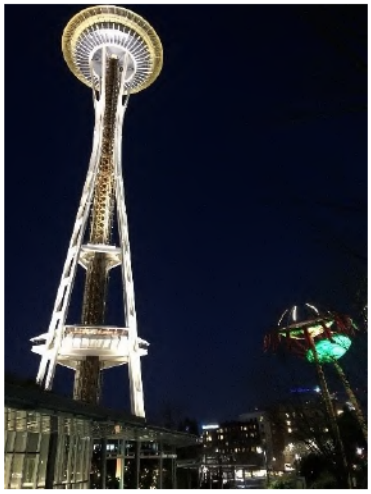
6.0 EXISTING LIGHT AND GLARE IN THE AREA

6.1 Project Site

Extensive illumination currently exists on the Seattle Center Campus site. The most prominent lighting element is associated with the illumination of the Space Needle which is visible within the entirety of the site. The other high levels of illumination and visible lighting consists of the platform lighting located at the Monorail station and the unshielded floodlighting at Memorial Stadium (Photos Q through X).

Most of the other illumination that exists on site are at low to moderate levels. Major elements of this site lighting include building façade lighting, area lighting, pathway lighting, and parking lot lighting. There is a mixture of shielded and unshielded lights used for these elements.

Photos of Existing Lighting within the Seattle Center Campus



Q - Space Needle

R - Monorail Platform

S - Walkway

T - South Fountain Lawn

U – Memorial Stadium Parking Lot

V - Walkway

W - Pacific Science Center

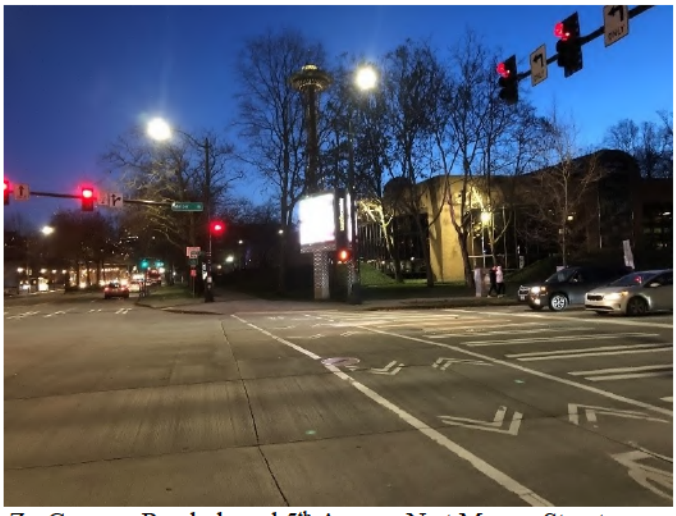
X - Space Needle Pavilion

6.2 Area Surrounding Project Site

Extensive outdoor illumination currently exists throughout the areas surrounding the Seattle Center. The illumination levels and lighting are typical for urban commercial and residential areas within the built environment of Seattle. Lighting used for illuminating surrounding arterial streets, commercial properties and residential properties is continuous and typical for an urban built environment (Photos Y through GG).

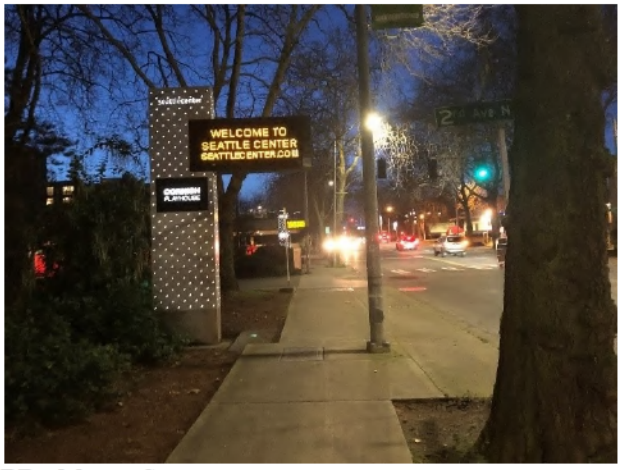
Photos of Existing Lighting along Perimeter of the Seattle Center Campus

Y - Campus Readerboard 5th Avenue N at Mercer Street

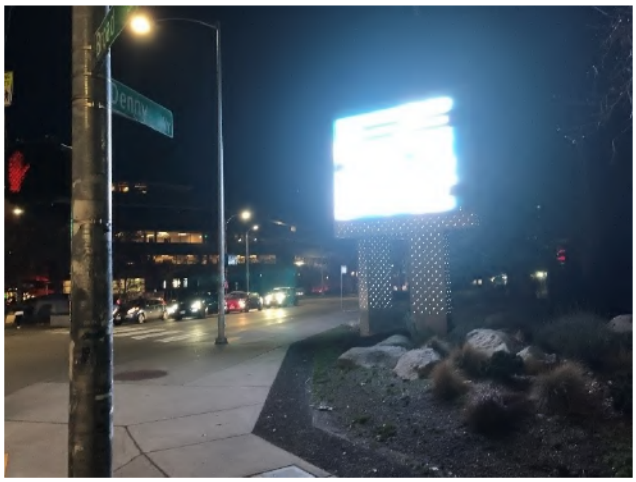


Z - Campus Readerboard 5th Avenue N at Mercer Street

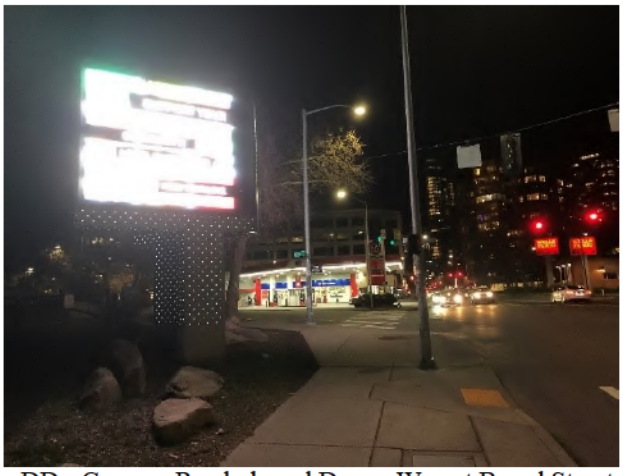
AA - 5th Avenue N at Mercer Street



BB - Mercer Street



CC - Campus Readerboard Denny Way at Broad Street



DD - Campus Readerboard Denny Way at Broad Street

EE - Digital Readerboard 5th Avenue N at Harrison Street

GG - 5th Avenue N

7.0 PROPOSED SIGN LIGHTING

7.1 Seattle Center

Illuminated signage is proposed for the site. The signage changes are as follows, and locations and depictions are shown in Appendix B of the SEPA Checklist:

- Replacement of the 3 existing LED campus readerboards with new LED displays
- Replacement of 3 existing amber text facility readerboards and two static text, with five new LED displays
- Replacement of 17 static wayfinding pylons with 20 wayfinding pylons with LED\LCD displays
- Replacement of 3 information kiosks with 3 kiosks with LED/LCD displays
- Add 3 new art walk display signs with LED/LCD displays
- Add 12 new pole banners with LED displays
- Replace the 3 static theater posters with 1 LED display

Digital garage signs include:

- Add 1 new garage wayfinding pylon with LED/LCD display

- Replace 4 static garage ID pylons with 4 with LCD displays
- Replace 4 static entry/exit ID signs with 7 with internally illuminated lettering and LED lane indicators
- Replace 4 static and neon wayfinding signs with 2 Garage wayfinding sign with LED displays
- Replace 4 static garage overhead entry signs with 4 overhead entry illuminated signs
- Replace 2 blade signs with 2 garage blade LED displays

The following documents were reviewed as part of analysis to determine potential light and glare impacts.

- Seattle Center Campus Signage Plan – February 2021
- Seattle Municipal Code Section 23.55 SIGNS
- Seattle Municipal Code Ordinance 125869
- Seattle Municipal Code Proposed Draft Amendments to 23.55
  Seattle Center Arena Renovation EIS Addendum – June 6, 2019
- Seattle Center Arena Renovation Project FEIS – August 2018

7.2 Impacts

The proposed LED displays on signs would increase the amount of light and glare in the areas where installed. The lighting impacts are assessed by evaluating the components listed above.

The signage plan basis of design is use of Daktronics JVX LED (LCD) displays. For the purposes of this analysis, it is assumed that all the LED displays would comply with all provisions provided in SMC 23.55 and the proposed amendment. It is the basis of this analysis that the brightness of the LED displays would not exceed code maximum.

7.2.1 Glare

Campus Signs

The replacement of the two existing Campus readerboards with new LED displays would not increase glare at these locations. The proposed Campus readerboards consist of two displays providing visual coverage in approximately opposite directions. Moderate levels of existing direct glare and reflected glare are evident at Mercer Street, 5th Avenue North, Denny Way, and Broad Street (see above photos Y, Z, CC, and DD). The incorporation of new LED technology and dimming of the new displays would maintain and even reduce the existing glare.

The replacement of the existing digital amber text displays on the 5th Avenue and Harrison Street sign (see above photos D and EE) with new LED displays would increase glare at this location. Low amounts of direct glare would be visible into and across the adjacent ROW at 5th Avenue North and Harrison Street. Levels of reflected glare from adjacent pavement surfaces and structures surfaces would be minor.

The incorporation of LED displays with the replacement of the 3-existing facility readerboards and the addition of a fourth facility readerboard at Phelps Center located along the perimeter (Mercer Street) of the Seattle Center would increase glare at these locations. Low amounts of direct glare would be visible into and across the adjacent ROW at Mercer Street. Levels of reflected glare from adjacent pavement, structure and building surfaces would be minor. Additionally, no LED displays exist for the theater poster on McCaw Hall. Glare from the theater poster LED displays would be minor as it is located near existing sources of glare and is set back from Mercer Street.

The new LED displays for the wayfinding pylons, information kiosks, art walk signs, and pole banners located interior to the Seattle Center Campus would increase glare for individuals at these locations. Levels of direct glare apparent to individuals on site would be low to moderate. Levels of reflected glare from adjacent pavement, structure and building surfaces would be low. This is due to the fact that existing ambient light levels within the site are similar to what would be produced by the LED displays. The LED displays also incorporate dimming to reduce brightness and are designed to not exceed maximum brightness allowed under the SMC. Off-site direct and reflected glare impacts would only be readily apparent from signs around the perimeter of the Campus and therefore would be low:

- Wayfinding pylons located at 5th Avenue North and Thomas Street; 2nd Avenue and John Street; Warren

Avenue North and Thomas Street; and Republican Street and Warren Avenue North.
- Pole banner at 1st Avenue North at Thomas Street, and
- Art Walk Display at 5th Avenue and Harrison Street; and Broad Street and John Street.

Garage Signs
The addition of the garage ID pylons, entry/exit ID signs, wayfinding signs, and garage blades would increase glare at these locations. The existing garage ID pylons have amber text; but currently no LED displays exist on the other existing garage signs. The additional glare from the garage blades would be low as they are small, located in well lighted areas along Mercer Street and Roy Street. The glare from the garage wayfinding signs at 3rd Avenue North and 4th Avenue North would be low to moderate as these displays are slightly larger with more visual exposure. Moderate levels of glare would affect drivers and pedestrians immediately adjacent to these displays. Low levels of glare primarily affect the residential buildings that face the signs across 3rd Avenue North and 4th Avenue North respectively. The garage overhead entry and Entry\Exit ID signs would have minimal impacts.

The glare from the Fifth Avenue Garage wayfinding pylon proposed along 5th Avenue North would be low as it is located adjacent to existing high levels of glare associated with the streetlights and building façade. The other new Garage ID Pylon, overhead entry signs, entry/exit signs around the 5th Avenue Garage would have minimal impacts.

7.2.2 Spill Light

The incorporation of LED displays into the wayfinding pylons, information kiosks, art walk display, and pole banners located interior to the Seattle Center Campus would not increase spill light levels into properties adjacent to the Seattle Center. The replacement of the existing Campus readerboards with new LED displays would not increase spill light at these locations. The incorporation of new LED technology and dimming of the new Campus readerboards will maintain and even reduce the existing spill light. The replacement of the amber text Campus readerboard on 5th Avenue and Harrison Street would have minimal spill light impacts into the adjacent 5th Avenue North and Harrison Street ROW only. The addition of the new digital theater poster, facility readerboards, and Mercer Street Garage ID pylons, entry/exit ID signs, wayfinding signs, and Mercer Garage blades would increase spill light at these locations. The spill light will be minor and localized to the areas immediately adjacent to each respective new display. The addition of 5th Avenue Garage wayfinding pylon, Garage ID Pylon, overhead entry signs, and entry\exit signs would have minimal to no impacts.

7.4 Sky Glow

The contribution of the proposed lighting systems to "sky-glow" would be direct light from the LED signs, light reflected from the adjacent pavement, landscape, and grass areas. The extent of sky glow is dependent on how much precipitation or particulate matter is in the air for the light to strike.

The sky glow above the project area is influenced by the existing light sources on site and throughout the surrounding area. The existing sky glow in the area is significant and the lighting produced by the project is minor and does not contribute to sky glow.

8.0 PROPOSED MITIGATION MEASURES

8.1 LED Board Design

Select LED displays that minimize luminance and spill light. Visual beam angles and brightness should be evaluated to determine positioning of displays to reduce impacts. Incorporate dimming of the displays under varying ambient background light conditions or hours of low vehicular and pedestrian traffic. Verify programming and brightness of the LED displays meet SMC requirements.

APPENDIX D - EVALUATION OF POTENTIAL EFFECTS OF PROPOSED DIGITAL SIGNS ON DRIVER DISTRACTION MEMO

FEHR PEERS

Memorandum

Date: March 26, 2021

To: Julia Levitt – City of Seattle
Claire Hoffman – ESA

From: Emily Alice Gerhart, AICP and Ariel Davis, AICP – Fehr & Peers

Subject: Seattle Center– Evaluation of Potential Effects of Proposed Digital Signs on Distracted Driving

SE21-0777

This memorandum documents an independent assessment of the potential for driver distraction related to the construction of on-site digital signs in and around the Seattle Center campus. The memo also provides recommendations for operational best practices for the City's consideration as it amends its Municipal Code for the Seattle Center sign overlay district, updates the Seattle Center Century 21: Signage Guidelines (Signage Guidelines), and considers installing new signs on the Seattle Center Campus.

Background

The proposed project includes new signs with video display capabilities that would not be allowed under the current SMC Section 23.55 (also referred to as the Sign Code). Seattle Center is proposing to amend the City's Sign Code to include regulations for the Center Campus Subarea.

The proposed project would include replacement signs in similar locations to those already existing on the campus, as well as new signs. **Figure 1** shows the proposed signs as provided in the "SC Campus Exterior Signage" (Sign Plan).

As shown in **Figure 1**, many of the proposed signs would be located in the interior of the Seattle Center campus and therefore would not be visible from adjacent roadways. Some signs may be physically visible from adjacent roadways, but because of their distance and orientation they are unlikely to be noticeable to drivers and therefore would not have the potential for distraction. **Table 1** describes the proposed digital signs that may have potential effects on driver distraction based on their proximity and visibility from the roadway.

Figure 1 – Draft Campus Signage Location Plan (February 2021)

CAMPUS SIGNAGE **SIGN LOCATION PLAN**

	SIGN TYPE	DISPLAY TYPE	QTY STUDIED	
●	WAYFINDING PYLON	DIGITAL CHANGING IMAGE	20	
●	ENTRY MARKER	STATIC	5	
●	CAMPUS READERBOARD	DIGITAL CHANGING IMAGE	3	
●	POLE BANNER	DIGITAL CHANGING IMAGE	12	
●	FACILITY READERBOARD	DIGITAL CHANGING IMAGE	5	
●	ART WALK DISPLAY	DIGITAL CHANGING IMAGE	3	
▭	INFORMATION KIOSK	DIGITAL CHANGING IMAGE	3	
●	DIGITAL POSTER	DIGITAL CHANGING IMAGE	1	

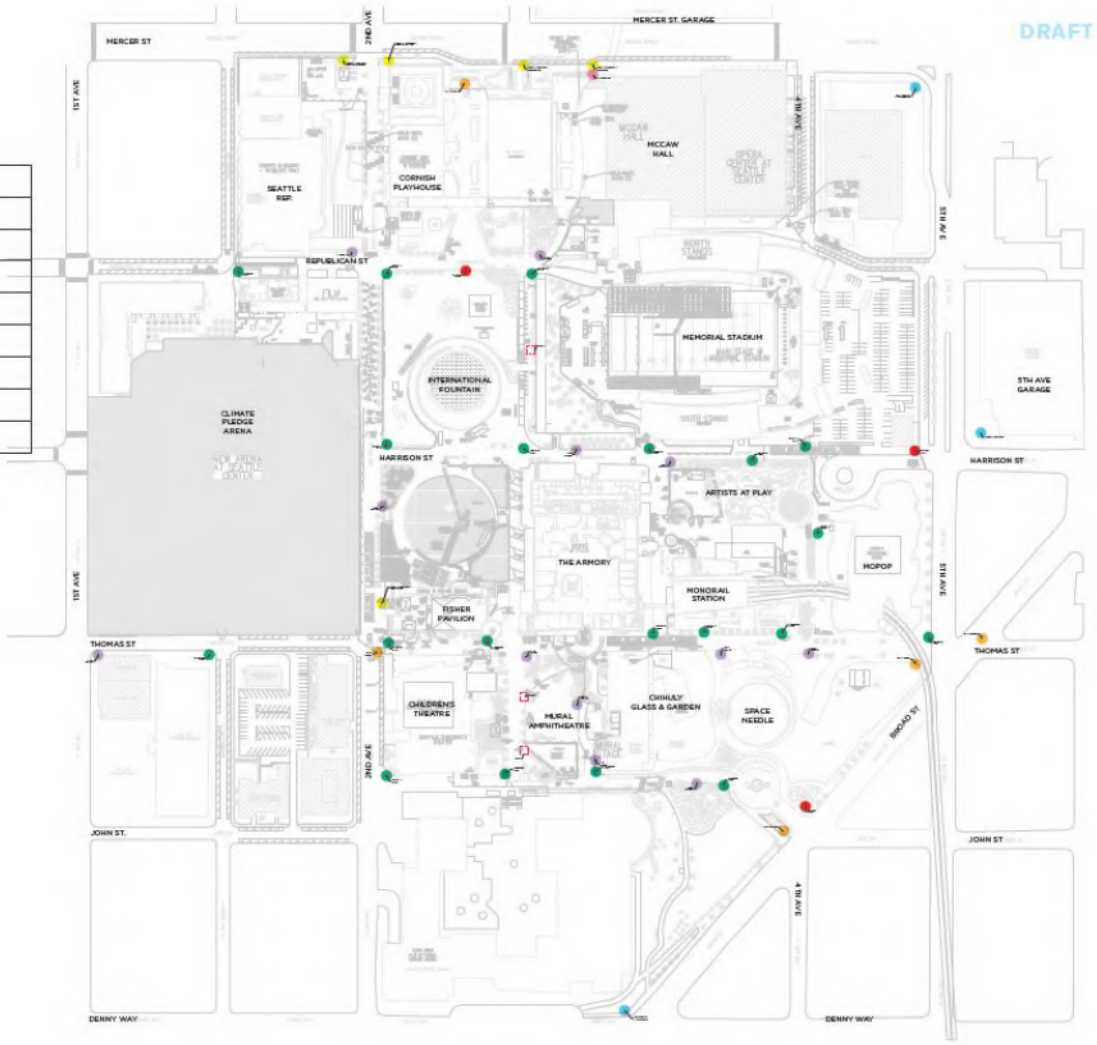


Table 1 - Proposed Digital Signs for Seattle Center Campus Subarea Visible from External Roadways

Type	General Location	Quantity Existing (Proposed)	Existing Dimensions (feet)	Proposed Dimensions (feet)	Existing Display	Proposed Sign Type / Display
Campus Readerboard	• 5th & Mercer • Denny Way • 5th & Harrison	3 (3)	• 12'-8 5/8" W x 20'-0" H • 12'-8 5/8" W x 20'-0" H • 7'-9 7/16" W x 20'-0" H x 1' 3 5/8" D	• 5'-3" W x 22'4"-0" H x 2' D • 5'-3" W x 22'4"-0" H x 2' D • 5'-3" W x 22'4"-0" H x 2' D	Digital image and text	Digital sign; changing image Daktronics LED Outdoor Display; edge-to-edge dynamic LED display (noninteractive); has capability to dim brightness of signage in response to ambient lighting conditions
Perimeter Facility Readerboard	• Mercer St. (4 signs)	4 (4)	• 3'-8" W x 15'-1 7/16" H x 1'-3/4" D	• 3'-9" W x 12'-6" H x 1'-0 3/4" D	3 Digital amber text signs and 1 static sign	Digital sign; changing image Daktronics LED Outdoor Display; edge-to-edge dynamic LED display (noninteractive); has capability to dim brightness of signage in response to ambient lighting conditions
Interior Facility Readerboard	• Fisher Pavilion (1 sign) (vacated 2nd Ave North)	1 (1)	• 3'-8" W x 15'-1 7/16" H x 1'-3/4" D	• 3'-9" W x 12'-6" H x 1'-0 3/4" D	Static marquis with manually updated letters	Digital sign; changing image or video
Campus Wayfinding signs	• Various - along pedestrian pathways	3 (5)	• 3'-0" W x 11'-0" H x 0'-8 1/4" D	• 3' W x 11' H x 2' D	Static Text	Digital sign; changing image (or video on signs not clearly visible from the right-of-way) Samsung Outdoor LCD (or equal); has capability to dim brightness of signage in response to ambient lighting conditions

Type	General Location	Quantity Existing (Proposed)	Existing Dimensions (feet)	Proposed Dimensions (feet)	Existing Display	Proposed Sign Type / Display
Art Walk Display Signs [1]	• Various - near significant outdoor artworks	0 (2)	• N/A	• 3' W x 11' H x 3' D	N/A	Digital sign; changing image (or video on signs not clearly visible from the right-of-way). Possible integrated lighting or artwork. Samsung Outdoor LCD (or equal); has capability to dim brightness of signage in response to ambient lighting conditions
Campus Pole Banners	• Various - interiors of campus	0 (1)	• N/A	• 5' 1 1/2" W x 19'-2 3/4" H	N/A	Digital sign; changing image (or video on signs not clearly visible from the right-of-way). Daktronics Outdoor Display; has technology that can dim the signage in response to ambient lighting conditions
Digital Theater Poster	• Mercer Street, on exterior concrete retaining wall outside McCaw Hall	3 (1)	• 2'-0" W x 4'-2" H	• 7'-4 1/2" W x 4'-1 1/4" H x 6" D	Three printed posters displayed in glass cases	Digital sign; changing image (or video on signs not clearly visible from the right-of-way). Daktronics Outdoor Display; has technology that can dim the signage in response to ambient lighting conditions
Garage Wayfinding Pylon - 5th Ave N	• 5th Ave N Garage	1 (1)	• 5'-4" H x 3'-2 1/2" tall sign mounted on 13'-4" pole	• 3'-0" W x 11'-0" H x 2' D	Programmable 1 line LED message at 5th Avenue North Garage	Digital sign; changing image Samsung Outdoor LCD (or equal); has capability to dim brightness of signage in response to ambient lighting conditions

Type	General Location	Quantity Existing (Proposed)	Existing Dimensions (feet)	Proposed Dimensions (feet)	Existing Display	Proposed Sign Type / Display
Garage ID Pylon	• Mercer Garage at both entries on 3rd Ave N and 4th Ave N • 5th Ave N Garage at both entries	3 (4)	• Mercer 3rd N: 15'-11" H x 5'-0" W x 1'-0" D • Mercer 4th N.: 16'-3" H x 5'-0" W x 1'-0" D • 5th Ave. 13' H x 4'-6" W x 9" D	• 3"-6" W x 12'-0" H x 2' D	LED sign "Full" at Mercer Street Garage and programmable 2 line LED message at 5th Avenue North Garage	Digital sign; changing image Daktronics Outdoor Display; has technology that can dim the signage in response to ambient lighting conditions
Entry/Exit ID Sign	• Mercer Street Garage entries and exits--3rd Ave N (2) and 4th Ave N (2) • 5th Ave N Garage entries and exits--Republican St (1) Harrison St (2)	7 (7)	• Mercer: 24'-4" to 26'-4 3/4" W x 1' H x 2" D • 5th Ave: 26' to 35" W x 1' H x 6" D	• Design Variant 1 (6 proposed signs: 26' W x 2' H x 6" D • Design Variant 2 (1 proposed sign): 35' W x 9'11" H	Yellow colored aluminum cabinet, internally illuminated each with programmable green LED X's and red LED down arrow's	Digital sign; changing image Internally illuminated lettering and LED lane indicators
Garage Wayfinding Sign	• Mercer Garage	4(2)	• 49 1/2"W x 24"H x9 1/2 D • 50"W x 18"H x 13 1/2" D • 85 1/2"W x 75"H X 10" D	• 6' 6 7/8" W x 3' 3 3/8" H x 6" D	Neon (some working)	Digital sign; changing image Daktronics Outdoor Display; has technology that can dim the signage in response to ambient lighting conditions

Type	General Location	Quantity Existing (Proposed)	Existing Dimensions (feet)	Proposed Dimensions (feet)	Existing Display	Proposed Sign Type / Display
Garage Blade	• Roy Street at Nob Hill Ave N and Mercer at 4th Ave N	2 (2)	• 75" W x 48" H x 9"D • 69" W x 36"H x 9"D	• 3' 3 1/2" W x 2' 5 1/2" H x 10" D	Neon at Roy St at Nob Hill N Programmable 1 line LED at Mercer and 4th Ave N	Digital sign; changing image Daktronics Outdoor Display; has technology that can dim the signage in response to ambient lighting conditions

Note: All digital signs would be video capable. Signs that are clearly visible from the ROW would be operated in a way that minimizes driver distraction.
Source: Seattle Center Campus Signage and Sign Code Update, SEPA Checklist – INTERNAL DRAFT (March 2021), Fehr & Peers, 2021.

Sign Type Descriptions

This section describes the main types of signs currently in use along roadsides. Signs generally range from least to most sophisticated according to:

- Static Signs (i.e., a single image and/or text on a sign panel).
- Tri-Vision Signs (i.e., a series of images are presented through mechanical rotation of multi-sided vertical strips).
- Scrolling Text/Image Signs (i.e., display of multiple static pieces of digital content).
- Video Signs (i.e., full motion, brilliant colors, and a readable display of video).

Static signs are considered 'passive', while the other three are considered 'active' or 'dynamic'. Active or dynamic signs can display multiple messages in sequences. These signs may also be referred to as: changeable message signs, electronic/digital billboards, animated signs, or digital reader boards. Based on the technical capabilities of the proposed signs, this study focuses on scrolling text/image signs (referred to as digital signs throughout), and video signs.

Transportation Context

In transportation, the local context is always important to consider. Seattle Center is a 74-acre arts, educational, tourism and entertainment center owned by the City of Seattle (City) located in the Uptown urban center, generally bounded by Mercer Street, Denny Way, 1st Avenue, and 5th Avenue in Seattle, Washington. Most of the roadways adjacent to Seattle Center are arterials with high traffic volumes as well as substantial multimodal activity including pedestrians, bicyclists, and transit users. A digital video sign proposed on a modestly traveled suburban street with few other visual distractions represents a much different condition than what is/will be present adjacent to Seattle Center if the proposed signs are implemented. Considering another context, a digital video sign on the Las Vegas Strip as part of an environment that is saturated with lights, display signs, and flashing features is also a much different condition than what will be present at Seattle Center. Design consistency from the perspective of physical size and visual continuity is an important factor when making roadway improvements (FHWA). From a user's perspective, perceiving the same conditions and characteristics while traveling along a roadway supports that their expectations are met and focus remains on navigation, control and guidance decisions while driving, rather than observing and adapting to new roadway characteristics.

Applicable Sign Code

The proposed Sign Code amends the existing SMC 23.55 to regulate specific signs on Seattle Center's campus, within the Center Campus Subarea. For signs on Seattle Center's campus that are not regulated under the proposed code amendment, Part 1 of SMC 23.55 will apply. The proposed Sign Code requires campus signs located within 20 feet of the street curb to comply with general standards provided in Part 1 of the sign code and requires campus signs located further than 20

feet from the street curb to comply with the standards in SMC 23.55.062.E and any applicable Seattle Center guidelines. Programming information for signs using video display methods within 20 feet of the street curb is provided in existing SMC 23.55.005. Notable provisions in SMC 23.55.005 related to sign programming include:

A. Development standards. Video display may be used on a sign when the sign meets all of the following development standards, except as allowed in Part 4 of Chapter 23.55:

1. The sign is an on-premises sign;

2. The sign is not located in a residential, NC1, or NC2 zone, Special Review District, Historical District, Preservation District, or shoreline environment;

3. The sign meets one of the following criteria:

a. The sign face is not visible from a street, driveway, surface parking area, or lot that is owned by a different person or entity, in which case the size of the sign is not limited by this subsection 23.55.005.A, and the standards for duration or pause periods and subsection 23.55.005.A.5 do not apply; or
b. The sign area is less than or equal to 1,000 square inches and no single dimension of the sign exceeds three feet; or
c. The sign meets the standards set out in subsection 23.55.005.B, in addition to meeting all other standards of this subsection 23.55.005.A.

4. The maximum height for any sign using a video display method is 15 feet above existing grade. Pole signs using a video display method shall be at least 10 feet above the ground;

5. The sign is at least 35 linear feet in any direction from any other sign that uses a video display method;

6. When located within 50 feet of a lot in a residential zone, any part of the sign using a video display method is oriented so that no portion of the sign face is visible from an existing or permitted principal structure on that lot;7. Duration: Any portion of the message that uses a video display method shall have a minimum duration of two seconds and a maximum duration of five seconds. Calculation of the duration shall not include the number of frames per second used in a video display method. Calculation of the maximum duration shall include the time used for any other display methods incorporated within that portion of the message displayed using a video display method;

8. Pause Between Video Portions of Message. There shall be 20 seconds of still image or blank screen following every message using a video display method;

9. Audio speakers are prohibited in association with a sign using a video method of display;

10. Between dusk and dawn the video display shall be limited in brightness to no more than 500 nits (candela per square meter) when measured from the sign's face at its maximum brightness; and

11. Signs using a video display method may be used after dusk only until 11 p.m. or, if the advertising is an on-premises message about an event at the site where the sign is located, for up to one hour after said event.

As currently described in SMC 23.55.03, flashing signs are prohibited in all zones, which applies to proposed Seattle Center signage. The proposed amendments to the Sign Code as described in SMC 23.55.062.E.10 prohibit Seattle Center's proposed permanent campus signs from including flashing signs. This code also prohibits rotating or have a rotating or moving part or parts that revolve at a speed in excess of seven revolutions per minute within the Center Campus Subarea.

For campus signs further than 20 feet from the street curb that utilize video display methods, the sign programming includes the following operation standards as provided in the proposed Sign Code:

4. Video displays
   a. The total duration of multiple video display messages together may not constitute more than 20 seconds of every two minutes.
   b. Video displays are prohibited between 10 p.m. and 7 a.m. except that video displays are permitted within an hour after an event in the Seattle Center Sign Overlay District ends.
   c. A video display message shall have a minimum duration of two seconds and a maximum duration of ten seconds. Calculation of the duration does not include the number of frames per second used in a video display.
   d. There shall be ten seconds of still image or blank display following every message using a video display method.
   e. All video displays, except those described in subsection 23.55.062.E.4.f, and except those regulated by subsection 23.55.062.E.5, shall be set back a minimum of 20 feet from the street curb of the nearest unvacated right-of-way.
   f. A video display using only scrolling alphanumeric characters is permitted and may be located adjacent to a right-of-way with no minimum setback, provided that such a sign may not exceed 42 feet in length and 18 inches in height. No more than 21 feet of any such sign face may be directed at the same right-of-way. Any such sign must be at least 8 feet above grade. A video display consistent with this

subsection 23.55.062.E.4.f is not subject to the standards in subsections 23.55.062.E.4.a through 23.55.062.E.4.d.[1]

Proposed Project

Campus Readerboards

Of the proposed signs, the proposed Campus Readerboards have the strongest potential for driver distraction based on their size, location, luminance, and intended audience. As described in the Sign Plan, the Campus Readerboards would be constructed to be approximately 5 feet wide, 22 feet tall, and 2 feet deep, with the LED face spanning nearly 5 feet wide by 12 feet tall. These three signs would be slightly larger than the existing digital signs they would replace, with increased visual capabilities. However, as summarized in Table 1, Seattle Center would not utilize the video capabilities for the Campus Readerboards because of their proximity in location to roadways. Campus Readerboards are proposed to be constructed at the following locations:

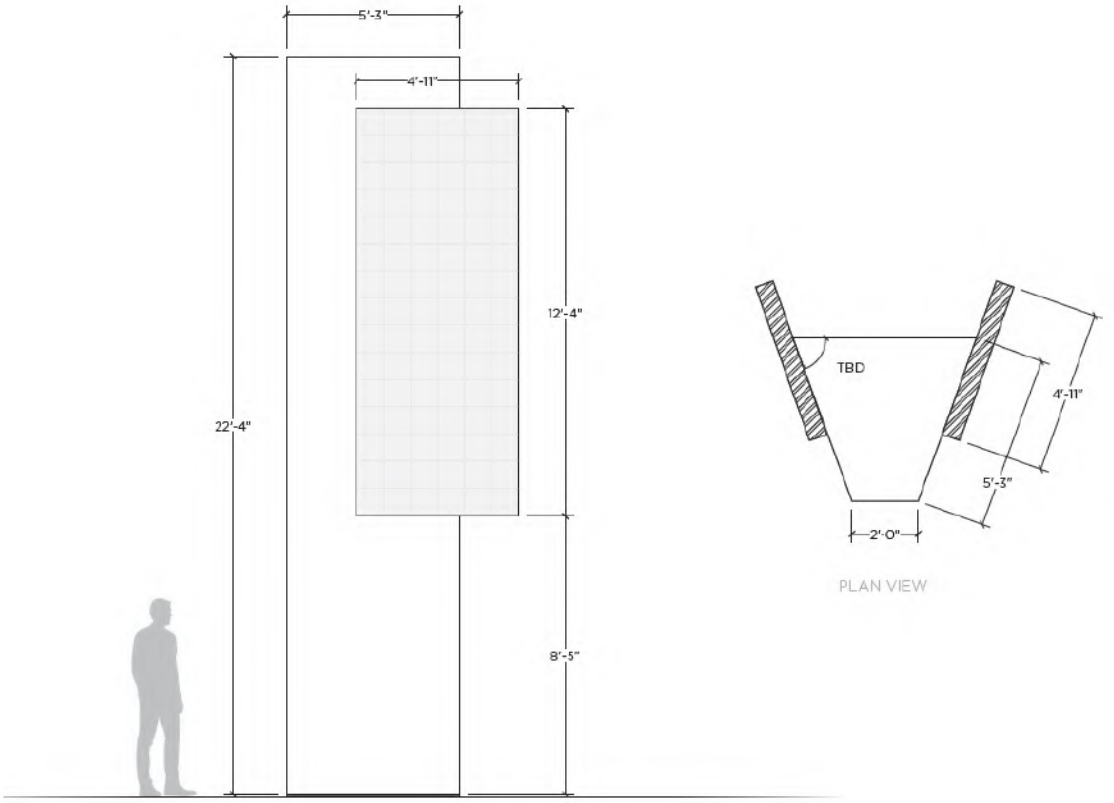
- 5th Avenue and Mercer Street (southwest corner)
- Denny Way and Broad Street (northwest corner)
- 5th Avenue and Harrison Street (northeast corner)

The Draft Seattle Center 2021: Signage Guidelines (February 11, 2021) describe the Campus Readerboards as follows:

> The function of this digital sign type is to communicate information about the activities and events occurring at Seattle Center to vehicular traffic and pedestrians. In addition, this sign type provides a prime opportunity to extend the Seattle Center brand and purpose, and to communicate other messages including sponsorship. The Campus Readerboards use digital LED technology, and are positioned at strategic and highly visible locations facing intersections with sufficient vehicular dwell time to allow a full reading of information on the sign. It has a distinct presence and is large in scale, displaying a unique mix of text, graphics or both.

[1] Environmental review for a sign meeting this description was completed as part of the Seattle Center Arena Replacement Project FEIS Chapter 9 Appendix G and the ordinance was approved by the City Council for the Seattle Center Sign Code District Overlay.

Figure 2 – Proposed Campus Readerboard Dimensions (February 2021)



The proposed signs could contribute to what is already a complex driving environment during events as well as typical peak hour traffic conditions. Motorists are attempting to process a number of attention-seeking variables in the vicinity of the proposed signs including:

- Comply with traffic signals and watch for stopped traffic ahead.
- Be aware of pedestrians in crosswalks and occasionally exiting/entering stopped vehicles in travel lanes.
- Be watchful for bicyclists and buses.
- Process special event traffic management including temporary street signs, traffic control officers, street closures, etc. during large events
- Be thoughtful in selecting appropriate travel lanes or curb space to reach trip destination or complete trip purpose (e.g., pick-up/drop-off at nearby curb, parking, through travel, etc.).

The location, size, and programming may distract drivers as they pass by or wait to proceed through the adjacent intersections. Consistent with Seattle Center's plans for the operation of these signs and SMC 23.55.062.E, these signs will not exercise video capabilities to reduce driver distraction. We recommend that any future signs proposed further than 20 feet from the roadway (that are visible from the roadway) similarly do not exercise video capacities to reduce driver distraction.

Facility Readerboards

Four Facility Readerboards are proposed along Mercer Street between 1st Avenue North and 4th Avenue North. These signs would be a conversion from existing signs with scrolling amber text approximately 4 feet wide, 15 feet high, and 1-foot-deep, to approximately 4 feet wide, 12.5 feet high, and 1 foot deep. The Draft Seattle Center 2021 Signage Guidelines describe the Facility Readerboards as follows:

> This sign type provides enhanced visibility for the resident arts organizations and Seattle Center on Mercer Street, one of the key goals of the Theater District plan. Facility Readerboards are located adjacent to specific facilities and communicate information about that facility, as well as a variety of messages related to campus programming and sponsorships. Facility Readerboards use digital LED technology for maximum messaging flexibility.

The location, size, and programming may distract drivers on Mercer Street. Consistent with Seattle Center's plans for the operation of these signs and SMC 23.55.062.E, these signs will not exercise video capabilities to reduce driver distraction. We recommend that any future signs proposed further than 20 feet from the roadway (that are visible from the roadway) similarly do not exercise video capacities to reduce driver distraction.

A fifth Facility Readerboard is proposed for Fisher Pavilion near the intersection of Thomas Street and 2nd Avenue North. Although the sign would be set back into the interior of campus, it would be visible from the vicinity of the Thomas Street/2nd Avenue North intersection. However, these roadways are local streets with lower speed limits so vehicles would already be traveling slowly particularly as they navigate the right angle turn between Thomas Street and 2nd Avenue. Given the transportation context and the distance of the sign from the roadway, this sign is not expected to result in a safety hazard.

Garage Signage

Multiple signs are proposed to be constructed in or near parking garages. Limited information is provided in the Draft Seattle Center 2021 Signage Guidelines regarding garage signage, and garage signage programming is not mentioned. It is our understanding from communication with Seattle Center that garage signage programming that is intended for the attention of vehicular traffic focuses on parking provisions, such as access and availability and would not use video capabilities. It is likely that drivers will be anticipating the content in these signs and would not be distracted by the imagery. For example, if a garage sign informs drivers how many spaces are available, that is within their expectations of what to see while looking for parking, and similar to a static sign.

Additional Signage

As provided in Table 1 and in the Draft State Environmental Policy Act (SEPA) checklist, a number of digital signs are proposed for construction throughout Seattle Center. While many are not

located adjacent to major roadways where they would be visible to drivers, others are located along lower volume roadways such as Thomas Street and 2nd Avenue North where they would be visible to drivers, but have less potential to distract drivers compared to the higher volume roadways. In addition, curvature of the roadway where Thomas Street and 2nd Avenue North intersect at a right angle, which requires drivers to slow down limiting the potential for a safety hazard. However, during peak travel times before or after an event at the Climate Pledge Arena or other Seattle Center facilities, these signs may distract drivers unfamiliar with the area, navigating heavy pedestrian volumes, and attempting to pick-up or drop-off passengers, such as Transportation Network Companies like Uber and Lyft. Seattle Center should monitor these locations during peak travel times. Monitoring could include reviewing crash data and near-misses and consider operational programming changes such as colors, imagery, and luminance settings. and luminance settings.

As shown in Table 1, the proposed campus wayfinding signs, art walk display signs, and campus pole banners would have video capabilities along 5th Avenue and Broad Street. However, Seattle Center would only operate the videos on faces of the signs that are oriented toward the campus. Sign faces oriented to the adjacent roadways would only operate as digital changing image.

Potential Sign Operations

As stated in SMC 23.55.005.3, the Sign Code would allow for signs within 20 feet of the street curb to use video display if the sign area is less than or equal to 1,000 square inches and no single dimension of the sign exceeds three feet. Though the proposed project does not include such operation, the Sign Code would allow signs meeting those location requirements to use a portion of their screens to meet those size limitations. While any type of video display oriented to the adjacent roadway does have the potential for driver distraction, this type and size of operation is compliant with existing City code. Such operations are unlikely to distract drivers beyond any other typical signage on the roadway and would therefore not substantively increase driver distraction.

Signs that are located more than 20 feet from the street curb would be able to use video display as regulated by proposed SMC 23.55.062.E.4. However, per Seattle Center's Draft Sign Guidelines, any signs that are clearly visible from the ROW would be operated in a way that minimizes driver distraction.

Literature Review

This section summarizes relevant literature on the topic of effects of digital signs on driver distraction. The academic research community and the digital sign and advertisement industries have not developed definitive guidance on all aspects of sign design and operations to address potential traffic safety effects of digital signs. Nevertheless, across the body of available literature, there are several research studies that have similar findings about strategies to reduce driver distraction.

Fehr & Peers previously documented relevant literature on the topic of effects of digital signs on driver distraction in "Technical Memo #9, Seattle Center Arena – Evaluation of Potential Effects of Proposed Digital Sign on Distracted Driving," provided in **Attachment A**. This section builds upon this content and references relevant information for this study.

Relationship Between Signage and Driver Distraction

A comprehensive literature review was performed by SRF Consulting in 2007 on behalf of the City of Minnetonka, Minnesota.[2] Their report concludes that there is a relationship between driver distraction and the presence of active electronic signs. The SRF Consulting Group report also included expert opinion input. One of the experts was Jerry Wachtel, an Engineering Psychologist and highway safety expert who led the Federal Highway Administration (FHWA)'s original 1980 study on electronic billboards. Amongst his various other comments, Mr. Wachtel noted that even though a driver's visual fixation on roadway signs tends to decrease as route familiarity increases, active digital/electronic billboards can continuously deliver new content. Thus, digital/electronic billboards can be much more of a distraction to drivers than static billboards, even to motorists familiar with their surroundings. Mr. Wachtel regularly publishes a Compendium of the latest research on studies on distraction from commercial electronic variable message signs. The latest publication (February 2018) was reviewed but no new major findings were reported related to this study.[3]

In 2009, AASHTO sponsored the study Safety Impacts of the Emerging Digital Display Technology for Outdoor Advertising Signs prepared by Jerry Wachtel. Despite being over a decade old, it remains one of the most recent and referenced reports available that provides guidance on digital billboards to date. As part of the study, Wachtel et al. reviewed 150 other studies and concluded that it was difficult to perform research that was not affected by small sample sizes, human factors, and generalizations.[4]

The 2009 Wachtel report, other recent academic studies, and numerous professional presentations and reports cite a "breakthrough study" conducted in 2006 using data collected over 18 months in a naturalistic setting, tracking the behavior of 100 vehicles equipped with video and sensor devices.[5] The database generated by this study allowed for analysis of factors associated with crashes, near crashes, and critical incidents. A follow-up analysis to the initial study, released by the National Highway Traffic Safety Administration (NHTSA) in 2006, found that distractions causing the driver to glance away from the forward roadway for more than two seconds increased the risk of crashing

---

[2] SRF Consulting Group (2007). Dynamic Signage: Research Related to Driver Distraction and Ordinance Recommendations.

[3] Jerry Wachtel (2018). Compendium of Recent Research Studies on Distraction form Commercial Electronic Variable Message Signs (CEVMS)

[4] Wachtel. J. (2009). "Safety Impacts of the Emerging Digital Display Technology for Outdoor Advertising Signs," NCHRP TRB.

[5] Wachtel (2009) & Klauer, S.G., Dingus, T., Neale, V., Sudweeks, J., & Ramsey D. (2006). "The Impact of Driver Inattention on Near-Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data," USDOT NHTSA.

or having a near crash by at least two times over normal driving.[6] However, the study also found that for drivers reporting drowsiness, the presence of a demanding driving environment resulted in lower crash risk compared to flat and less visually demanding environments.[7] While crash incidence was shown to increase overall with diverted glances longer than two seconds, correlations based on the type and severity of crashes were not included in the study.

A series of Federal Highway Administration (FHWA) commissioned studies comprehensively review the literature on electronic and digital signage, beginning with Wachtel and Netherton in 1980, continuing with Farbry, et al in 2001, and most recently with Wachtel in 2009. A 2007 FHWA memorandum entitled *Guidance on Off-Premise Changeable Message Signs*[8] recommends an 8-second duration of display followed by a 1 to 2 second transition between messages. The memorandum also states "Other standards that the States have found helpful to ensure driver safety include….requirements that a display contain static messages without movement such as animation, flashing, scrolling, or intermittent or full-motion video."

Since the 2009 Wachtel report, several studies that aim to expand understanding of the effects of digital signage on driver distraction and traffic safety have been published. These peer-reviewed studies often use the two-second rule established by the *100 Car Naturalistic Study*, which found that glances of two seconds or greater at electronic signs doubled the risk of crashes or near-crashes.[9]

However, the driving environment is often so complex that, as Wachtel points out, it may be impossible to attribute direct causality between a feature of the external environment and an increase or decrease in the number of traffic collisions.[10] The 2013 FHWA Study (Perez et. Al. 2012), "Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)", concluded that typical eye glance duration for digital signs and standard billboards is usually less than 1.4 seconds.[11]

A 1994 study by the Wisconsin DOT analyzed the effects of introducing a new electronic sign on a high-volume curving roadway.[12] This study was performed to test the hypothesis that introducing a source of distraction in an already demanding driving environment is more likely to result in crashes. The study found that the sign was a likely contributing factor in the 80 percent increase in side-swipe crashes since it was installed. This study is particularly relevant because the driving task

---

[6] Klauer et al. (2006).
[7] Klauer et al. (2006).
[8] Accessed at: http://www.dot.ca.gov/hq/research/researchreports/preliminary_investigations/docs/digital_display_safety_preliminary_investigation.pdf
[9] National Highway Traffic Safety Administration (2006). *Impact of Driver Inattention on Near-Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data.*
[10] Wachtel (2009).
[11] Perez, W.A.; Bertola, M.A.; Kennedy, J.F.; Molino, J.A. (2013) "Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)". Report No. FHWA-HEP-11-014, (2013).
[12] Wisconsin DOT (1994). Milwaukee County Stadium Variable Message Sign Study.

becomes more demanding in urban environments featuring multiple modes of travel and congestion.

Smiley et al. conducted pre- and post-digital billboard installation collision analyses on urban intersections.[13] The study evaluated three intersections with video billboards within the City of Toronto, measuring crashes approximately three years before sign installation and one year after sign installation. Two intersections demonstrated increases in both total and rear-end crashes; the third intersection showed no significant increase in crashes. Due to the small sample size, the results were inconclusive with regards to the overall relationship between the potential for traffic safety impacts due to distracted driving and digital billboards.

Driver distraction and associated risks vary depending on the roadway classification and land use setting or context. Numerous studies states that simple driving-related tasks consume relatively little information processing; however, when additional conditions such as traffic congestion, weather, or complicated roadway geometries exist, the additional distraction of a dynamic sign could lead to driving errors. On urban arterials, in contrast to freeways or rural highways, drivers are exposed to a more complex environment and encounter vulnerable road users such as pedestrians and bicyclists.[14] Perez et al. found that drivers on urban arterials were more likely to look at digital billboard displays for longer durations than drivers on freeways, likely attributed to slower travel speeds. However, long "dwell times" (referring to the length of time a driver's eyes remain on the billboard) on digital billboards were not observed or recorded on urban arterials.[15]

Psychology and Human Behavior

Many of the studies referenced in these reviews establish a theoretical underpinning of the traffic safety concern in human factors research, cognitive science, and the field of psychology. The 2009 Wachtel report reviews 150 academic and industry studies, pointing out the challenges of generalizing findings from any single study, particularly in developing context-specific regulations.[16] A corollary report for the FHWA outlining future research needs in this area states that the available literature is inconclusive, despite a trend of minimal but present safety effects due to digital signage.[17] Wachtel concludes that existing research, along with the established (and intended) cognitive and psychological effects of digital billboards on driver distraction, warrant a conservative approach to developing regulations for digital billboard signage.[18]

---

[13] Beijer & Smiley (2004). Observed Driver Glance Behavior at Roadside Advertising Signs. University of Toronto,
[14] Perez et al. (2013).
[15] Perez et al. (2013).
[16] Wachtel (2009).
[17] Molino, John A., Jerry Wachtel, John E. Farbry, Megan B. Hermosillo, and Thomas M. Granda. (2009). "The Effects of Commercial Electronic Variable Message Signs (CEVMS) on Driver Attention and Distraction: An Update." Federal Highway Administration.
[18] Wachtel (2009).

Similarly, driver characteristics affect the risk of distraction or inattention. Results from a survey given all participating drivers as part of the "100 Car Naturalistic Study" indicated that driver age, experience, self-reported traffic violations and accidents, daytime sleepiness rating, and personality result in significantly different levels of involvement in inattention-related crashes and near crashes.[19] These factors are largely outside the control of the regulatory environment for digital signage.

Page 3-7 of the Highway Safety Manual describes the interactive effects of human factors, roadway factors, and vehicle factors on vehicle crashes.[20] Human factors existing prior to a crash that can contribute to increased crash potential include driver distraction, fatigue, inattention, poor judgment, age, cell phone use, and deficient driving habits. Page 2-13 describes four distracting situations that could lead to failure to detect slowing or stopping vehicles (or pedestrians in a crosswalk) ahead at intersections. One of the four cited sources of distraction is an object of interest on the roadside, such as a roadside advertising sign.

A study commissioned for the City of Seattle in 2001 concluded that dynamic signs contribute to driver distraction for longer intervals than static signs.[21] This report examined how this may be due to the psychological need to follow a task to its conclusion, which is known as the "Zeigarnik Effect". The report also described how this effect is influenced by the delivery and content of the message:

- Scrolling messages of particular importance/interest could result in multiple seconds of distraction depending on its length.
- Sequential image or short video clips that tell a story may also result in longer periods of distraction.
- Anticipation of a new message could cause distraction (even if unrelated to the prior image).

Sign Industry Sponsored-Research

Four key studies have been published with support from the advertising industry, demonstrating no adverse effects from digital billboards.[22] These studies range from more naturalistic experiments with real drivers on real roadways to simulator studies in a laboratory. However, these and similar

[19] Klauer et al. (2006).

[20] American Association of State Highway and Transportation Officials (2010). Highway Safety Manual, 1st Edition

[21] Wachtel, The Veridian Group (2001). Video Signs in Seattle – Final Report

[22] Lee, S. (2007). "Driving Performance and Digital Billboards." Virginia Tech Transportation Institute & Foundation for Outdoor Advertising Research and Education.

Tantala, M. & Tantala, A. (2009). "An Update of a Study of the Relationship between Digital Billboards and Traffic Safety in Cuyahoga County, Ohio," Tantala Associates, Foundation for Outdoor Advertising Research and Education.

Hawkins, K., Kuo, P. and Lord, D. (2012). "Statistical Analysis of the Relationship between On-Premise Digital Signage and Traffic Safety." Texas A&M & The Signage Foundation, Inc.

findings have been refuted by Wachtel, in his 2018 "Compendium of Recent Research Studies on Distraction from Commercial Electronic Variable Message Signs (CEVMS)."

Digital Sign Programming and Luminance

The International Sign Association (ISA) produced guidelines for the "five key regulatory distinctions:" brightness, message hold times, transition method, transition duration, and area/square footage, which have been taken into consideration in developing recommendations in this memorandum.[23]

Some types of movement are considered to be more distracting than other types, such as "flashing, strobing, or racing" effects.[24], [25] The presence of distractions along an urban arterial demands a constant level of attention, which are compromised by video imagery.

According to the Federal Highway Administration (FHWA)[26], disability glare is defined as glare resulting in reduced visual performance and visibility. Disability glare may be more pronounced in older people.[27] Veiling luminance is the prevailing metric used to measure disability glare. It measures the intensity of light scattered within the eye, which causes loss in visual contrast of objects. It impairs a person's ability to see dimmer obstacles, creating a sensation of having a 'veil' over one's head. The veiling luminance threshold is expressed as the ratio of the luminance of the lighting system to the average luminance of the road surface. Therefore, a higher ratio allows for more brightness or visual contrast than a lower ratio. As it represents the ratio of two luminance measurements, this metric does not contain any units.

The FHWA handbook also describes nuisance glare, which results from bright light sources that may cause distraction, drawing the eye to them. Lighting that is used for advertising may cause visual clutter and add complexity to the scene, making the driving task more challenging. Since there is no defined method or measurement system for assessing nuisance glare, it is not evaluated any further in this memorandum.

Another type of glare often mentioned in the literature is discomfort glare, which may accompany disability glare. This type of glare can cause pain/irritability, but does not impair visibility.

---

[23] Carpentier, James, Mike Freeborg and Wendy Moeller. (2014). "Regulating Electronic Message Centers." International Signage Association for the American Planning Association, presented September 24, 2014.

[24] Morris, Marya. (2009). "LED & Video Display Signs: The Next Frontier for Sign Codes." April 25, 2009.

[25] Roberts, Paul. (2013). "Designing evidence-based guidelines for the safe use of digital billboard installations: Experience and results from Australia." Proceedings of the 16th International Conference Road Safety on Four Continents; Beijing, China, 15-17 May 2013.

[26] FHWA Lighting Handbook (2012) accessed at: https://safety.fhwa.dot.gov/roadway_dept/night_visib/lighting_handbook/

[27] The Bartlett School of Graduate Studies, University College London (2013). Disability Glare: A Study in Simulated Road Lighting Conditions Accessed at:
http://journals.sagepub.com/doi/pdf/10.1177/1477153513510168

The WSDOT Design Manual (July 2017) identifies a maximum veiling luminance threshold of 30% for freeway facilities. The City of San Jose, CA applies a 30% threshold to both major and local streets.[28] A 2000 IESNA document suggests using a 30% ratio threshold on "major" surface streets and a 40% threshold on collector and local streets.[29] This same guidance also appears in the Roadway Lighting Handbook (2014) published by the Illuminating Engineering Society (IES).

Best Practices

The following summarizes best practices obtained from the literature for design and operational standards to minimize the potential for driver distraction and traffic safety hazards.

Animation and Movement

Some types of non-video content can be more distracting than other types; these include strobing or racing text and color pairs that may be confused for emergency vehicles. SMC 23.55.03 prohibits flashing signs in all zones, which applies to proposed Seattle Center signage.

Placement and Spacing

Lateral placement should reduce the driver's need to turn their head in order to view the sign by minimizing the angle away from the forward view.[30, 31] Signage should not be placed in spaces that are already visually cluttered or along segments that are highly demanding for drivers based on the geometry of the roadway.[32]

The roadway segment alignments at the Campus Readerboards and Facility Readerboards are generally straight. The inclination for drivers to turn their heads would be considered comparable to other urban elements in the area and therefore not substantively increase driver distraction.

Message Sequencing

Concern about message sequencing developed out of an understanding of the Zeigarnik Effect, which refers to the subconscious compulsion to wait until a message is complete before looking away. For signs with scrolling or sequential messages, this effect may encourage drivers to unexpectedly slow down to see the conclusion of the sequence. [33] Roberts recommends message sequencing should be prohibited.[34]

---

[28] City of San Jose (2016). *City of San Jose Public Streetlight Design Guide* (2016).
[29] Rensselear Polytechnic Institute (2011). Recommendations for Evaluating Street and Roadway Luminaires. Accessed at: http://www.lrc.rpi.edu/programs/solidstate/assist/pdf/AR-RoadwayEvaluation.pdf
[30] Roberts (2013).
[31] Smiley, et al. (2005).
[32] Roberts (2013).
[33] Morris, Marya, John Baker and Daniel Mandelker. (2009). "Regulating Digital Signs and Billboards (S606)." APA National Conference, presented April 28, 2009.
[34] Roberts (2013).

SMC 23.55.062.E requires ten seconds of still image or blank display following every message using a video display method.

Message Hold Time/Refresh Rate

Message hold time refers to the length of time a message must remain fixed before transitioning to another message.[35] The FHWA recommends an eight-second duration of display. SMC 23.55.062.E requires a minimum duration of two seconds and a maximum duration of ten seconds. Calculation of the duration does not include the number of frames per second used in a video display. SMC 23.55.062.E.10 prohibits signs that are flashing or that rotate or have a rotating or moving part or parts that revolve at a speed in excess of seven revolutions per minute, which equates to a minimum message hold time of approximately 8.5 seconds.

SMC 23.55.003.A.2 prohibits signs that rotate or have a rotating or moving part or parts that revolve at a speed in excess of seven revolutions per minute. This is consistent with FHWA recommendation of 8 second duration. Draft code SMC 23.55.062.E requirement for minimum 2 seconds/ maximum 10 seconds refers to video display. (Comment by Julia Levitt)

Transition Method & Duration

Transition method refers to the way in which one message changes to another message.[36] This transition can occur instantaneously, via a dissolve effect, or through some other motion-dependent effect. Roberts recommends transition method should be instantaneous in order to minimize the potential for involuntary distraction or prolonged driver dwell time.[37]

The FHWA recommends the transition is kept between 1-2 seconds.[38] Similarly, industry standards recommend transition duration specifically for Electronic Message Centers is kept to a maximum of one second.[39]

Sign Luminance

We understand that the new signs will have more capability to adjust screen luminance than the existing signs, which can be utilized to evaluate the veiling luminance ratio. As described in the Literature Review section, multiple industry groups as well as WSDOT recommend a 30% veiling luminance ratio.

Conclusion

Based on the transportation context and literature review, there is no clearly defined or adjudicated threshold for a transportation safety impact from digital signage. However, the literature is clear that the proposed signage's size, operation, and programming could cause driver distraction, which could adversely affect roadway safety. However, several important design and operational

[35] Carpentier, et al. (2014).
[36] Carpentier, et al. (2014).
[37] Roberts (2013).
[38] FHWA. (2007). "Guidance on Off-Premise Changeable Message Signs." Policy and Guidance Memorandum, issued September 25, 2007. Updated 9/5/2014. <http://www.fhwa.dot.gov/real_estate/oac/policy_and_guidance/offprmsgsnguid.cfm>
[39] Carpentier, et al. (2014).

characteristics were identified through the literature review to support the reduction of driver distraction. Incorporating these practices into the proposed Sign Code and/or Sign Guidelines would limit distracting features.

Attachments

Attachment A – Technical Memo #9, Seattle Center Arena – Evaluation of Potential Effects of Proposed Digital Sign on Distracted Driving

FEHR PEERS

TECHNICAL MEMORANDUM #9

Date: July 19, 2018

To: Molly Adolfson & Claire Hoffman – ESA

From: Fehr & Peers

Subject: ***Seattle Center Arena – Evaluation of Potential Effects of Proposed Digital Sign on Distracted Driving***

SE17-0562

Background

The proposed project includes a 15 foot by 20 foot digital sign that would be situated within the plaza area facing 1st Ave N. On non-event days, it would operate from 7 AM to 10 PM. During events, its operating hours would extend up to one hour after the event concludes. The digital sign would display video content up to 20 seconds in length before there is a still or blank image.

Chapter 9 (Visual Resources) of the *Seattle Center Arena Renovation Project Draft EIS* included a detailed evaluation of the potential for this sign to impair driver safety caused by driver distraction and glare (i.e., the sign's brightness contrasting with the darker surrounding ambient nighttime light conditions, making it difficult for drivers to see darker objects such as pedestrians). These impacts were found to be potentially significant.

This memorandum provides an independent review of that assessment based on our own literature review. This memorandum also includes an evaluation of the digital sign's expected luminance and its potential to create glare, which could affect traveler safety.

Sign Definitions

This section describes the main types of advertising signs currently in use along roadsides. Signs generally range from least to most sophisticated according to:

- Static Signs (i.e., a single image only altered by replacing it with another).
- Tri-Vision Signs (i.e., a series of images are presented through mechanical rotation of multi-sided vertical strips).
- Scrolling Text/Image Signs (i.e., display of multiple static pieces of digital content).
- Video Signs (i.e., full motion, brilliant colors, and a readable display of video).

Static signs are considered 'passive', while the other three are considered 'active' or 'dynamic'. Active or dynamic signs can display multiple messages in sequences. These signs may also be referred to as: changeable message signs, electronic/digital billboards, animated signs, or digital reader boards.

Literature Review

This section summarizes relevant literature on the topic of effects of digital signs on driver distraction.

Page 3-7 of the *Highway Safety Manual* describes the interactive effects of human factors, roadway factors, and vehicle factors on vehicle crashes.[1] Human factors existing prior to a crash that can contribute to increased crash potential include driver distraction, fatigue, inattention, poor judgment, age, cell phone use, and deficient driving habits. Page 2-13 describes four distracting situations that could lead to failure to detect slowing or stopping vehicles (or pedestrians in a crosswalk) ahead at intersections. One of the four cited sources of distraction is an object of interest on the roadside, such as a roadside advertising sign.

A 2004 University of Toronto study found that active signs attract more than twice as many glances as static signs. Moreover, Video and Scrolling Text Signs received the longest average maximum glance duration. [2]

A study commissioned for the City of Seattle in 2001 concluded that dynamic signs contribute to driver distraction for longer intervals than static signs.[3] This report examined how this may be due to the psychological need to follow a task to its conclusion, which is known as the "Zeigarnik Effect". The report also described how this effect is influenced by the delivery and content of the message:

- Scrolling messages of particular importance/interest could result in multiple seconds of distraction depending on its length.
- Sequential image or short video clips that tell a story may also result in longer periods of distraction.
- Anticipation of a new message could cause distraction (even if unrelated to the prior image).

A 2006 study using instrumented vehicles found that glances of two seconds or greater at electronic signs doubled the risk of crashes or near-crashes.[4]

A 1994 study by the Wisconsin DOT analyzed the effects of introducing a new electronic sign on a high-volume curving roadway.[5] This study was performed to test the hypothesis that introducing a source of distraction in an already demanding driving environment is more likely to result in crashes. The study found that the sign was a likely contributing factor in the 80 percent increase in side-swipe crashes since

---

1 *Highway Safety Manual, 1st Edition* (American Association of State Highway and Transportation Officials, 2010).

2 *Observed Driver Glance Behavior at Roadside Advertising Signs* (Beijer & Smiley, University of Toronto, 2004).

3 *Video Signs in Seattle – Final Report (*Wachtel, The Veridian Group, 2001).

4 *Impact of Driver Inattention on Near-Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data* (National Highway Traffic Safety Administration, 2006).

5 *Milwaukee County Stadium Variable Message Sign Study* (Wisconsin DOT, 1994).

it was installed. This study is particularly relevant because the driving task becomes more demanding in urban environments featuring multiple modes of travel and congestion.

A comprehensive literature review of these and many of other studies was performed by SRF Consulting in 2007 on behalf of the City of Minnetonka, Minnesota.[6] Page 25 of their report concludes that there is a relationship between driver distraction and the presence of active electronic signs.

The SRF Consulting Group report also included expert opinion input. One of the experts was Jerry Wachtel, an Engineering Psychologist and highway safety expert who led the Federal Highway Administration (FHWA)'s original 1980 study on electronic billboards. Amongst his various other comments, Mr. Wachtel noted the even though a driver's visual fixation on roadway signs tends to decrease as route familiarity increases, active digital/electronic billboards can continuously deliver new content. Thus, digital/electronic billboards can be much more of a distraction to drivers than static billboards, even to motorists familiar with their surroundings.

A 2007 FHWA memorandum entitled *Guidance on Off-Premise Changeable Message Signs*[7] recommends an 8-second duration of display followed by a 1 to 2 second transition between messages. The memorandum also states "Other standards that the States have found helpful to ensure driver safety include….requirements that a display contain static messages without movement such as animation, flashing, scrolling, or intermittent or full-motion video." Therefore, these recommendations may not be directly applicable to the proposed sign given its planned display of video material.

Regulatory Approach

Numerous public agencies include regulatory requirements (i.e., sign ordinances) governing the placement, design, and operation of digital/electronic billboards. Seattle Municipal Code (SMC) 23.55.005 addresses video display methods including sign location, size, luminance (i.e., brightness), hours of operation, and minimum/maximum length of video messages.

The design and operation of the proposed project's signs would not comply with multiple components of SMC 23.55.005, specifically:

- It would exceed the maximum allowable 1,000 square inches in size.
- Its maximum height above grade would exceed the maximum allowable 15 feet.

---

6 *Dynamic Signage: Research Related to Driver Distraction and Ordinance Recommendations* (SRF Consulting Group, 2007).

7 Accessed at: http://www.dot.ca.gov/hq/research/researchreports/preliminary_investigations/docs/digital_display_safety_preliminary_investigation.pdf

- Its proposed delivery of video content would exceed the maximum of five seconds for a given message.
- The required pause between messages would be reduced from 20 seconds of still image to 10 seconds of still image.
- The proposed nighttime luminance of video displays would exceed 500 nits (candelas/m^2)

The proposed digital sign on 1st Ave N would further contribute to what is already a complex driving environment during events. Motorists are already attempting to process a number of attention-seeking variables including:

- Comply with traffic signals and watch for stopped traffic ahead, including the potential for unexpected stops caused by vehicles dropping off passengers in-lane.
- Be aware of pedestrians in crosswalks and occasionally exiting/entering stopped vehicles in travel lanes.
- Be watchful for bicyclists and buses on 1st Ave N.
- Process special event traffic management including temporary street signs, traffic control officers, street closures, etc.
- Be thoughtful in selecting appropriate travel lanes or curb space to reach trip destination or complete trip purpose (e.g., pick-up/drop-off at nearby curb, parking near arena, through travel, etc.).

In transportation, the local context is always important to consider. Transportation solutions are not one size fits all. A digital video sign proposed on a modestly traveled suburban street with few other visual distractions represents a much different condition than what is/will be present on 1st Ave N if the proposed project is developed. Considering another context, a digital video sign on the Las Vegas Strip as part of an environment that is saturated with distraction is also a much different condition than what will be present near the arena site.

Digital Sign Luminance

Fehr & Peers was asked to review an evaluation performed by RWDI regarding the likely effects of the proposed digital sign on nighttime disability glare and driver safety. According to the Federal Highway Administration (FHWA)[8], disability glare is defined as glare resulting in reduced visual performance and visibility. Disability glare may be more pronounced in older people.[9]

---

[8] *FHWA Lighting Handbook* (2012) accessed at: https://safety.fhwa.dot.gov/roadway_dept/night_visib/lighting_handbook/

[9] *Disability Glare: A Study in Simulated Road Lighting Conditions* (The Bartlett School of Graduate Studies, University College London, UK, 2013) Accessed at: http://journals.sagepub.com/doi/pdf/10.1177/1477153513510168

Veiling luminance is the prevailing metric used to measure disability glare. It measures the intensity of light scattered within the eye, which causes loss in visual contrast of objects. It impairs a person's ability to see dimmer obstacles, creating a sensation of having a 'veil' over one's head. The veiling luminance threshold is expressed as the ratio of the luminance of the lighting system to the average luminance of the road surface. Therefore, a higher ratio allows for more brightness or visual contrast than a lower ratio. As it represents the ratio of two luminance measurements, this metric does not contain any units.

The FHWA handbook also describes nuisance glare, which results from bright light sources that may cause distraction, drawing the eye to them. Lighting that is used for advertising may cause visual clutter and add complexity to the scene, making the driving task more challenging. Since there is no defined method or measurement system for assessing nuisance glare, it is not evaluated any further in this memorandum.

Another type of glare often mentioned in the literature is discomfort glare, which may accompany disability glare. This type of glare can cause pain/irritability, but does not impair visibility.

As mentioned in the RWDI study, the *WSDOT Design Manual* (July 2017) identifies a maximum veiling luminance threshold of 30% for freeway facilities. The RWDI study cites a 2005 IESNA report as providing guidance for using a 40% threshold for City streets, based on its use on city streets in the United States. As a point of clarification, a 40% threshold allows for more brightness or visual contrast than a 30% threshold.

The following summarizes our review of pages 9 – 14 of the RWDI memo, which pertain to nighttime glare.

- Sufficient justification is not provided for the 40% veiling luminance ratio threshold for city streets.
    - Our literature review did not identify any specific cities that have applied this standard (though that is not to say that a more exhaustive review could not identify some). However, we did identify the City of San Jose, CA as one such agency that applies a 30% threshold to both major and local streets.[10]
    - A 2000 IESNA document suggests using a 30% ratio threshold on "major" surface streets and a 40% threshold on collector and local streets.[11] This same guidance also appears in the *Roadway Lighting Handbook* (2014) published by the Illuminating Engineering Society (IES).
- The RWDI analysis rightfully acknowledges many of the variables that could influence the sign's actual veiling luminance such as the presence/foliage of street trees, car headlights, greater ambient exterior lighting, and the presence/absence of moonlight. The RWDI conclusion on page

---

10 *City of San Jose Public Streetlight Design Guide* (2016).

11 *Recommendations for Evaluating Street and Roadway Luminaires* (Rensselear Polytechnic Institute, 2011). Accessed at: http://www.lrc.rpi.edu/programs/solidstate/assist/pdf/AR-RoadwayEvaluation.pdf

13 that "these elements would brighten a driver's environment and likely decrease the luminance ratio to an acceptable level" may be true, but is not supported by citations or evidence.

- Page 13 of the RWDI report cites the speed of travel along 1st Ave N and the presence of the sign in a motorist's peripheral vision as 'further reducing the risk of glare'. However, as can be observed during a large event at Key Arena and as reported in the *Seattle Center Arena Renovation Project Draft EIS*, motorists on 1st Ave N routinely experience lengthy delays and stop-and-go traffic, which is counter to this mitigating assertion of the effect being transient.

Based on this independent literature review and assessment of site conditions, Fehr & Peers concurs with the findings of the *Seattle Center Arena Renovation Project Draft EIS* that the project's proposed digital sign size and operation could cause driver distraction, which could adversely affect roadway safety. Below are several potential recommendations (based on our literature review) and next steps to reduce the severity of this impact.

Recommendations and Next Steps

- Any video content should be no longer than two to five seconds in length (and preferably on the shorter side of that range) and have static breaks between content. The recommended maximum length of video content should consider the prevailing research conclusion that driver fixations on signs that exceed two seconds increases crash risk. A static break between successive videos is needed to ensure that motorists do not remain fixated on the sign.

- With respect to digital sign luminance, the following recommendations are offered:
    - Collect additional data during an evening event at Key Arena so that multiple luminance conditions can be evaluated (i.e., both without and with frequent vehicle taillights). Additional analysis that considers the effects of enhanced street lighting associated with new traffic signals on 1st Ave N at Thomas St and John St should also be performed.
    - If evidence cannot be provided to substantiate a 40% veiling luminance ratio threshold for 1st Ave N, then a 30% threshold should be used.
    - If the updated lighting analysis shows a veiling luminance ratio well above 30%, then RWDI recommendations relating to a variable brightness system should be considered. Other measures related to the sign placement, size, orientation, and content may also need to be considered.