SEATTLE COORDINATED STREET FURNITURE PROGRAM: HUMAN FACTORS CONSIDERATIONS

Report submitted to Seattle Department of Transportation

by
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BACKGROUND:

The City of Seattle, Washington wishes to develop and implement a coordinated street furniture program that will incorporate state-of-the-art interactive street-side information kiosks for public use. These kiosks will include internet-connected computer terminals providing information about city services and events, and will provide cost-free Internet access to the general public. As such, this program promises to offer a new, "high tech" public amenity to residents and visitors alike. The cost and maintenance of these kiosks will be funded, in part, by the incorporation of advertising messages on the kiosks, some of which will include LED signage with messages that change every several seconds. The kiosks will also have the potential to display images in full motion video. As a result of these bright, frequently changing digital displays, the kiosks have the potential to distract drivers, bicyclists, and pedestrians, and thus raise traffic safety concerns. Because these kiosks will be predominantly located in a dense urban environment, there are, of course, an untold number of existing distractions that raise equal or greater concerns. Such existing distractors include, but are not limited to: buses and taxis with side or roof top advertising, storefront and other on-premise signs and advertisements, uncontrolled entrances to and exits from businesses and parking facilities, street-side banners and flags, sidewalk vendors, food trucks, etc. Although the additive distraction from the proposed kiosks is likely to be small, the city wishes to ensure that any such distraction that might result from the new Coordinated Street Furniture Program is reduced to the extent possible, to minimize any possible risks to public safety.

GENERAL:

The Veridian Group was asked to evaluate, from a human factors perspective, the street-level display screens that are a key component of the city's proposed Coordinated Street Furniture Program, with specific regard to concerns about possible driver and other street-user distraction, and to suggest ways to minimize these concerns.

We note at the outset that these potential signs, if visible to drivers, cyclists and pedestrians *will* cause distraction – there is no getting around that. The question is how to minimize the level of distraction to acceptable levels.

A series of studies at University of Massachusetts, Amherst (4, 6), suggest that outside-the-vehicle distractions are as dangerous, if not more so, than in-vehicle distractions. This is because, with in-vehicle distractions, the driver is aware that he has taken his eyes off the road, whereas, when attending to an outside distracter such as a sign or billboard, the driver tends to think that he maintains a view of the road in his peripheral vision and can therefore respond to incidents that may arise; this research, however, demonstrates that such response is compromised.

The small size of the city's proposed signs is, to some extent, offset by their likely proximity to the drivers' eyes. Let's assume we have a 12 ft. wide lane and a 6 ft. wide car (with the driver's eye 2 ft. from the left edge of the car) centered in the lane. The driver's eye is thus approximately 5 ft. to the right of the left lane edge, and 7 ft. to the left of the right lane edge. Let's also assume an 8 ft. wide curb/parking lane, and a 48 in. wide sign that stretches from 24 in. to 72 in. from the curb. If we project out a cone of vision for the driver, such signs would occupy the same extent of the driver's visual field as a 48 ft. wide highway billboard seen from approximately 550 ft. away.

PEDESTRIAN VS. VEHICLE ORIENTATION:

In response to our initial questions, the city responded "we can limit text and graphic size for intended audience of pedestrians and transit patrons." The city also said (Email dated 3/7/16 from B. Henry) that the program will: "upgrade all downtown/SLU bus shelters and add *pedestrian technology kiosks* (italics ours) on streets in downtown." City correspondence further said (B. Henry [3/7/16]) that these signs were to be pedestrian oriented. If that is what is intended, there are several ways to achieve this:

- by shielding the individual LED sources from the driver's approach side
- by mounting the LEDs within the cabinet at an angle to the street such that light fall-off makes them nearly invisible to drivers
- by redesign of the kiosk itself so that the display panels are not perpendicular to the curb line, but rather offset by a certain angle to face away from traffic and toward pedestrians.

We suggest that the city consider requiring the displays to be oriented away from drivers' eyes by shielding or angling the actual LED elements or by requiring that the display screen itself be angled away from the street and toward the sidewalk.

VIDEO OR STATIC IMAGES:

Studies of simulated video billboards show that they are more distracting to drivers than signs with static images (5, 14).

In response to our questions, the city responded "no interval, no transitions, no motion or simulated motion, immediate change only" and "no video, static only on digital monitors." But in a city email to us (B. Henry, 6/8/16), a link was provided to *"intersection.com"* with displays referred to as "limited motion." This suggests that motion for these displays is under consideration, and this raises a safety concern.

Although some of the video images on the *intersection.com* website appear to have minimal attention-getting content (e.g. dripping water), others encourage the driver to look for extended periods (e.g. Sephora). This takes advantage of the Zeigarnik Effect* to hold the viewer's attention for longer intervals in order to present a longer or more complex message. Further, some of these exemplar images demonstrate message sequencing – where multiple changes of the image are used to communicate the complete message. Each of these uses of video adds an additional layer of potential distraction, and the city should consider prohibiting message sequencing or video clips lasting longer than a certain agreed-upon maximum duration (discussed later in this report).

If video imagery is to be used, we suggest that the city consider setting a maximum duration for each video clip and a minimum blank screen period between each successive clip. In addition, we recommend that the city consider prohibiting message sequencing for both static and video imaging.

RELATIONSHIP TO OFFICIAL TRAFFIC CONTROL DEVICES:

A series of studies by Holahan and his colleagues in the 1970s (10) documented concerns with billboards at urban intersections.

Displays that are visible to motorists at the same time as traffic control devices (TCDs - primarily traffic signals, Stop signs, Yield signs) were found to delay the motorist's responses to such TCDs. In addition, the authors concluded that displays should not be permitted to depict any images that could be mistaken for such official traffic control devices.

Because they are likely to be placed close to eye level for drivers, the proposed display kiosks run the risk of obscuring official signs and signals, driveway entrances, etc. If possible, signs should not be permitted to visually block or obscure official traffic signs or signals, or signs that identify driveway or garage entrances or exits.

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* The Zeigarnik Effect, originally identified by psychologist Bela Zeigarnik in 1924, refers to the human need for completion and closure, and consequent discomfort about being unable to complete a task such as viewing an advertisement that unfolds over time. The Zeigarnik Effect is widely employed in the field of advertising to capture the viewer's attention for extended periods of time (8).

We suggest that the city consider not permitting display faces to block or obscure official traffic control devices or signs identifying the exit or entrance to parking facilities. We further suggest that the city consider prohibiting displays that could be viewed at the same time as official traffic control devices, as well as the display of any image that could be confused with a traffic control device.

LIGHTING, BRIGHTNESS, GLARE:

In a research paper prepared on behalf of the on-premise advertising sign industry, Kuhn, Garvey, and Pietrucha concluded that nighttime sign luminance should be between 30 and 75 candela per square meter (cd/m^2, also known as "nits"), and went on to state: "falling below or exceeding recommended nighttime luminance values will result in a loss of legibility distance" (11, p. 86). Other experts have offered similar recommendations with regard to nighttime sign luminance.

In an unpublished manuscript, David M. Keith, a Fellow of the Illuminating Engineering Society of North America (IESNA), commented on Colorado DOT's proposal to establish 300 cd/m^2 as the upper limit for digital billboard luminance. Keith wrote: "This is excessive. … The proposed level corresponds to 200 to 300 times the luminance recommended for the brightest roadways, over ten times as bright as what is recommended by IESNA for the brightest objects in view. A significant portion of the population – including older drivers and anyone who has been through RK or corneal surgery – have reduced visual performance, particularly high sensitivity to glare and delayed recovery from looking at bright lights. Excessive sign brightness by itself can become glare and so create problems. These proposed limits for digital billboard brightness are too high and if applied would create glare and reduce visual performance and so decrease public safety."

Measurements of nighttime luminance of conventional (floodlit) billboards in several U.S. jurisdictions by ourselves and others demonstrate that they rarely exceed luminance levels of 100 cd/m^2 (3, 7). We believe, therefore, that there is no reason why the city's proposed signs need to be as bright as 400 nits at night. The other comparison should be to traffic signals – the city likely has a standard for their luminance level – kiosk signs should not be brighter than this. Research shows that the human eye is unconsciously drawn to the brightest objects in the field of view. In downtown traffic, we do not believe that it is appropriate that these brightest objects be advertisements.

Bullough and Skinner, working on behalf of the New York State Department of Transportation, concluded a laboratory and field research effort by stating; "sign luminances of no more than 100 cd/m^2 were found to optimize legibility and acceptability, even when competing signs were present" (3, p. 6).

If the city sets firm luminance limits for displays within its Coordinated Street Furniture Program, it can avoid the need to conduct periodic inspections of the signs

by requiring the program vendor to certify that they meet the requirement, and then performing spot checks on a random or complaint-driven basis.

We do not know whether any of the proposed displays will be located near residences. If this is the case, the city should consider studying whether light trespass from the signs would affect nearby residents, and, if this is found to be the case, consider a requirement that the light from these signs be aimed or shielded such that this light trespass is minimized or eliminated.

We recommend that the city consider setting an upper bound for display face nighttime luminance of 100 cd/m^2, and consider requiring the vendor to certify that all of its signs comply with this criterion. We further recommend that the city consider evaluating displays that may be located in residential areas for light trespass to nearby windows and requiring that any such displays be shielded or angled in such a way as to minimize or eliminate this unintended consequence.

LATERAL CONTROL:

Three recent research studies [one in Australia (16), one in the U.S. (17), and one in Saudi Arabia (2)] have shown that distraction from roadside billboards causes lateral displacement of vehicles, even *after* the driver has passed the billboards. This suggests a potential cause for concern with locating these signs on two-way roadways and on roadways with unprotected bicycle lanes adjacent to vehicle lanes of travel.

Several streets within the downtown and SLU area being considered for display installation under the Coordinated Street Furniture Program are described as having bicycle lanes "in street (with) minor separation (from traffic)." Assuming that such minor separation implies only a traditional (four to six in.) longitudinal pavement marking to delineate the lane separation, we are concerned about the placement of signs on kiosks or bus shelters on these streets given their attendant risks of drivers' compromised lane control. Since drivers tend to steer where they are looking, there is a risk of vehicular traffic steering in the direction of the signs on the sidewalk; this is of greater concern when there is the presence of two-way traffic or adjacent bicycle lanes with no physical separation from vehicular traffic. Such locations include, for example, portions of Second Avenue, East Pine Street, and Yesler Way. Streets with "protected bike lanes" such as Broadway, lower Second Avenue, and Dexter Avenue, do not raise this concern.

In lieu of a physical separator to protect adjacent bike lanes (curb or barrier), reasonable mitigation might be achieved by freshly painted lane line markings that are wider than standard, perhaps as wide as eight or 12 in., or by placing a double line in such locations. The Federal Manual of Uniform Traffic Control Devices for Streets and Highways (MUTCD, 13) sets a standard for longitudinal pavement markings that prohibit or discourage crossing, and defines a normal line as "100 to

150 mm (4 to 6 in) wide." It further defines a "wide line" as "at least twice the width of a normal line. The width of the line indicates the degree of emphasis" (16, 3A-3). The MUTCD also allows the provision of a double line, which consists of two normal lines separated by a discernible space. "A double line indicates maximum or special restrictions."

We cannot discern from the information provided by the city whether certain two-way streets have physical dividers separating directional traffic. For those that don't, we suggest that the city consider not placing signs on both sides of the street where there may be bus shelters or kiosks directly opposite one another. For example, on Third Avenue between Cedar and Vine Streets, and again between Lenora and Virginia Streets.

We believe that satisfactory mitigation from the risks of possible vehicle lateral deviation in the presence of kiosk or bus shelter-mounted signs can be achieved by freshly painted wide longitudinal lane line markings, or double lane line markings where space permits, and we suggest that the city consider the use of such pavement markings. We further suggest that the city consider not permitting the placement of signs on both sides of a street where bus shelters or kiosks are located directly opposite one another.

LONGITUDINAL PLACEMENT OF SIGNS:

Speed Limits in the program area are predominantly 30 MPH (44 fps). Research (although not universal) shows that when a driver takes his eyes off the road for two seconds or longer, the crash rate increases by a factor of nearly three. Several studies have shown that a small, but significant percentage of participants look at digital billboards for two seconds or longer (12), and a recent on-road study in Denmark (9) found such behaviors even when headways to a lead vehicle in the traffic stream were less than 1.5 seconds. Allowing for a two-second margin of error, this data suggests that we should not allow signs within 88 ft. upstream of intersections or driveway entrance/exits from businesses, commercial parking lots or garages. Adding a reasonable driver perception-reaction time (PRT) of 0.75 seconds, we would add an additional 33 ft. to this safety distance, with the result that such signs would not be placed closer than 120 ft. from intersections or driveways.

We recommend that the city consider not permitting signs to be located within 120 ft. in advance of intersections or driveways. This separation distance will assist, not only vehicle drivers, but potentially distracted pedestrians and bicyclists as well.

DWELL TIME:

A recent Canadian study (15) developed proposed guidelines that suggest that digital signs "emulate" static billboards. This means that they should be no brighter

than conventional billboards (which rarely exceed 100 nits at night), and that they should appear static to the extent possible, to any given motorist. This suggests establishing a minimum dwell (image display) time such that no driver (in free flowing traffic) could see more than one message change – this is less of a concern in stop-and-go traffic where drivers have more time to visually take-in the environment while not moving.

It is difficult to establish a uniform recommended minimum dwell time given the differences in sight distance to and character size within each potential sign, as well as the periodicity of traffic flow through the city. If we assume free-flowing traffic (since motorists have more time to read the signs in stop-and-go traffic), and a speed of 30 MPH, and if we assume a sign with 8 in. high letters and characters, which can be read from a distance of 240 ft. (the common roadway standard is 30 ft. of readability distance for each one in. of character height), we should set minimum dwell time at six seconds (240 ft. divided by 44 ft. per second of travel = 5.45 seconds). Thus, the city's proposal of "a minimum change rate of 7 seconds for static images" is reasonable under the urban conditions likely to be present.

We agree with the city's minimum seven (7) second dwell time, and we suggest that the city consider a requirement that the change from one static message to the next be completed instantly, with no transition effect of any kind from one displayed image to the next.

CONCLUSION:

The city of Seattle is developing a leading-edge coordinated street furniture program that will provide no-cost, advertising-funded, information displays and kiosks featuring public Internet access. This program promises to offer new, valuable amenities to Seattle residents and visitors alike. The proposed advertising signs that will support the program, however, bring with them the potential for driver, bicyclist, and pedestrian distraction that could compromise public safety. A series of mitigations, discussed in this report, should reduce such risks to acceptable levels, given the program's promised benefits.

There is no way to eliminate all of the risk of driver distraction from the proposed signs without either orienting the signs toward the sidewalk and away from the vehicular traveled lanes, or constructing the sign infrastructure such that individual LEDs are angled away from the roadway or shielded to avoid visibility to vehicular traffic. Short of these measures, which would be likely to fully mitigate the driver distraction potential of these signs, the measures suggested for consideration in this report would be likely to achieve the greatest possible reduction in distraction potential from these signs, and should enable them to be deployed in the safest manner possible.

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