UNITED STATES DISTRICT COURT FOR THE
SOUTHERN DISTRICT OF NEW YORK

AMERICAN COUNCIL OF THE BLIND OF NEW YORK, INC., MICHAEL GOLFO, AND CHRISTINA CURRY, on behalf of themselves and all others similarly situated,

Plaintiffs,

-against-

THE CITY OF NEW YORK, NEW YORK CITY DEPARTMENT OF TRANSPORTATION, BILL DE BLASIO, in his official capacity as Mayor of the City of New York, and POLLY TROTTENBERG, in her official capacity as Commissioner of the New York City Department of Transportation,

Defendants.

No. 18-CV-5792 (PAE)

AMENDED EXPERT REPORT OF JANET M. BARLOW

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I. QUALIFICATIONS

I am Janet M. Barlow, a Certified Orientation and Mobility Specialist ("COMS") who worked for over 25 years at the Center for the Visually Impaired in Atlanta, Georgia, teaching independent travel skills to individuals who are blind or have low vision. My work with the Center for the Visually Impaired involved providing instruction to individuals who had recently lost their vision in use of a white cane, orientation and listening skills, sidewalk travel, street crossings, and bus and rapid transit travel skills and techniques.

In the early 1990s, I started working with traffic engineers as I began to understand the computerized functioning of traffic signals and realized that signal changes were fundamentally affecting the safety of the typical techniques used by blind pedestrians in crossing streets. I began researching accessibility of street crossings, moving full time into research work in 2001 with two projects on accessible pedestrian signals ("APS"): one as part of a National Eye Institute research project, *Blind Pedestrians' Access to Complex Intersections*, and the National Cooperative Highway Research Program ("NCHRP") Project 3-62, *Guidelines for Accessible Pedestrian Signals*.

I have continued to research street crossing techniques and treatments to provide access to pedestrians who are blind or have low vision with research on roundabouts, shared streets, and use of guidance surfaces. My projects have been sponsored by Federal Highway Administration, the NCHRP, Transit Cooperative Research Program, National Institute on Disability, Independent Living and Rehabilitation Research, and the National Eye Institute of the National Institutes of Health.

In addition, I've consulted with cities, including New York City, and traffic engineering firms on the design of street crossing facilities. As part of NCHRP Project 3-62, I co-led a training course about APS in New York City on October 4, 2011, jointly hosted by the New

York City Department of Transportation ("NYC DOT") and the Mayor's Office for People with Disabilities. Attendees ranged from NYC DOT employees, local orientation and mobility agencies, and local blind consumers. Because the majority of New York City's intersections are pre-timed with a large number of residences near busy intersections, it presented an opportunity to discuss some of those issues with individuals working on APS installations in New York City. Prior to the course, the project team took a tour of some of the recently installed APS units at several downtown intersections. Most recently, on October 23, 2015, I was part of a workshop in New York City titled "Panel Discussion and Q&A on Increasingly Complex Intersections with Environmental Accessibility Experts" sponsored by the Pedestrians for Accessible and Safe Streets ("PASS") Coalition.

In addition, I consulted with NYC DOT from August 2012 to June 2014 on the development of updated designs to enhance access to pedestrian plazas for people who are blind or have low vision. The tasks included providing expertise in issues and design concepts affecting this population and serving as a facilitator in meetings, workshops, and site visits for people who are blind or have low vision to develop design treatments to enhance the accessibility of plazas.

My C.V., attached as Exhibit A, includes the two cases in which I have testified as an expert witness at deposition and trial. It also includes research in which I have been involved related to standards for APS. Attached as Exhibit B is a list of the documents and sources I consulted in preparing this report.

II. SCOPE OF WORK

I have been retained by Plaintiffs' counsel, Disability Rights Advocates, in this litigation to explain the following:

a) how blind and low vision pedestrians navigate streets generally, by describing common street crossing techniques;

b) how APS work, including identifying how blind pedestrians use APS in the context of common street crossing techniques;

c) how the New York City environment and/or its policies and practices would affect the ability of blind pedestrians to navigate the city;

d) the intended purpose of the NCHRP Prioritization Tool, which is the basis of the tool currently used by the NYC DOT in its APS program; and

e) the availability and viability of future street-crossing technologies intended to aid blind pedestrians.

For my work on this matter, I am being compensated at an hourly rate of $150 per hour for reporting and consultation, $250 per hour for testimony for or during a deposition or trial, including preparation, plus reimbursement of expenses. I have no financial interest in the outcome of this matter.

III. METHODOLOGY

In preparing this report, I relied on my knowledge gained over my more than 25 years of work on APS, information gleaned from participation in the numerous presentations I have delivered to groups such as the American Council of the Blind and Association for Education and Rehabilitation of the Blind and Visually Impaired, a literature review of relevant APS research as well as documents related to the NYC APS program. I also reviewed over 30 research studies spanning more than 20 years of APS research. In addition, I relied on information that I gained through interactions with Orientation and Mobility Specialists and blind and deafblind individuals from New York City as well as time I have spent examining APS installations in New York City.

IV. SUMMARY OF OPINIONS

Accessible Pedestrian Signals are audible and vibro-tactile signals that communicate to a blind or deafblind pedestrian when the walk signal is activated. The APS emits a "pushbutton locator tone," or audible signal that helps a blind pedestrian locate it. When the button, which has a raised arrow aligning with the crosswalk, is pressed, it will indicate audibly and by vibrating when the walk signal is on and it is the appropriate time to cross.

As I explain in more detail below, APS provides equivalent street-crossing information to pedestrians with visual disabilities to that provided to sighted pedestrians. The audio-tactile information that APS communicates provides pedestrians with visual disabilities notice when the WALK signal is on, which sighted pedestrians rely on to cross streets safely. APS also compensates for many of the difficulties that blind pedestrians face when crossing streets by helping with locating the intersection and crosswalk, orienting oneself properly in the direction of travel, knowing when to cross the street, and maintaining alignment while crossing.

Without APS, pedestrians with visual disabilities are at substantial risk of beginning their crossing at the wrong time, being delayed in beginning their crossings, not completing their crossing before the light turns green for cars on the street they are crossing, and veering outside of the crosswalk. This risk is especially acute when signals include certain pedestrian safety measures, such as Leading Pedestrian Intervals ("LPIs") and Exclusive Pedestrian Phases ("EPPs"). LPIs and EPPs have been added to thousands of intersections in New York City for the benefit of sighted pedestrians despite the fact that blind pedestrians cannot benefit from these measures without APS, and they make inaccessible crossings more dangerous for blind pedestrians. LPIs and EPPs do away with or confuse the auditory cues from moving vehicles that blind pedestrians rely on to cross the street, and often leave blind pedestrians with insufficient crossing time. This means they begin to cross after other pedestrians, when drivers are not

expecting pedestrians to begin crossing, and have begun to turn across the crosswalk, putting them at serious risk of collisions.

Finally, it is my opinion that there exist today no meaningful technological alternatives to APS. The various apps and Global Positioning System ("GPS") alternatives that are currently being developed have serious drawbacks when compared with APS because most require: a) owning and operating a smartphone device or accessory; b) maintaining and carrying a device that is always charged and getting a reliable signal; and c) holding the device in the hand and pointing accurately. For these reasons, it is my opinion that future technology would more appropriately complement than replace APS.

V. STREET CROSSING TECHNIQUES OF BLIND AND LOW VISION PEDESTRIANS

In order to understand the importance of Accessible Pedestrian Signals, it is first necessary to understand how blind and low vision pedestrians navigate city streets.

A. Who is a Blind or Low Vision Pedestrian

According to the report for the 2017 National Health Interview Survey ("NHIS"), 19.1 million American adults between the ages of 18 and 64 and 7.8 million American adults 65 years and older report experiencing significant vision loss. (American Foundation for the Blind, 2019a). Individuals are considered legally blind when they have visual acuity of 20/200 or less with best correction or a visual field of less than 20 degrees. (Social Security Act, 2019). A person with 20/200 vision is able to see an object at 20 feet that people with "normal" vision are able to see when 200 feet away. (Social Security Act, 2019). A restriction in the visual field to less than 20-degrees is often referred to as tunnel vision. Approximately 85% of people who are legally blind have some usable vision and may consider themselves low vision or partially

sighted rather than blind. (American Foundation for the Blind, 2019b).[1] Individuals who are deafblind typically have some vision or some hearing, but the combination of hearing and visual losses causes communication and other developmental and educational needs. (National Center on Deafblindness, 2019). Approximately 35,000 to 40,000 adults are deafblind in the United States. (National Center on Deafblindness, 2019).

Those who are legally blind or have low vision may experience reduced visual acuity, reduced contrast sensitivity, and glare or other adverse consequences of environmental illumination which can prevent them when walking from being able to drive or see many details, including visual pedestrian signals. Most, but not all, blind and low vision individuals use a long white cane as a travel aid at least some of the time. Less than 5% of individuals who are blind or have low vision may travel with a dog guide. (Franck, L., Haneline, R., Brooks, A., and R. Whitstock, 2010). Dog guides do not make decisions about the route or when to cross the street; the handler has to make that decision and give the dog commands to direct their travel and movement. Individuals who are blind or who have low vision, including those who are deafblind, travel independently to unfamiliar destinations and cross streets to which they have not been oriented.

B. How Blind Pedestrians Cross City Streets

Navigating a street crossing involves four tasks which are performed by all pedestrians but require specific attention and techniques for individuals who are blind or have low vision. The four tasks are: 1) locating the edge of the street and crossing point, 2) aligning to cross the street, 3) deciding when to begin crossing, and 4) maintaining alignment or proper heading while

[1] Low vision can be defined either by visual acuity, i.e. as "a condition caused by eye disease, in which visual acuity is 20/70 or poorer in the better-seeing eye and cannot be corrected or improved with regular eyeglasses," or in terms of functional ability: "uncorrectable vision loss that interferes with daily activities." (American Foundation for the Blind, 2019a) (internal citations omitted).

crossing. These tasks may be done in different ways depending on the vision and mobility aid (if any) used by the person. It should also be noted that in all these tasks, the pedestrian who is blind or has low vision will also be attending to the movements of other pedestrians, street traffic, the slope and crown of the street and gutter, and other environmental information.

1. Locating the Crossing Point

The traditional technique or strategy for locating the street and crosswalk used by pedestrians who are blind is to stop when they encounter a curb or a detectable warning surface[2] and assume that the crosswalk is at that location. This technique is not effective when the crosswalk is not in a direct line with the sidewalk approaching it, such as locations with offset crosswalks, rounded corners, angled streets, and some plazas. Some individuals search for the curb ramp and detectable warning surface, but most do not, because of the potential for disorientation. Some individuals with low vision may be able to see the crosswalk lines, depending on the contrast with the street and condition of the crosswalk line paint.

Research has confirmed problems locating the crosswalk for blind pedestrians. In one research study, blind participants were permitted to start crossing from any location so long as they were in no immediate danger. Participants requested assistance in locating the crosswalk on 19% of street crossings. (Crandall, Bentzen, and Myers, 1999; Crandall, Brabyn, Bentzen, and Myers, 2001). On 30% of trials, subjects who located the crosswalk independently began crossing from outside the crosswalk, meaning they may have walked into traffic lanes. (Crandall, et al., 2001).

[2] A detectable warning surface is a distinctive surface pattern of truncated domes detectable by cane or underfoot that alert people with vision impairments of their approach to street crossings and hazardous drop-offs. They are required to contrast with the surrounding surface, either light on dark or dark on light for low vision users. (U.S. Access Board, 2014).

2. *Aligning to Cross*

To align to cross, individuals who are blind listen to traffic moving beside the crosswalk and align themselves to cross beside that traffic. With many traffic lanes, some with trucks and loud vehicles and others with almost silent cars, or bicycles, picking out the right audible cues and aligning correctly with the lanes of traffic is difficult for many pedestrians who are blind or have low vision. At best, there is the potential for a 10-degree error in aligning using hearing (Guth, *et al.*, 2010), which means the blind pedestrian may be aligned 10 degrees to the right or left of the crosswalk. For a wide street, this kind of error can result in the pedestrian finishing their crossing outside the crosswalk, potentially in the traffic of the parallel street or in between waiting vehicles in the traffic lanes of the street they are crossing.

3. *Deciding When to Cross*

Deciding when to begin crossing is the traditional technique that has been most negatively affected by new signal timing and traffic management strategies. The traditional technique is to listen for vehicles to stop on the street being crossed and for cars to begin moving in the lanes closest to the crosswalk. This is often referred to as the surge of traffic on the parallel street. Pedestrians who are blind begin crossing as those vehicles enter the intersection. This technique relies on the assumption that vehicles in the closest parallel traffic lane have a green light and the WALK signal is being displayed for pedestrians walking on the crosswalk beside those lanes.

Without an APS, pedestrians who are blind are essentially guessing that the walk signal is displayed when the traffic in the closest lane begins moving. With changes in signalization and traffic signal timing, that may not be a correct assumption. In some cases, there may not be traffic that begins moving just as the signal changes, particularly crossing a wide street at its

intersection with a smaller street (at the intersection of a minor and major street). In research in San Francisco at relatively small urban intersections, Crandall, *et al.* (1999, 2001) found that participants began crossing during the walk interval on only 66% of crossings. Marston and Golledge (2000) found that at crossings without APS, almost half (48%) of the participants attempted to cross during the don't walk interval, when vehicles on the street being crossed had a green signal, which is unsafe and puts pedestrians at risk for a collision.

Even without signal timing changes discussed below, pedestrians who are blind or have low vision using traditional techniques are typically delayed in beginning their crossing compared to sighted pedestrians, reducing the time they have to complete the crossing before the signal changes. Research has documented that listening for and confirming the traffic surge results in an average latency of 6.4 seconds in the amount of time it takes pedestrians who are blind or low vision to begin crossing. (Barlow, *et al.*, 2006; Scott, Barlow, Bentzen, Bond, and Gubbe, 2008).

4. Maintaining Alignment

For maintaining alignment or heading while crossing, pedestrians who are blind listen to the traffic moving beside them as they cross and try to maintain a consistent distance from those lanes of traffic. If there is not consistent traffic on the street beside the crosswalk, or traffic is not in the closest lane, even very experienced blind pedestrians "exhibit variable error sufficient to result in veering into the parallel street when crossing at intersections." (Guth, *et al.*, 2010, pg 36). This means they may walk into traffic in lanes on the street beside the crosswalk and become disoriented, possibly missing their destination corner, and be out in traffic lanes when more vehicles arrive in those lanes.

VI. ACCESSIBLE PEDESTRIAN SIGNALS

Figure 1: Accessible pedestrian signal (Photo taken by Raysonho @ Open Grid Scheduler / Grid Engine - Own work, CC0 (Public Domain))

Accessible Pedestrian Signals, featured in Figure 1, assist blind pedestrians with the four orientation and mobility tasks used to cross a street safely, which are described in Section (III). They provide audio and vibro-tactile information to the pedestrian that helps them locate the crossing location, orient themselves to walk in the correct direction, know when the WALK signal is on so they can begin crossing, and maintain alignment on their heading to the other side of the street.

Various types of audible signals have been installed in the United States since the 1930s. In 2000, some guidance and standards for APS were adopted in the Manual on Uniform Traffic Control Devices ("MUTCD"). Major changes in the standards and guidance for APS were adopted in the 2009 MUTCD after the completion of National Eye Institute and National Cooperative Highway Research Project research. The MUTCD is published by the Federal Highway Administration and was adopted by New York State in 2010 as the state standard for devices installed to control traffic, including signs, signals, and pavement markings.

APS devices installed at intersections must comply with the standards and guidance provided by the MUTCD, and traffic engineers refer to the MUTCD in making installation decisions. MUTCD standardizes APS pushbutton installation location, acceptable audible messages and volume, form of the APS device, and features of the APS device, such as extended press options to announce the street being crossed. MUTCD specifically highlights for traffic engineers the ways blind pedestrians are unable to safely cross streets without APS: "The

existing environment is often not sufficient to provide the information that pedestrians who have visual disabilities need to cross a roadway at a signalized location." (MUTCD 4E.09(02)).

A. The APS Locator Tone Assists Blind Pedestrians in Locating the Crossing Point.

A properly positioned APS, with its pushbutton locator tone, provides information and certainty about the location of the street and beginning of the crosswalk. A pushbutton locator tone repeats constantly at one tone per second to let pedestrians who are blind know there is a crossing point there and to help them find the APS so they can use the other features, such as the tactile arrow. [Listen to pushbutton locator tone. 🔊] The pushbutton locator tone is supposed to be audible 6 to 12 feet from the pushbutton, or to the building line, whichever is less. This tone also responds to ambient sound, so it may be louder when traffic is heavy and quieter when traffic is light.

When the button is pressed, a verbal message stating "wait" sounds, which lets the pedestrian know that the button has been pressed. There is also a red light on the APS device that illuminates so sighted pedestrians can recognize that the button has been pressed. The red light goes out when the walk indication is displayed/sounded.

The APS is supposed to be positioned close to the edge of the crosswalk farthest from the center of the intersection, so the pedestrian who finds the APS/pushbutton and begins their crossing from that location is properly positioned within the crosswalk area and not too close to the traffic moving on the street beside their crossing. As noted above, typical techniques for finding the crosswalk do not work well if the crosswalk is slightly offset, angled, at a midblock location, at the "top of the T" at a T-intersection, or on a rounded corner. The APS pushbutton locator tone helps the blind pedestrian find the crosswalk and begin their crossing from the correct location.

For blind pedestrians, starting crossing from within the crosswalk increased from 70% to 97% with use of the APS. (Crandall, *et al.*, 1999, 2001). Research at complex intersections in Portland, Oregon found significant increases in the ability of blind participants to begin crossings from within the crosswalk with APS at locations where pushbutton locator tones were installed. Pre-installation, 77% of crossings began from within the crosswalk; post-installation, 97% of crossings began within the crosswalk, indicating that locating the crosswalk was significantly improved by the presence of pushbutton-integrated APS. (Barlow, Bentzen, Bond and Gubbe, 2006).

B. The Location of the APS and Directional Arrow Assist Blind Pedestrians in Aligning with the Correct Crosswalk.

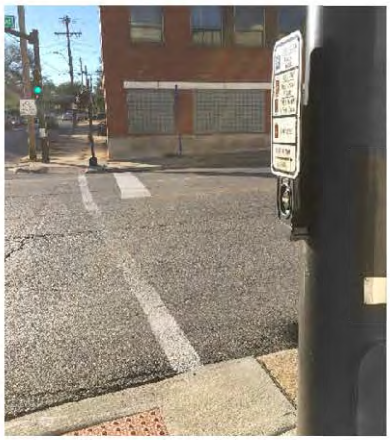


Figure 2: Pushbutton with tactile arrow aligned with crosswalk direction (Photo taken by Janet Barlow)

The tactile arrow, which can be seen in Figure 2, on an APS provides an alignment cue since it is supposed to be aligned with the direction of travel on the crosswalk. This allows blind pedestrians to match the APS device with a crosswalk.

At some intersections, it can be difficult to determine whether the pushbutton is for the desired crossing or the crossing of the parallel street. The tactile arrow allows blind pedestrians to confirm that the APS is for the street they intend to cross. Research has shown that the presence of APS improved the task of aligning to cross, with 70% of independent crossings starting from an aligned position pre-installation and 84% post-installation. (Barlow, *et al.*, 2006).

C. The Audible WALK Indication Assists Blind Pedestrians in Knowing When to Safely Begin Crossing.

When a visual pedestrian crosswalk signal changes to the WALK signal, an APS emits a rapidly repeating percussive tone (between 8 and 10 ticks per second) during the walk interval. [Listen to the repeating percussive tone. 🔊] This percussive tone has been found to be detectable in the presence of traffic sound, so pedestrians can hear when the pedestrian phase begins and start their crossing promptly. If APS devices cannot be separated by at least 10 feet, APS may announce the street and WALK signal with a speech message. The MUTCD requires that speech messages follow a prescribed format of "street name, walk sign is on to cross "street name," as in "Broadway, walk sign is on to cross Broadway." [Listen to a speech message. 🔊] A pushbutton information message, or audio message played when a pedestrian holds down the pushbutton for several seconds, is also required so the blind pedestrian knows the street name and can make a correct decision. [Listen to a pushbutton information message. 🔊] During the walk interval, in addition to the audible percussive signal, the pushbutton arrow vibrates so a person can put their hand on the pushbutton to detect the WALK if they have difficulty hearing the APS. This can be very helpful in noisy traffic locations or for individuals who are deafblind.

As noted in previous discussion, without APS, pedestrians who are blind typically use traffic movement and sounds to decide when to cross, and their accuracy in starting their crossings during the walk interval is relatively poor. Starting crossing at the wrong time puts blind pedestrians at risk for a collision with a vehicle. APS improves the safety of crossing for pedestrians with visual disabilities by providing information about when the traffic engineer intended pedestrians to make their crossings and allowing them to cross at the same time as sighted pedestrians.

Research has documented that APS significantly improved the crossing safety of pedestrians who are blind. As I understand it, New York City's crossings are largely pre-timed, meaning a pedestrian need not push a button for the walk signal to come on, which functions essentially the same as some crossings studied that were "on recall." At crossings that are pre-timed or on recall, there is a pedestrian phase (and adequate time for a pedestrian to cross) during every traffic cycle. Crandall, Bentzen, and Myers (1999) and Crandall, Brabyn, Bentzen, and Myers (2001) found that blind participants began crossing during the walk interval at pre-timed intersections on only 66% of crossings without APS, but on 99% of crossings with APS. Marston and Golledge (2000) found that at crossings on recall without APS, almost half (48%) of the participants attempted to cross during the don't walk interval. With APS, no participant started crossing at an unsafe time. *Id.*

In Portland, Oregon, at locations where the signal was on recall and no APS were installed, 82.1% of the crossings started during the walk interval, but 5.7% still completed their crossing after the perpendicular traffic began moving against them (called the "perpendicular green"). (Barlow, *et al.*, 2005). In Charlotte, North Carolina, without APS, blind pedestrians began their crossings 58.1% of the time during WALK and 20.9% of crossings ended after the onset of perpendicular traffic, when cars on the street being crossed have the green light. *Id.* The installation of APS at all these crossings resulted in significant improvement, with 97% starting during WALK and 0% completing their crossing after perpendicular green in Portland and 85% starting during WALK and 5% ending after perpendicular green in Charlotte. (Scott, *et al.*, 2008).

With respect to the few NYC intersections that may be pedestrian actuated, blind pedestrians likely fare much worse in correctly guessing appropriate timing and safely crossing

streets. In research conducted in Portland, Oregon, without APS, the pedestrian-actuated crossings were highly problematic for pedestrians who are blind. Without APS at wide complex crossings, participants began crossing during WALK on only 25% of crossings. (Barlow, *et al.,* 2006). After APS installation, blind pedestrians properly initiated their crossings during the walk interval 84% of the time. *Id.* Similarly, without APS, participants completed 50% of crossings dangerously late, when the perpendicular vehicular traffic had the green light, compared to 12% of crossings after the installation of APS. *Id.* In research conducted in Charlotte, North Carolina, pedestrian-actuated crossings without APS resulted in 11.4% of the crossings starting during the walk interval, with 44% of the crossings ending after the onset of perpendicular traffic. (Scott, *et al.*, 2008). After APS installation, 68% of crossing began during WALK and 13% ended after traffic on the street being crossed had begun to move. *Id.* Williams, Van Houten, Ferraro, and Blasch (2005) found that mean latency in beginning crossing without APS was more than 5 seconds, which was reduced to 3.8 seconds with a pushbutton-integrated APS using speech messages.

The installation of APS can also improve crossing delay for sighted pedestrians. A San Francisco study found: "While primarily intended to serve visually impaired pedestrians, the devices also appear to benefit sighted pedestrians. The proportion of sighted pedestrians finishing on the solid Red Hand phase decreased from 27% to 17%, while the proportion starting on the Walk phase increased from 59% to 70%." (Federal Highway Administration, 2008). APS can make the streets safer for all pedestrians.

D. Because APS is Installed at Both Corners of a Crosswalk, It Assists Blind Pedestrians in Maintaining Alignment During Their Crossing.

The APS at the far end of the crosswalk emits a pushbutton locator tone during the flashing DON'T WALK portion of the pedestrian crossing phase. Pedestrians with visual

disabilities may be able to hear that locator tone and use it as a target to assist in completing their crossing within the crosswalk. The pushbutton locator tone of the APS at the far end can result in correction and improvement in ending within the crosswalk. (Scott, *et al.*, 2008; Barlow, Scott, Bentzen, and Graham, 2013).

VII. NEW YORK CITY ENVIRONMENT

New York City presents unique challenges to blind and low vision pedestrians attempting to navigate city streets, making APS especially important. First, New York City is one of the loudest cities in the country, making the soundscape particularly challenging for pedestrians who rely on their hearing. Second, New York City has implemented numerous traffic design choices, such as leading pedestrian intervals, exclusive pedestrian phases, protected intervals, and bike lanes, that render unreliable the traditional street-crossing techniques used by blind pedestrians. Combined, these factors make navigation in the absence of APS very difficult for blind, low vision, and deafblind New Yorkers.

A. The New York City Soundscape

New York City has some of the loudest transportation and road noise in the country. (United States Department of Transportation, 2019). Cars, construction, buses, trains, food trucks, and other vendors add to the soundscape. In addition, some vehicles, such as hybrid or electric vehicles, and bicycles, are almost silent at lower speeds, meaning their movement and presence is undetectable by pedestrians relying on listening to car sounds to make their travel and street crossing decisions.

B. Pedestrian Safety Measures for Sighted Pedestrians Can Make the Landscape Even More Challenging for Pedestrians with Visual Disabilities

As signal timing has become more sophisticated, and traffic patterns and vehicles have changed, the traditional techniques used by pedestrians with visual disabilities for determining

when to begin crossing the street no longer work reliably, making APS even more critical for safe navigation. Signal timing changes include changes in the order of phases (LPIs and EPPs), and protected intervals (left turn and right turn arrows).

1. Leading Pedestrian Intervals

Leading pedestrian intervals are timing changes that have been widely installed by NYC DOT for the benefit of sighted pedestrians. Where an LPI is installed, the walk signal is displayed for approximately 5-10 seconds while vehicles still have a red light. LPIs give pedestrians a "head start" on their crossing, ahead of cars that may be turning right on green across the crosswalk. This helps force the yield that is commonly not obeyed in the usual situation in which drivers in parallel traffic are allowed to turn right during WALK and are supposed to yield to pedestrians. This practice essentially forces the yield, by allowing pedestrians to be in the crosswalk before cars are given the light to proceed.

LPIs have been installed at over 3900 locations in New York City. (NYC Open Data, 2019). Without an APS, pedestrians with visual disabilities are left waiting for the surge of traffic, which does not occur until after the LPI concludes, thus depriving them of any advantage the LPI offers to sighted pedestrians. In fact, LPIs can result in even more dangerous intersections for pedestrians with visual disabilities, as LPIs cause blind or low vision pedestrians to begin their crossing late, as the cars begin moving and when the drivers do not expect pedestrians to begin crossing. The MUTCD recognizes this concern and recommends the consideration of APS wherever LPIs are installed. (FHWA, 2009). Pedestrians with visual disabilities may begin their crossing just as cars begin turning, putting them at risk for a crash and leaving them with inadequate time to complete the crossing before the signal changes. (Bourquin and Bieder, 2018).

APS is necessary at the crossings with LPIs because of these dangers. APS sounds and vibrates when the walk interval begins and allows the pedestrian who is blind or has low vision to know that the WALK signal is being displayed and to start crossing at the beginning of the WALK. APS gives pedestrians who are blind the same information as a sighted pedestrian, giving them adequate time to complete their crossing and enabling them to cross with other pedestrians, when vehicles are expecting them to cross.

2. Exclusive Pedestrian Phases

As of 2017, NYC DOT had installed Exclusive Pedestrian Phases at 635 intersections, including 86 All Pedestrian Phases, 386 Signalized "T-Away" intersections, and 163 Midblock signals, (New York City, 2017), and the NYC DOT has continued to install them since then. (Ferrari, 2019). EPPs are crossings where no vehicular traffic is moving (all lights are red) but pedestrians may cross. Where there is an EPP, the proper time for pedestrians to cross is when all vehicles have a red signal. However, there is no vehicle surge to cue the blind or low vision pedestrians that the walk signal has begun, nor can they use the traffic movement parallel to the crosswalk in maintaining alignment while crossing. Because no traffic is moving, maintaining a straight line of travel within the crosswalk can be difficult for pedestrians with visual disabilities.

Without an APS, pedestrians with visual disabilities are likely to begin crossing with movement of traffic parallel to their crosswalk, when the DON'T WALK signal is displayed and drivers are not expecting them to cross. This puts blind pedestrians in danger and APS is necessary at all EPPs to make those intersections safe for blind pedestrians. An APS helps by indicating when the walk interval starts, how to properly align for the crossing, and providing a target sound at the end of the crosswalk.

3. *Protected Intervals*

Protected intervals are times when vehicular traffic is allowed to turn right or left with a signal display, usually a left turn or right turn arrow. The length of these turn intervals often changes each cycle, in response to the number of vehicles in the left or right turn lane. When vehicles have a left or right turn arrow, the pedestrian is not supposed to be crossing and the visual pedestrian signal displays an orange hand to show that the pedestrian should not cross.

For decades, pedestrians with visual disabilities have depended on listening to traffic and getting familiar with the intersection and order of traffic movement as an aid to their decisions, since they have been unable to see the visual pedestrian signals. With the newer computer control of intersections, the order and timing of traffic movement can change every cycle. During some cycles, there may be no left turn arrow and at other times there may be a left turn arrow for several seconds. In the absence of an APS, pedestrians who are blind may not recognize the protected turns, when pedestrians are not supposed to be crossing. Instead, pedestrians with visual disabilities may think that the traffic turning left is the main surge of traffic on the street and begin crossing, which is a dangerous situation because drivers expect to have the right of way in making their turns.

With emergency preemption or transit priority systems, which shorten the time for one street in order to change the signal in favor of the emergency or transit vehicle, the signal timing may change at any time there are emergency or transit vehicles approaching the intersection. These systems make intersections more unpredictable. Without APS, these signal timing changes are unknown to blind pedestrians and can make affected intersections unsafe to them.

4. Geometry Changes and Bike Lanes

Some of the geometry and street redesign changes also affect crossings by pedestrians with visual disabilities. When there are separated bike lanes and/or parking between the parallel pedestrian crosswalk and the vehicle lanes, the vehicle movement is harder to hear or detect. This may further delay pedestrians with visual disabilities in starting the pedestrian crossing or make them miss the light completely. The addition of plazas and bike lanes and other features can make it difficult to maintain orientation and accurately align for street crossings. Bike signals have been installed in some locations in New York City, so bicycles may begin moving at times when motorized vehicles are held. Bicycles are silent and blind pedestrians cannot detect the bicycle movement by listening and may not recognize that the bicyclist has the right of way, increasing chances of a crash with a bicycle. Without an APS, a blind pedestrian may decide the lack of other traffic movement indicates an EPP and start crossing during the bicycle phase. This puts blind pedestrians in danger of collisions with bicycles.

VIII. LOCATION SELECTION AND INSTALLATION

Cities must address two issues in the development of their APS programs: 1) how to determine the order of intersections at which to install APS, and 2) how to install them in the correct location at the selected intersections.

A. Prioritization Tool

To aid cities in the process of determining at which intersections to install APS, the NHCRP project I worked with developed a Prioritization Tool. The Prioritization Tool developed as part of NCHRP Project 3-62, *Guidelines for Accessible Pedestrian Signals,* was in response to questions from the oversight panel about: a) installations as part of an Americans with Disabilities Act ("ADA") transition plan, and b) cities' response to requests for APS installations when there were more APS requests than could be immediately installed. The

direction of the NCHRP panel, which included representatives from the Access Board and Federal Highway Administration, was that in developing the Prioritization Tool, cities should assume that all new or reconstructed intersections would have APS installed during the initial construction. This was based on the fact that the Access Board, which is the federal agency charged with developing minimum technical specifications for compliance with the ADA, had issued draft Public Rights-of-Way Guidelines ("PROWAG") that required APS at all new and reconstructed intersections. The NCHRP panel advised that, even without a finalized rule on Public Rights-of-Way, the ADA required equivalent communication and a city's project team should assume that new or reconstructed intersections with pedestrian signals would be equipped with APS. The NCHRP Guide developed in Project 3-62 states: "The information regarding prioritizing intersections for installation of APS is not intended for application to new or reconstructed intersections. In new construction or reconstruction projects, it is appropriate to consider the Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (proposed PROWAG) or Draft PROWAG as the best guidance available at this time (Isler memo, 2006). In new construction, APS should be installed wherever pedestrian signals are installed." (www.apsguide.org, 2017 revision).

The NCHRP intended for the Prioritization Tool only to be used on existing intersections as part of a transition plan, in order to rank the installation order of APS and compare the difficulty of specific crosswalks, or to rank requests for intersection modifications. There is no minimum score that can be assigned through the Prioritization Tool below which APS is assumed not to be needed because the NCHRP panel, and thus the Prioritization Tool, assumed that APS would be installed at every intersection where pedestrian signals are installed. The

expectation was that the jurisdiction would recognize the waiting list in the next budget year and the budget would be increased to respond to requests that had been received.

As I understand from the NYC DOT's 2018 APS Program Reports (NYC DOT 2018), the Prioritization Tool being used by NYC DOT in the evaluation and prioritization of intersections is based on the one we developed through the NCHRP. However, it appears that it is not being used as it was intended because the NYC DOT has used the prioritization tool for both new and altered intersections since the genesis of its APS program. The tool was never intended to be used with new or altered intersections, which are supposed to be outfitted with APS regardless of its worksheet score.

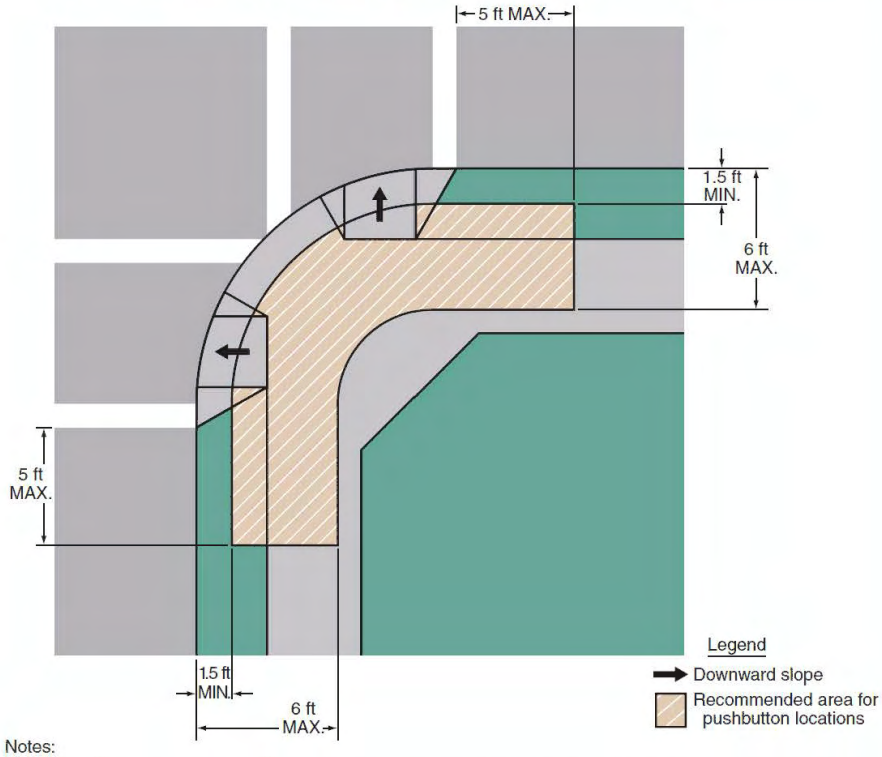
B. APS Installation

APS are mounted on poles close to the crosswalk they control, on the side of the crosswalk that is farthest from the center of the intersection. The tactile arrow is aligned with the direction of travel on the crosswalk. To install APS at a typical intersection (4 crosswalks) requires 8 pushbutton units/devices and a control unit that is added to the controller cabinet or 8 pushbutton units and control units that are installed in each pedestrian signal head. The APS device has a wire or set of wires that needs to be connected either to the controller or the control unit in the pedestrian signal head.

Because New York City has traditionally had pedestrian signals that do not require pedestrians to push a button to call the WALK indication, pushbuttons and poles for pushbuttons have not been typically installed. In order to install APS, additional poles must be installed for the APS devices. Installing poles requires a base that is appropriate for the location, and wiring to the device, either from the signal controller or the pedestrian signal head. In general, the poles must have a stable foundation, usually requiring concrete footing or bolts to a depth of 12 inches.

The location of the APS devices on the corner is critical to their providing accurate information to pedestrians who are blind regarding the crossing. The sound of the APS must be audible from the beginning of the crossing and the tactile arrow and vibrotactile indication must be reachable from a level landing. The tactile arrow is supposed to be aligned with the direction of travel on the crosswalk. The device is supposed to be within 10 feet of the curb and no more than 5 feet from the crosswalk line farthest from the center of the intersection. The MUTCD provides recommendations for placement of the pushbuttons in Part 4, Section 4E.08, and the graphics below are the MUTCD illustrations of typical pushbutton location.

Figure 4E-3. Pushbutton Location Area

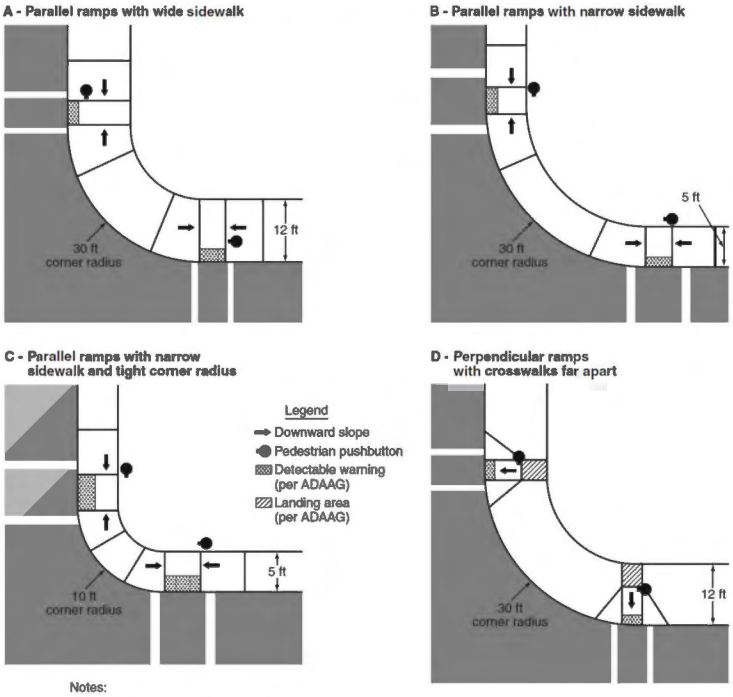


Notes:

1. Where there are constraints that make it impractical to place the pedestrian pushbutton between 1.5 feet and 6 feet from the edge of the curb, shoulder, or pavement, it should not be further than 10 feet from the edge of curb, shoulder, or pavement.
2. Two pedestrian pushbuttons on a corner should be separated by 10 feet.
3. This figure is not drawn to scale.
4. Figure 4E-4 shows typical pushbutton locations.

Figure 4E-3 shows the recommended pushbutton location area. (Part 4, Section 4E.08, MUTCD, 2009). Additional graphics in Figure 4E- 4 provide examples of typical locations of pushbuttons with different widths of sidewalks and types of curb ramps. (Part 4, Section 4E.08, MUTCD, 2009).

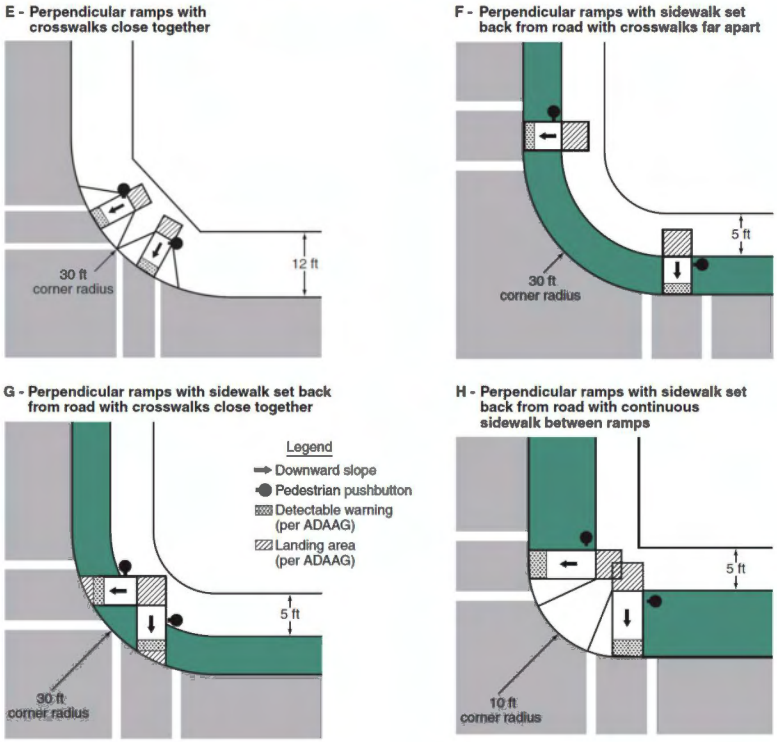
Figure 4E-4. Typical Pushbutton Locations (Sheet 1 of 2)



Notes:

1. This figure is not drawn to scale.
2. These drawings are intended to describe the typical locations for pedestrian pushbutton installations. They are not intended to be a guide for the design of curb cut ramps.
3. Figure 4E-3 shows the recommended area for pushbutton locations.

Figure 4E-4. Typical Pushbutton Locations (Sheet 2 of 2)



Notes:
1. This figure is not drawn to scale.
2. Tese drawings are intended to describe the typical locations for pedestrian pushbutton installations. They are not intended to be a guide for the design of curb cut ramps.
3. Figure 4E-3 shows the recommended area for pushbutton locations.

IX. ALTERNATE TECHNOLOGIES

Any hope that technological advances could provide a less costly alternative to APS remains unfulfilled. Today there is no technological alternative to APS that provides the same kind of reliable information to blind and low vision pedestrians as APS.

Numerous developers are working on smart phone applications and other devices that may assist pedestrians with visual disabilities in navigating city streets. In reviewing the information and studies completed to date on devices attempting to provide walk signal information, there are numerous problems with such technology. There are many GPS devices that provide mapping information or information about nearby businesses, such as Sendero GPS, Wayfinder, SmartCane, Nearby Explorer, BlindSquare, Sunu Band, AIRA, and Trekker, but they do not (and at this time, cannot) provide the one feature hat blind pedestrians need most:

street crossing signal information. Additionally, most alternatives require: a) owning and operating a reliable, charged, and connected smartphone device or accessory; b) holding this device in one's hand, which is often in use, particularly for blind users with a cane or dog guide; and c) properly orienting and pointing the device, which can be difficult if a pedestrian becomes disoriented in any way.

Each of these three requirements presents problems. First, maintaining and carrying a device that is always charged and getting a reliable signal can be difficult in the best of times. Batteries die, and cell service can be lost in some locations or Bluetooth communication may not function effectively. Second, most prototype apps require holding the device in the hand and pointing accurately. Pedestrians with visual disabilities may already have a white cane or dog guide in one hand. They often need their other hand free for carrying objects and/or may not be able to point accurately across the street to the proper location on the end of the crosswalk. That could result in getting information for the diagonal crosswalk and potentially crossing at the wrong time. Third, while some devices use a type of headphone for GPS information or communicating with their phone on the street, that may interfere with pedestrians with visual disabilities hearing traffic and other cues needed to safely cross the street. These requirements, even if available, add to the cognitive demand people with visual disabilities experience when trying to cross a street.

It is also important to consider the demographics of the population of individuals who are blind or have low vision. Many are elderly and may not be familiar with or proficient in the use of technology. Moreover, 70% of individuals who are blind are not employed full time, meaning their earnings are limited and they may not have the funds to buy and maintain a smart phone or other smart device. (American Foundation of the Blind, 2019).

These issues must be considerations in any technology that is providing information about the traffic signal functioning and are quite challenging to resolve. In my opinion, there is no meaningful alternative to APS devices that provides the same information currently available or likely to become available in the near future.

X. CONCLUSION

APS are essential for the navigation of pedestrians with visual disabilities to improve safety and convenience. Without APS, pedestrians who are blind, deafblind, or who have low vision are deciding to cross based on unreliable cues and essentially guessing when the traffic engineering department has designated as the appropriate and safe time for them to cross the street. They may be delayed in their crossing decisions or make decisions to cross at the wrong time when drivers are not expecting them to be in the crosswalk, which puts them at risk for collisions.

New York City has been installing LPIs, EPPs, protected right and left turn arrows, and bicycle signals intended to make crossings safer for pedestrians but make the crossings more dangerous to pedestrians with visual disabilities. LPIs and EPPs do away with the auditory cues that pedestrians with visual disabilities rely on to cross the street. Thus, pedestrians with visual disabilities are denied the benefit of these safety improvements, prompted to cross when pedestrians are not expected in the intersections but vehicles have begun to turn across the crosswalk, and often left with insufficient time to complete their crossing before traffic begins moving on the street they are crossing. Each of these increased risks can be reduced by the installation of APS.

There are not any technological alternatives that can replace APS. Future technology is more likely to complement than replace APS.

I certify that, to the best of my knowledge and belief:

1. The statements of fact in this report are true and correct.
2. The reported analyses, opinions, and conclusions are limited only by the reported assumptions and are my personal, unbiased and professional analyses, opinions and conclusions.
3. I have no personal interest or bias with respect to the parties involved.
4. My compensation is not contingent on an action or event resulting from the analyses, conclusions or opinions of this report.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct, and that this Declaration was executed on the 7 of August, 2019, in Asheville, NC.

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Education

MS, Special Education, December 1975, Florida State University, Tallahassee, Florida
Concentration of degree program was mental retardation, hearing impairment, and other disabilities in conjunction with vision loss
BS, Habilitative Sciences, Visual Disabilities, March 1973, Florida State University, Tallahassee, Florida;
Education of the visually impaired, with emphasis on orientation and mobility instruction

Work Experience

10/05-present	President, Barlow Design, Inc., dba Accessible Design for the Blind
2017-2018	Adjunct faculty, Salus University, Elkins Park, PA
3/08- 3/09	Adjunct faculty, Pennsylvania College of Optometry, Elkins Park, PA
5/99 – 10/05	Consultant/Research Associate, Accessible Design for the Blind
7/04-8/04	Part-time instructor, Department of Blindness and Low Vision Studies, Western Michigan University
10/95 - 6/01	Manager, Rehabilitation Services, Center for the Visually Impaired, Atlanta, Georgia
9/95 - 12/95	Part-time Instructor, Georgia State University, Atlanta, GA
9/94 - 12/94	Part-time Instructor, Georgia State University, Atlanta, GA
9/93 - 10/95	Manager of Independent Living Services, Center for the Visually Impaired, Atlanta, Georgia
10/92 - 3/93	Research Associate, contract with Boston College, *Cues Blind Travelers Use to Detect Streets*
9/86 - 8/93	Orientation and Mobility Specialist, Center for the Visually Impaired, Atlanta, Georgia
9/77-8/86	Part-time contract Orientation and Mobility Specialist, Center for the Visually Impaired, Atlanta Georgia

Expert Witness Cases

Lori Scharff, Michael Godino, Edward Molloy, and Long Island Council of the Blind, Plaintiffs, v. County of Nassau and Shila Shah-Gavnoudias, Commissioner of Nassau County Department of Public Works, in her official capacity, Defendents. Case No. 2:10-cv-04208-DRH-GRB in the United States District Court Eastern District of New York, 2014.

Mary Cuthbertson, Colen B.Cuthbertson-Holloway, Daryl R. Cuthbertson, Sharon E. Jemison, and the Estate of Cameron Cuthbertson, Plaintiffs vs. Los Angeles County Metropolitan Transportation Authority, Does 1 to 10, Defendants. Case No.: BC413070 in the Superior Court of the State of California for the County of Los Angeles, 2011

Certifications

Certification as Orientation and Mobility Specialist (COMS) by Academy for Certification of Vision

Rehabilitation and Education Professionals, (ACVREP) 2015 - 2020

Professional Affiliations

Asheville Bicycle and Pedestrian Task Force. Co-facilitator, 2016 to present, Member 2007 to present

Pedestrian Committee (ANF-10), Transportation Research Board, Member, 2014 – Present

Environmental Access Committee, Orientation and Mobility Division, Association for Education and Rehabilitation of the Blind and Visually Impaired (AERBVI), 1992 – present, Chair, 2002 – 2012, 2013 - present

Committee on Roundabouts (ANB-75), Transportation Research Board, Member, 2012 – 2017

Task Force on Roundabouts (ANB-75T), Transportation Research Board, Member, 2007 – 2012

Public Rights-of-Way Access Advisory Committee, U.S. Access Board, Representative of Association for Education and Rehabilitation of the Blind and Visually Impaired, Intersection Subcommittee and Editorial Subcommittee, 1999 –2007, Chair of Technical Assistance Manual subcommittee, 2001 - 2007

Pedestrian and Bicycle Council Executive Committee, Institute of Transportation Engineers, 2001 - 2011

Right Turn on Red Recommended Practice Committee, Institute of Transportation Engineers, 2004

Metropolitan Atlanta Rapid Transit Authority's Elderly & Disabled Access Advisory Committee, 1987 - 1997, Chairperson, 1990 – 1992

Association for Education and Rehabilitation of the Blind and Visually Impaired, member, 1987 – present

Institute of Transportation Engineers, Member, 1999 – present

Association of Pedestrian and Bicycle Professionals, Member 2001 – present

Tributes and Honors

Pedestrian Committee Best Paper Award, Transportation Research Board, Washington, D.C., 2012

Lawrence E. Blaha Award from the Orientation and Mobility Division of the Association for Education and Rehabilitation of the Blind and Visually Impaired, July 2008

Pedestrian Committee Best Paper Award, Transportation Research Board, Washington, D.C., 2006

Access Award from the American Foundation for the Blind, 2004

Tribute for Advocacy in Environmental Access from the Orientation and Mobility Division of the Association for Education and Rehabilitation of the Blind and Visually Impaired, 2002

Funded Projects:

Transit Cooperative Research Program Project B-46, *Tactile Wayfinding in Transportation Settings for Travelers Who Are Blind or Visually Impaired*. Subcontract to Accessible Design for the Blind from UNC Highway Safety Research Center, March 2019 – August 2021. The objective of this research is to produce guidance for transportation planners, engineers, and orientation and mobility specialists that will provide for consistency in the design, installation, and usability of TWSIs in multimodal transportation in the United States. ADB will work with partners to plan and design research to test products and usability in a lab setting as well as in field settings.

National Cooperative Highway Research Program Project 03-133, *Traffic Signal Design and Operations Strategies for Non-Motorized Users*. Subcontract to Accessible Design for the Blind from Kittelson and Associates, April 2018 to March 2020. ADB will provide input on all project tasks regarding accessibility issues and consideration of pedestrians with disabilities, particularly those who are blind or who have low vision.

National Cooperative Highway Research Program Project 03-130, *Guide for Roundabouts.* Subcontract to Accessible Design for the Blind from Kittelson and Associates, June 2018 to November 2020. ADB will provide input on project tasks regarding accessibility issues and consideration of pedestrians with disabilities, particularly those who are blind or who have low vision, and lead the preparation of the research plan for any tasks involving wayfinding or other pedestrian related issues.

National Cooperative Highway Research Program Project 07-25 G*uide for pedestrian and bicycle safety at alternative intersections and interchanges (All)* Subcontract to Accessible Design for the Blind from Kittelson and Associates, March 2017 – February 2019. ADB will provide input in all project tasks regarding accessibility issues and consideration of pedestrians with disabilities, particularly those who are blind or who have low vision, in recommended designs for alternative intersections and interchanges.

National Cooperative Highway Research Program Project 3-78c, *Technology Transfer and Training, Guidelines for the Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*. Subcontract to Accessible Design for the Blind from Kittelson and Associates, January 2017 – January 2019. This project is developing and providing technical assistance and training on the guidebook developed in NCHRP 3-78b. Project team will provide webinars and in-person training sessions to engineers, administrators, and designers responsible for roundabout and CTL designs and installation.

National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR). *Effect of Guidance Surfaces on Travelers with Vision and Mobility Impairments.* Subcontract to Accessible Design for the Blind from Western Michigan University, January 2017 – January 2020. ADB is major participant in this project which includes an international literature search and data collection with individuals with mobility impairments and with individuals who are blind or who have low vision regarding guidance surfaces and installation at street crossings. Project outputs include a guidance document that can be used by cities and municipalities to standardize their approach to using tactile guidance surfaces at street crossings for people who are blind.

Federal Highway Administration. *Innovative Street Design Practices and Accessibility*. Subcontract to Accessible Design for the Blind from Cambridge Systematics, September 2016 - September 2017. Project focused on the extent to which new and emerging street designs and practices, such as shared streets, meet the needs of people with disabilities, specifically regarding navigation for pedestrians with vision disabilities. Produced a guide to shared streets.

National Cooperative Highway Research Program Project 15-60, *Update of the AASHTO Guide for the Development of Bicycle Facilities*. Subcontract to Accessible Design for the Blind from Toole Design Group, July 2015 – October 2018. Subject matter expert on accessibility and pedestrian and bicycle interaction issues for pedestrians with disabilities.

Ransom Engineering. Roundabout Design Project, Portland Maine. August 2014 – August 2015. Review 30% and 90% designs for roundabout, and work with City staff, consultants and individuals at local agency serving persons with disabilities to develop accessibility

solutions.

National Cooperative Highway Research Program Project 3-78b, Guidelines for the Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities. Subcontract to Accessible Design for the Blind from North Carolina State University, April 2013 – December 2015. Field research, and subsequent development of guidelines for the installation of pedestrian crossing solutions at roundabouts and channelized turn lanes that address accessibility for pedestrians with vision disabilities and consider multiple alternatives for a range of geometric and traffic operational conditions and solutions.

Federal Highway Administration *Project TOPR34, Accelerating Roundabout Implementation in the United States*. Subcontract to Accessible Design for the Blind from North Carolina State University, 2012 – 2015. Evaluation of effectiveness of rectangular rapid flashing beacon (RRFB) treatments at multilane pedestrian crossings at roundabouts.

New York City Department of Transportation. *Access to plazas for blind and low vision pedestrians*. August 2012 – June 2014. Consult in the development of updated designs to enhance access to pedestrian plazas for people who are blind or have low vision. Tasks included: Provide expertise in issues and design concepts that affect people who are blind or have low vision; Serve as a facilitator in meetings, workshops and site visits for people who are blind or have low vision to develop design treatments to enhance the accessibility of plazas.

Transit Cooperative Research Program Project A-38, *Guidebook for Pedestrian Crossings for Public Transit Rail Services*. Subcontract to Accessible Design for the Blind from Texas A&M Transportation Institute, February 2013 – August 2014. Identify literature and treatments related to safety mobility and accessibility concerns for pedestrians with disabilities at rail public transit crossings, participate in case study reviews, and preparation of the guide and final report.

Altamont Engineering. Design Services & Construction Documents for ART (Asheville Redefines Transit) Shelters. November 2012 – March 2013. Consultant on ADA and Public Rights-of-Way Accessibility Guidelines requirements at transit shelters in Asheville, NC.

VHB,Vanasse Hangen, Brustlin, Inc. Roundabout Design Project, Portland, ME. January – March, 2013. Consult on best practices for accommodating visually impaired pedestrians at proposed roundabout, including communication with nearby facilities for visually impaired individuals.

National Cooperative Highway Research Program Project 20-07, *Recommendations for Update of the AASHTO Pedestrian Guide.* Subcontract to Accessible Design for the Blind from Toole Design Group. Feb – April 2009. Subject matter expert in developing and reviewing materials developed in this project, focusing on issues of ADA compliance and accessibility of facilities to pedestrians with disabilities.

VHB,Vanasse Hangen, Brustlin, *White Papers for: Toward Zero Deaths: A National Strategy on Highway Safety*. February 2010 - December 2010. Consultant on white paper on vulnerable users.

TY Lin and Monroe County DOT, New York. Audible/Tactile Device Study. November 2009 - February 2011. Accessible Design for the Blind worked with engineering firm TY Lin and Monroe County and an advisory group of blind and visually impaired individuals to inform parties about newer types of accessible pedestrian signals and prioritize intersections for installation of accessible pedestrian signals.

National Cooperative Highway Research Program Project 3-78A, *Crossing Solutions at*

Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities; Subcontract to Accessible Design for the Blind from North Carolina State University, February 2005 – March 2010. Field research on recommended practices for geometric designs, traffic control devices, and other treatments at roundabouts and channelized turn lanes that will enhance safety, wayfinding, and independence of pedestrians who are blind.

National Cooperative Highway Research Program Project 3-89, *Design Guidance for Channelized Right-Turn Lanes*, Consultant to Midwest Research Institute, 2008 – 2011. Develop design guidance for construction of channelized right turn lanes, considering needs of all users, including pedestrians with disabilities.

Wisconsin Council of the Blind and Visually Impaired and Wisconsin DOT, *Roundabout Training Workshop*, April 2010. Workshop for orientation and mobility specialists on roundabout design and suggestions for information to be provided to clients regarding crossing at roundabouts

National Institute on Disability and Rehabilitation Research, *Fundamental issues in wayfinding technology*. Subcontract to Accessible Design for the Blind from Smith-Kettlewell Eye Research Institute, November 2006 – March 2010. Develop and validate methods and measures for evaluating assistive technologies for wayfinding.

US Access Board. *Common Problems Arising in the Installation of Accessible Pedestrian Signals.* January - June 2009. Develop guidance bulletin with simple explanation of typical problems in installation of accessible pedestrian signals and description of potential solutions.

Association of Pedestrian and Bicycle Professionals, May – February 2008. Work with team revising *Designing Pedestrian Facilities for Accessibility* course.

National Cooperative Highway Research Program *Project 15-35, Geometric Design of Driveways*. Subcontract to Accessible Design for the Blind from Urbitran (merged with AECOM), June 2006 – May 2009. The objective of the research is to develop recommendations for geometric design of driveways. Accessible Design for the Blind's role is to consult on issues related to the accessibility to pedestrians with disabilities of sidewalks crossing driveways.

Western Michigan University and University of California, Santa Barbara: National Institute on Disability and Rehabilitation Research, *Wayfinding Technologies for People with Visual Impairments: Research and Development of an Integrated Platform,* December 2001 – November 2007. Development and testing of features of wayfinding technology and identification of information needed by pedestrians who are blind or who have low vision.

National Cooperative Highway Research Program Project 3-72, *Lane Widths, Channelized Right Turns, and Right-turn Deceleration Lanes in Urban and Suburban Areas*, Subcontract to Accessible Design for the Blind from Midwest Research Institute, May 2003 – May 2005. Consultant on issues related to pedestrians with disabilities.

Institute of Transportation Engineers: Easter Seals Project ACTION project, *Online Training Course on Alteration of Pedestrian Facilities for Accessibility*, September 2003 – March 2005. Subject matter expert for Module 1, Pedestrian Accessibility and Module 4, Accessible Pedestrian Crossings.

Western Michigan University: Easter Seals Project ACTION, *Accessible Pedestrian Signals – Curriculum Development*, February 2002 - December 2003

University of Massachusetts, Amherst: U.S. Access Board. *Interfacing Accessible Pedestrian Signals with Traffic Signal Control Equipment*. April 2002 – April 2003

Accessible Design for the Blind: *Specifying speech messages for accessible pedestrian signals*,

May 2001 - January 2002

National Cooperative Highway Research Program Project 3-62 and 3-62A, *Guidelines for Accessible Pedestrian Signals;* Subcontract to Accessible Design for the Blind from University of North Carolina Highway Safety Research Center, October 2001 – November 2006, extended through 2017 for training workshops and updates of materials. Field research to identify, from currently available accessible pedestrian signal products, those features that best promote safety, wayfinding, and independence of pedestrians who are blind. Development of training to implement research results.

Performtech, Inc: FHWA course, *Designing Pedestrian Facilities for Accessibility*, November 2001 – June 2002, development of section of on accessible pedestrian signals.

OTAK, Inc. *Georgia Pedestrian and Streetscape Guide*, July 2001 - April 2004, consultant on accessibility issues.

Center for the Visually Impaired: VA R&D Center, *Accessible Pedestrian Signals,* April 2000 – October 2003

National Eye Institute, National Institutes of Health, *Blind Pedestrians' Access to Complex Intersections*. Subcontract to Boston College from Western Michigan University. 2000-2005; continued July 2007 – June 2010; subcontract to Accessible Design for the Blind, July 2010 – June 2013. Laboratory and field research to identify the features of accessible pedestrian signals that best promote safety, wayfinding, and independence of pedestrians who are blind. Laboratory and field research on technologies and materials to aid pedestrians who are blind in aligning to cross streets and maintaining alignment while crossing.

T.Y.Lin Bascor, *Planning, Design and Operation of Pedestrian Facilities,* May 1999 – December 2000, Professional Peer Review Panel.

Accessible Design for the Blind: U.S. Access Board, *Detectable Warnings: Synthesis of U.S. and International Practice,* September 1999 - May 2000

Publications

Guth, D. A., Barlow, J. M., Ponchillia, P. E., Rodegerdts, L. A., Kim, D. S., & Lee, K. H. (2019). An Intersection Database Facilitates Access to Complex Signalized Intersections for Pedestrians with Vision Disabilities. *Transportation Research Record*. https://doi.org/10.1177/0361198118821673

Bentzen, B.L., Barlow, J.M., Scott, A.C., Guth, D.A., Long, R. & Graham, J. (2017). Wayfinding problems for blind pedestrians at non-corner crosswalks: A novel solution. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2661, 120-125. DOI: 10.3141/2661-14

Bourquin, E. A., Wall Emerson, R. Sauerburger, D. & Barlow, J.M. (2017) The Effect of the Color of a Long Cane used by Individuals who are Visually Impaired on the Yielding Behavior of Drivers. *Journal of Visual Impairment and Blindness*. Volume 111, Number 5, September-October, 401 – 410.

Elliott, J., Lohse, K., Toole, J., Lockwood, I., Barlow, J., Bentzen, B., & Porter, C. (2017) *Accessible Shared Streets: Notable Practices and Considerations for Accommodating Pedestrians with Vision Disabilities*, Washington, D.C.: Federal Highway Administration. FHWA-HEP-17-096

Fazzi, D. L. & Barlow, J.M. (2017) *Orientation and Mobility Techniques: A Guide for the Practitioner*, *2nd Edition*. New York, NY: AFB Press.

Schroeder, B., Rodegerdts, L., Myers; E., Jenior; P., Cunningham, C., Salamati; K., Searcy, S.,

O'Brien, S. Barlow, J., & Bentzen, B. (2017) *NCHRP Report 834: Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities, A Guidebook*. Washington, D.C.: Transportation Research Board (TRB) of the National Academies of Sciences.

Schroeder, B., Rodegerdts, L., Myers; E., Jenior; P., Cunningham, C., Salamati; K., Searcy, S., O'Brien, S. Barlow, J., & Bentzen, B. (2017) *NCHRP Web Only Document 222: Application of Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities*. Washington, D.C.: Transportation Research Board (TRB) of the National Academies of Sciences.

Bourquin, E. A., Wall Emerson, R. Sauerburger, D. & Barlow, J.M. (2016) Conditions that Influence drivers' yielding behavior: Effects of pedestrian gaze and head movements. *International Journal of Orientation and Mobility.* Volume 8, Number 1,13-26.

Schroeder, B., Salamati, K., Rouphail, N., Findley, D., Hunter, E., Phillips, B., Barlow, J., & Rodegerdts, L. (2015) *Accelerating Roundabout Implementation in the United States, Volume I of VII: Evaluation of Rectangular Rapid Flashing Beacons (RRFB)at Multilane Roundabouts*. Washington, D.C.: Federal Highway Administration

Fitzpatrick, K., Warner, J., Brewer, M., Bentzen, B., Barlow, J., & Sperry, B. (2015) *TCRP Report 175, Guidebook on Pedestrian Crossings of Public Transit Rail Services.* Washington, D.C.: Transportation Research Board.

Bourquin, E. A., Wall Emerson, R. Sauerburger, D. & Barlow, J.M. (2014) Conditions that Influence Drivers' Yielding Behavior in Turning Vehicles at Intersections with Traffic Signal Controls. *Journal of Visual Impairment and Blindness*. Volume 108, Number 3, May-June, 173-186

Potts, I., Harwood, D., Bauer, K., Gilmore, D., Hutton, J., Torbic, D. Ringert, J., Daleiden, A., & Barlow, J. (2014) *NCHRP Web-Only Document 208: Design Guidance for Channelized Right-Turn Lanes.* Washington, D.C.: Transportation Research Board.

Scott, A. C., Bentzen, B. L., Barlow, J. M., Guth D. A., & Graham, J. (2014). Far-side beaconing for accessible pedestrian signals: Is it confusing? *Transportation Research Record: Journal of the Transportation Research Board, No. 2464,*135 -143.

Bentzen, B.L. & Barlow, J.M. (2014). Automated pedestrian detection and pedestrians who are visually impaired. *IMSA Journal,* Vol. 52, No. 4, 24-28.

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Exhibit B – Documents and sources consulted

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Discussions or review of listserv posts regarding APS or travel by blind pedestrians in NYC:

- Lukas Franck, Guide Dog Instructor and Certified Orientation and Mobility Specialist, The Seeing Eye, Morristown, NJ
- Eugene Bourquin, Certified Orientation and Mobility Specialist, New York, New York
- Pedestrians for Accessible and Safe Streets (PASS) Coalition, New York
- Matt Baker, National Sales Manager, Polara Enterprises (who granted permission for use of all audio files)
- David Ayres, Eastern Region Sales Manager, Polara Enterprises

Case-Related Documents from Counsel

- Complaint
- Documents Bates-numbered: NYC_00017274, NYC_0000001, NYC_00017076, NYC_00015723
- NYS DOT Guidance TSMI-15-01, TSMI 1-17-02

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